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

HAER FL-8-11-I
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
SOUTHEAST REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
100 Alabama St. NW
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 39, ORBITER PAYLOAD CANISTERS

HAER NO. FL-8-11-I

Location: John F. Kennedy Space Center, Cape Canaveral, Brevard County, Florida

USGS Orsino, Florida, Quadrangle, Universal Transverse Mercator Coordinates: E 534345.7 N 3154693.2 Zone 17, NAD 1983.

Date of Construction: 1978

Architect: Dr. Hui-Han (Hank) Liu, lead engineer with McDonnell Douglas Space Systems Company, Kennedy Space Center, Florida.

Builder: Belko Steel, Orlando, Florida, and Specialty Maintenance and Construction, Inc., Lakeland, Florida.

Present Owner: National Aeronautics and Space Administration (NASA)

Present Use: Orbiter Payload Canisters

Significance: The Orbiter Payload Canisters, also known as the canisters, were designed and built exclusively to protect and transport space shuttle payloads from various processing facilities to the launch pads or the Vehicle Assembly Building (VAB) where the payloads are subsequently transferred to the space shuttle orbiters. Only two canisters were constructed and they have served in the same capacity since 1979. Determined eligible for the National Register of Historic Places (NRHP) in a survey of U.S. Space Shuttle Program (SSP) facilities completed for NASA, the Orbiter Payload Canisters (8BR2017) were one of twenty-six assets on Kennedy Space Center (KSC) determined individually eligible for their role in the SSP.

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

Date: May 15, 2011

PART I. HISTORICAL INFORMATION

A. Physical History

1. Date of Construction

The two canisters were completed between 1978 and 1979.

2. Engineers

Structural Engineers:	
Canister Lower Structure:	Hui-Han Liu, Sudakar Bhide
Main Door:	Phil Kocol
Analysis:	Karl Meyer
Mechanical Engineers:	
Door Latch:	David Johnson
Pull-Up Mechanism:	David Johnson
Door Actuation System:	Harold Begley
Outrigger:	Jesse Harris
ECS:	Denis Testa
Pneumatics:	A. Curl

3. Builder/Contractor/Supplier

Belko Steel of Orlando, Florida, built Canister 1, while Specialty Maintenance and Construction, Inc. of Lakeland, Florida, built Canister 2. The canisters cost approximately $200,000.00 each.

4. Original Plans

NASA's complete collection of engineering drawings for the canisters consists of 112 structural designs. These drawings show the current state of the canisters, with the exception of minor modifications that may have been completed based on Engineering Orders (EO). Original plans, which do not show modifications, are not available. The canisters were not re-tasked and/or modified from an earlier NASA program, but were constructed in the late 1970s to serve their current function. Therefore, most changes have been minor; original drawings were produced in 1977 with minor modifications added occasionally until

March 2006. On each plan, the original drawing date is noted in the title block, as is each modification. The twelve plans that were the most important for understanding the design of the canister were photographed and included in this HAER documentation. These drawings were chosen with the assistance of Dr. Hui-Han Liu, the lead structural engineer for the project. Some of the plans were also redrawn for use as photo keys in this documentation. The full set of 112 drawings is archived at KSC and can be accessed by interested researchers.

The following description of the canisters, as originally designed, is derived from a comparison of the drawings described above with historic photography archived at KSC. Where appropriate, the KSC photograph number is included in a footnote. The appendix to this document contains a number of images showing the canisters in use at various times in their history and at different locations at KSC. In the descriptions that follow, these are referenced by figure number.

NASA and McDonnell Douglas designed and constructed the canisters to replicate the exact dimensions of the space shuttle orbiter's payload bay. This allows the payload to be preloaded into a vessel shaped identically to the shuttle's payload bay. The canisters contain identical mounting points and exact environmental specifications, which are customized for each payload. The length of time the payload is in the canister varies on the type of payload, the number of payloads, and the overall shuttle schedule. The average amount of time the payload spends in the canister is about seven days. The canisters usually deliver the payload to the shuttle's payload bay between two and four weeks before launch.

The loaf-shaped canisters were designed to be 64'-6" long, 18'-0" wide, and 22'-7" high at their highest point.[1] The approximate weight, when empty, is 105,000 pounds. The canisters were designed to carry payloads up to 15' in

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[1] Sheets 3 and 4, January 17, 1978, from notebook of plans entitled, "Orbiter Payload Canister," on file CRF Offices; "Inside the Canister Rotation Facility," *Spaceport News*, January 11, 2002, p. 4.

diameter and up to 60′ in length. The carrying capacity is 65,000 pounds.[2] The primary material used for construction was steel.

The canisters are transported on two custom-built flatbed trucks called the Payload Canister Transporters. When the canister is mated to the transporter, it is often referred to as the TransCan or known as a transporter throughout the rest of this document. There have been two sets of transporters used for the canisters. One transporter from the first set was adapted from an older Solid Rocket Booster Transporter vehicle.

Based on photographs of the canisters from early 1979, the canisters appear to have been originally painted with gray paint or primer on the outside, while the interior surfaces were painted white (Figure 3).[3] By the time of the first shuttle launch in 1981, the canisters' exterior surfaces were painted white, with the red "worm" NASA logotype on each side.[4] This logo was in use from 1975 to 1992 (Figure 10).

The initial design of the canisters called for the capacity to process payloads horizontally and vertically and the hardware, software, and controls were designed to accommodate the needs of rotating the canister in the VAB. Most of the changes completed on the canisters since construction have been in response to changes in how the payload is loaded into the canisters and then into the shuttle's payload bay. These changes, in turn, stemmed from the primary types of shuttle missions occurring at that time. While the early SSP focused on deploying satellites, later flights would emphasize Spacelab Missions and *Mir* support, until finally the shuttle became

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[2] *NASA Facts: Canister Rotation Facility* (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC, Revised 2006).
[3] Kennedy Space Center photograph negative number 108-KSC-380C-2150 FR07, dated August 13, 1980, from Kennedy Space Center Archives.
[4] Kennedy Space Center photograph negative number Print001.jpg, undated from Kennedy Space Center Archives.

increasingly dedicated to transporting the components of the International Space Station (ISS).

Spacelab, a joint effort of NASA and the European Space Agency (ESA) consisted of a reusable microgravity laboratory that was fixed within the shuttle's payload bay. Operated by payload and mission specialists from both agencies, Spacelab components flew on a total twenty-eight shuttle missions between 1983 and 1998.[5] Space shuttle support for the Russian *Mir* Space Station also played an important role in shuttle missions between 1995 and 1998. The joint U.S./Russian Shuttle-*Mir* program involved the shuttle docking with *Mir* nine times, delivering Russian and U.S. crew, as well as ferrying supplies and equipment to and from *Mir*.[6] Lessons learned from the joint work on Spacelab and the Shuttle-*Mir* program would contribute to the development of the ISS.

The descriptions of the canisters in the following section focus on the original design.[7]

The canisters are labeled with same designations as the orbiter: zenith (top), forward (front), starboard (right), aft (rear), port (left), and nadir (bottom). The top of the canister consists of two large clamshell doors, identical in size and shape to the payload doors of the orbiter.[8] These doors open to the starboard and port sides along the dorsal midline of the canister. Seven door latches are evenly spaced along the door seal.[9] Each door contains two door actuators, positioned vertically and lying halfway

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[5] Deming, Joan and Patricia Slovinac, *NASA-Wide Survey and Evaluation of Historic Facilities in the Context of the U.S. Space Shuttle Program: Roll-Up Report* (Prepared for the National Aeronautics and Space Administration, Environmental Management Division, Office of Infrastructure and Administration, Headquarters; Prepared by Archaeological Consultants, Inc., Sarasota, Florida, February 2008, revised July 2008), 2-23.
[6] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2-23.
[7] Notebook of plans entitled, "Orbiter Payload Canister," on file KSC.
[8] "Orbiter Payload Canister," 79KO7577, Sheet 3, on file KSC (HAER No. FL-8-11-I-28).
[9] "Orbiter Payload Canister," 79KO7577, Sheet 55, on file KSC (HAER No. FL-8-11-I-32).

between the midline and forward and aft ends. These door actuators attach to the screw jacks and brackets on the starboard and port sides of the canister doors. The grab rails are positioned to the outside of each of these door actuators, with two on each door.[10]

The forward end, as originally designed, is a flat vertical surface containing a personnel door leading into the canister payload bay and safety rails.[11] The original steel safety railings were in eight sections (Figure 3). Each section is a two-railed unit that folds flat against the forward end when not in use. Two longer sections of railing line the base of the canister, while the remaining smaller six sections ring the half oval side walls and top. The personnel door resides just starboard of the vertical midline and opens to the port.[12] The original railings served as safety features for the staff that would need to be on top of the canister after rotation to the vertical position when rotating in the VAB (Figure 6). These have since been removed. The forward end of the canister faces the aft of the transporter when the two are mated together.

The starboard side of the canister contains a door actuator pneumatic drive located in the middle of the starboard side, slightly more than halfway above the horizontal midline.[13] This pneumatic drive is connected to the two screw jack bracket assemblies by the horizontal pipes of the pneumatic system, which extend forward and aft. When the door actuator system is activated in the horizontal configuration, the door actuator pneumatic drive pulls the screw jacks down vertically, tilting as necessary in their brackets to clear the opening doors.[14] To the outside of each screw jack bracket, there are access platforms aligned

[10] "Orbiter Payload Canister," 79KO7577, Sheet 3, on file KSC (HAER No. FL-8-11-I-28).
[11] Kennedy Space Center photograph negative number 108-KSC-381-30 FR02.jpg, dated January 8, 1980, from Kennedy Space Center Archives.
[12] "Orbiter Payload Canister," 79KO7577, Sheet 3, on file KSC (HAER No. FL-8-11-I-28).
[13] "Orbiter Payload Canister," 79KO7577, Sheet 4, on file KSC (HAER No. FL-8-11-I-27).
[14] "Orbiter Payload Canister," 79KO7577, Sheet 52, on file KSC (HAER No. FL-8-11-I-3).

with the vertical grab rails on the doors. Beyond each of these platforms is a closely mounted ladder for accessing the platforms.

At the forward end of the starboard side, there is one half of a pair of canister outriggers, the other being located on the forward end of the port side. These outriggers can be folded or extended as needed for transfer of the canister to the Payload Changeout Room (PCR) at the launch pads.[15] In the extended position, the outrigger guides the canister as it is pulled up in a vertical position to the rotating service structure (RSS) at the launch pad to mate with the PCR. The outriggers serve to keep the canister, and by extension the shuttle's payload, as stable as possible as it is lifted up to the PCR. The smooth guide on the outrigger is referred to as the guide shoe.

At the aft end of the starboard side are a group of four instrumentation panels. The smallest panel, located above the other three, is an Instrumentation & Communication System (I&CS) panel with cable ports. These cables connect to the I&CS on the transporter.[16] This monitors variables such as temperature, humidity, or ammonia levels. Each payload has a carefully defined set of parameters for each variable. If the instrumentation inside the canister's payload bay records a reading outside those parameters, it will send a signal to the I&CS located on the transporter, which will in turn send an alarm to the operators in the cab. The two closed panels below the cable ports, and closer to the aft end, provide additional instrumentation for the system.

The fourth panel, the one farthest forward, provides instrumentation and access to the Environmental Control System (ECS). The ECS provides the specific environmental conditions to the payload housed in the canister. Like the

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[15] "Orbiter Payload Canister," 79K07577, Sheet 49, on file KSC (HAER No. FL-8-11-I-35).
[16] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.

I&CS, the ECS for the canister ties to the ECS on the transporter.[17]

On the starboard side, between the door actuator pneumatic drive and the forward ladder, there is a small door for access to the space immediately below the payload bay.[18] This area carries an environmental warning, signaling that its conditions mirror those inside the payload bay. This door allows for access to the ECS ductwork, particularly the return ducts.

At the top aft corner of the starboard side, there is an aft lifting trunnion used as an attachment point to rotate the canister to a vertical position. At the forward end of the starboard side, below the outrigger and approximately halfway up the starboard side, lies the forward lifting trunnion. Like the aft lifting trunnion, this serves as a cable attachment for rotating the canister to the vertical position. The forward and aft lifting trunnions are located at different heights on the side of the canister to keep the cables from intersecting and interfering with one another as the canister is rotated to the vertical position.

Where the starboard side meets the aft end of the canister, near the bottom of the canister and the door seal, are two rounded, flat steel structures with holes, oriented with their flat sides parallel to the transporter bed. These hold-down clevises, which are flattened steel mounted rings, serve as anchor points for fastening the canister with large steel pins to the transporter deck when the canister is in the vertical position.

The aft end of the canister originally duplicated the base of the shuttle with two "earlike" extensions on its top to mirror the profile of the rear half of the orbiter where the engines are located (Figure 3). The staff referred to

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[17] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.

[18] "Orbiter Payload Canister," 79K07577, Sheet 4, on file KSC (HAER No. FL-8-11-I-27).

these extensions as "mouse ears."[19] They were intended to hold the canister more securely in the vertical position. The surface of the aft end is flat except for four shallow metal blocks that the canister rests on when it is in the vertical position. At the top of the aft end, the tail, which again mimics the shuttle, contains the upper door seal control panel.

On the port side of the canister, certain elements are mirror images of their counterparts on the starboard side.[20] These include: the outrigger; the ladders, access platforms, door actuator pneumatic drive, and two screw jack bracket assemblies, which serve to open the port payload bay door; hold down clevis structures; and the forward and aft lifting trunnions. The port side, however, lacks the small panel on the starboard side that allows access to the ECS underneath the floor of the payload bay.

The primary difference in the port and starboard sides lies in the elements located at the aft end on either side. While the aft end of the starboard side holds the I&CS interfaces and panels, as well the ECS panel, the port side contains the personnel door, which leads to the payload bay, ECS duct attachments, and the pneumatic interface panel for the lower door seals.[21] Beneath the personnel door, which lies fairly close to the aft end, there is an access platform. Immediately aft or left of the door, the main ECS supply hoses are attached to the ECS supply duct. Just forward of the door, level with the platform, the external ECS return hoses are attached to the ECS return duct. Finally, the door seal interface panel is located just forward of the personnel door, at the same height as the top of the door.

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[19] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 9, 2010; Kennedy Space Center photograph negative number 108-KSC-380C-2150 FR07.jpg, dated August 13, 1980, from Kennedy Space Center Archives.
[20] "Orbiter Payload Canister," 79KO7577, Sheet 4, on file KSC (HAER No. FL-8-11-I-27).
[21] "Orbiter Payload Canister," 79KO7577, Sheet 4, on file KSC (HAER No. FL-8-11-I-27).

Moving inside from the port side personnel door to the interior of the payload bay, there is an access door to the crawlspace below the interior of the payload bay; this lies to the left as you are entering. The interior open space of the payload bay is bilaterally symmetrical.[22] When the clamshell doors are closed, the top of the bay is rounded from one door hinge to the other. Along the long sides of the canister (port and starboard sides) the walls drop straight down for approximately 4′ and then slope down toward the floor at approximately a 45-degree angle.[23] This leaves a flat section of the floor approximately 5′ across, which runs the length of the payload bay. Attached along the centerline of the floor is a two-rail structure called the keel support structure. This structure was intended to function as the payload attachment points.

The entire interior of the payload bay featured white, painted steel.[24] Beneath the sloped portions of the walls, access crawlspaces run along both sides. These are reached by the interior hatch near the personnel door on the port side, and by the exterior access door on the starboard side.[25]

Near the floor on both starboard and port sides, there are four return air vents for the ECS. Arrayed longitudinally along the interior surface of the doors, two supply air ECS ducts with multiple openings provide the appropriate mix for each payload.[26]

Along the sloped surface of the interior starboard side are five payload interface panels labeled A-E.[27] Plans called

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[22] "Orbiter Payload Canister," 79K12170, Sheet 1, on file KSC (HAER No. FL-8-11-I-29).
[23] "Orbiter Payload Canister," 79KO7577, Sheet 11, on file KSC (HAER No. FL-8-11-I-30).
[24] Kennedy Space Center photograph negative number 108-KSC-380C-3392 FR07.jpg, dated November 12, 1980, from Kennedy Space Center Archives.
[25] "Orbiter Payload Canister," 79KO7577, Sheet 4, on file KSC (HAER No. FL-8-11-I-27 and HAER No. FL-8-11-I-14).
[26] "Orbiter Payload Canister," 79K12170, Sheet 1, on file KSC (HAER No. FL-8-11-I-29).
[27] "Orbiter Payload Canister," 79K12170, Sheet 1, on file KSC (HAER No. FL-8-11-I-29).

for these payload interface panels to be customized for each specific mission. These panels include controls for the accelerometers, temperature, humidity, ammonia, fuel, and internal pressure. At the aft end of the starboard side, interior to the I&CS panels on the exterior of the canister there is an umbilical interface panel. Just above this, an ammonia sensor is mounted. Along the top of the sloped wall from aft to stern are an aft smoke detector, particulate level sensor, and forward smoke detector. Aft and forward fire detectors are located near the starboard wall on the aft and forward ends of the canisters.[28]

Along the top, interior surface of the starboard and port walls, eight payload fitting assemblies lie identically spaced, with four along each side.[29] These assemblies anchor the payload trunnions in the exact same manner that they are mounted in the orbiter's payload bay. This ensures that the payloads are held and then transported to the orbiter's bay in the same manner that they will be in the shuttle, thereby assuring the load stresses on various components remain the same.

At the far forward end of the interior space, immediately in front of the forward end wall, two symmetrical steel ladders with handrails allow access to the top of the canister doors while open in the horizontal position.

The forward end of the canister payload bay features a personnel door, offset to the port side of the midline, with its top approximately level with the straight walls on the side of the canister. An access platform on the inside of the door and a ladder allow safe access to the payload bay floor.

The interior aft end of the canister is a flat, vertical steel wall. Behind this wall, the main ECS ducts provide air to the ducts along the doors. HEPA filters mounted in

[28] "Orbiter Payload Canister," 79K12170, Sheet 1, on file KSC (HAER No. FL-8-11-I-29).
[29] "Orbiter Payload Canister," 79K12170, Sheets 5 and 6, on file KSC (HAER No. FL-8-11-I-33 and HAER No. FL-8-11-I-34).

these ducts remove particulates from the supply air before it enters the canister payload bay.[30]

Finally, each canister requires a specialized transporter, not only to transport it from one place to another, but also to supply the control systems to maintain the payload to individualized specifications and to rotate the canister between horizontal and vertical positions.[31] There have been two sets of transporters used for the canisters. While the second set was built specifically for the canisters, one of the earlier transporters was originally configured to carry the solid rocket boosters.

5. Alterations and Additions

Since the canisters were constructed in 1979, NASA has completed a number of alterations to them. While some of these may have been performance based, it appears that most have been in response to either changes in the mission types or a change in the primary method or location of payload processing and rotation. The major changes that can be determined from the engineering drawings, KSC archives, and those mentioned by the engineers responsible for the design or operation of the canisters are summarized below.

As originally designed, the canisters had "earlike" extensions on the aft end of the canister (Figure 3).[32] These can be clearly seen on certain images from 1979 and 1980, and it is obvious from these photographs that Canister 1 had these extensions removed by January of 1980. Pictures of what is presumed to be Canister 2 on delivery, dated August 13, 1980, show the original grey paint or primer color and the ears intact (Figure 3).

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[30] "Orbiter Payload Canister," 79K12170, Sheet 1, on file KSC (HAER No. FL-8-11-I-29).

[31] "Orbiter Payload Canister," 79K15395, Sheet 4, and 105788/1110.D on file KSC (HAER No. FL-8-11-I-36 and FL-8-11-I-37).

[32] Kennedy Space Center photograph negative number 108-KSC-380C-2150 FR07.jpg, dated August 13, 1980, from Kennedy Space Center Archives.

Both canisters were initially painted white on all interior surfaces of the payload bay.[33] It appears, however, that by possibly 1981, and definitely by October of 1982, the paint had been removed from all interior surfaces.[34] Current canister staff reported that the paint began to chip or flake, which could damage or contaminate the payloads. Workers used ground walnut shells to blast the paint from the interior walls. Ground walnut shell is a superior blasting material that is less likely to cause etching or other damage to the underlying surface. Due to the invasive nature of blasting, the extremely small size of the medium, and the inaccessible locations in the interior walls and crawlspaces of the canister, employees working with the canister have reported finding small fragments of nutshell years later.

The initial contingency plan for keeping the canister dry, if it was caught outside in the rain, consisted of a specially made grey rain cover, which covered the entire top surface of the canister to below the door hinges (Figure 10).[35] Although this cover worked, it was difficult to put in place as it involved the use of two cranes. This rain cover was retired in favor of a small cover shaped like a long rectangular strip that was attached by Velcro and covered only the door seal from end to end.[36]

At some point, one of the canisters was caught in the rain and the water seeped below the floor into grid-like pockets formed by the canister's support structure and outer skin. The trapped water had no outlet, so small drain holes were drilled into each of the square pockets on the bottom surfaces of both canisters and these were plugged with small rubber plugs.[37]

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[33] Kennedy Space Center photograph negative number 108-KSC-380C-3392 FR07.jpg, dated November 12, 1980, from Kennedy Space Center Archives.
[34] Kennedy Space Center photograph negative number 108-KSC-381-1855_2.jpg, from Kennedy Space Center Archives; Kennedy Space Center photograph negative number 108-KSC-82PC-1164.jpg, from Kennedy Space Center Archives.
[35] Kennedy Space Center photograph negative number 108-KSC-380C-3307 FR06.jpg, dated November 11, 1980, from Kennedy Space Center Archives.
[36] Kennedy Space Center photograph negative number KSC-08PD-3303 FR07.jpg, dated October 21, 2008, from Kennedy Space Center Archives.
[37] HAER No. FL-8-11-I-29.

The keel support railings have also been altered over time. They appear to have been, at various times, fully stretched along the floor of the payload bay, at about two-thirds length, to even about half length.[38] Overall, these were used infrequently, as the payload trunnion fittings along the tops of the walls were used more often.[39]

In 1992, a detachable ladder was added to the forward end of each canister to make the top more accessible when the canister was horizontal.[40] Although it is not clear from the historic photographs, since the ladder is removed during certain tasks, the ladder was likely changed more than once, each time altering the safety rails or the cage.

As noted earlier, most of the changes to the canister were either due to changes in rotating the canister due to location, or changes in payload processing due to the shifting mission objectives for the shuttle. Although this is described in more detail in later sections, over the SSP's history, certain payloads had to be processed horizontally and others vertically. This necessitated the canister transporting cargo either horizontally or vertically. Some payload protocols have even been complex enough to require multiple canister rotations before loading into the orbiter's payload bay.[41]

One major change that has occurred in the rotation process since the beginning of the program is the location where the canister is routinely rotated. At the start of the program, this was completed in the VAB as it had high clearance and heavy lifting cranes (Figure 4).[42] While rotation could be safely accomplished in the VAB, it was

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[38] HAER No. FL-8-11-I-12.
[39] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.
[40] "Orbiter Payload Canister," 79K12170, Sheet 3, on file KSC (HAER No. FL-8-11-I-28).
[41] *NASA Facts: Canister Rotation Facility* (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC,Revised 2006); "Inside the Canister Rotation Facility," *Spaceport News*, January 11, 2002, pp. 4-5.
[42] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.

more difficult, required multiple cranes, and often created additional safety precautions as payloads were in closer proximity to the stack as it was assembled (Figures 5 and 6).[43] For this reason, a new facility was built in 1993 called the Canister Rotation Facility (CRF), M7-777.[44]

Although there have been many different types of missions for the SSP, generally there has been a pattern in the frequency of certain types of shuttle missions, which has resulted in a direct effect on payload processing. The early shuttle missions dealt with satellite deployment and Spacelab. A number of changes were called for in 1982 after the first few shuttle flights had been completed. Spacelab missions began in 1983 and continued until 1998. Correspondingly, the engineering drawings may show a number of canister modifications in 1982 in preparation for Spacelab. Changes made to the canister in 1982 consisted in part of modifications to the door end restraint, spreader assemblies in the VAB, changes to the door latch and pull-up mechanism, and a hypergol sensor in the payload bay.[45]

The Hubble Space Telescope was launched in 1990 and was probably the most complex payload ever processed for the SSP. This likely contributed to the discussion that a dedicated space was needed to complete canister rotation. The first Hubble servicing mission occurred in 1993 and that year, the CRF was constructed and other modifications were made to the canisters. Some modifications included changes to: the pneumatic controls, the ECS, the configuration of the forward part of the canister for

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[43] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.

[44] The CRF, like other eligible components of the SSP, is covered by a separate HAER documentation.

[45] The cover sheet of "Orbiter Payload Canister," 79K07577 (HAER No. FL-8-11-I-26) notes in the title block that the following changes were made to the plans in June of 1982, "Revised picture this sheet. Sheet was 1 of 60. Added sheets 26A, 26B, 26C, 61, 62, and 63. Revised sheets 1 thru 17, 20, 21, 24, 26 thru 31, 35, 37 thru 48, 52, 54 thru 62. Included EO 20-29, 31, 32, 33, 35, 36, & 38-49. EO 19, 30, 34, & 37 cancelled prior to release."

rotation in the CFR, adding a ladder to the forward end, and modifications to the outriggers.[46]

Missions dedicated to the construction, servicing, and staffing of the ISS began in 1998 and have continued through present with almost all of the missions, except for servicing the Hubble, dedicated to the ISS since 2002. After the loss of the *Columbia* in 2003, a number of minor or cosmetic changes were made to the canisters while the shuttles were grounded.[47]

B. Historical Context

NASA was created in 1958 in response to the Soviet launching of *Sputnik*. 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 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 by Nixon in 1972. The SSP was based on the idea that a series of reusable space flight vehicles would make orbital space flight "routine."[48]

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[46] The cover sheet of "Orbiter Payload Canister," 79KO7577 (HAER No. FL-8-11-I-26) notes in the title block that the following changes were made to the plans in July of 1993: "Inc EO 50 thru 68, 70 thru 73, 75 thru 88, 90 thru 103, & 105 thru 117. EO 69, 74, 89, &104 cancelled. Revised Sheets 1 thru 8, 10, 14 thru 18, 20 thru 26, 26B, 28, 30 thru 36, 38 thru 44, 46-49, 51, 52, 57 thru 63. Revised Logo (Rev E Sheets only). Sheet No. was 1 of 63. Include EO 56, 58, 116, & 117 this sheet."

[47] Canister Rotation Facility Manager, Liz Boyd, Personal Communication, August 10, 2010.

[48] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.1.

The SSP started during the 1970s, as contracts were awarded, new space vehicles were designed, old facilities were retro-fitted, and new facilities were built. After a decade of preparation, the first shuttle flight occurred on April 12, 1981. After almost three decades of operations, the SSP is scheduled to retire in 2011.[49]

During those twenty-nine years of operation, there have been 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 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*).[50] 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* 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 crew members on board.[51] Both of these accidents resulted in lengthy flight down time for the program, while exhaustive investigations led to extensive physical and procedural improvements.

Most of the Space Transportation System (STS) was in place by the time of the first shuttle launch in 1981 including the canisters. 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-

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[49] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.1.
[50] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.22-24.
[51] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.15.

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. To understand the function of the canisters, it is necessary to first understand the various components that comprise a typical space shuttle flight and the various steps required to prepare the shuttle and its payload for a launch.

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 Kennedy Space Center 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 VAB. 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.[52]

These launches were conducted from Kennedy Space Center's Launch Complex 39, Pad A. By the mid-1980s, Launch Complex 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.[53]

The space shuttle, a vehicle designed to be launched vertically, orbit the Earth, and then land horizontally, is comprised of three main components that are 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 (SRB) that flank either side of the ET. Of these three parts, only the ET is expendable and is not recovered after each flight.[54]

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

The orbiter or space shuttle is the central component of any shuttle flight. The orbiter carries the shuttle astronauts and the payload. Equipped with its own engines, it is versatile in space and capable of re-entry into Earth's atmosphere, after which it can land like a glider. It is not, however, capable of leaving the Earth's gravitational pull upon launch. For this, it requires the ET and the two SRBs.

The ET is 154′-0″ tall and 27′-0″ in diameter. It serves as the structural backbone for the whole shuttle assembly; both the orbiter and the two SRBs are attached to it. Designed in the 1970s by Martin Marietta Corporation, the ET contains liquid hydrogen and liquid oxygen, which serve as a fuel and oxidizer for the orbiter's three main engines. The fuel in the ET provides the shuttle with approximately 29 percent of the thrust needed to escape the Earth's gravitational pull and enter orbit. When expended, the ET is jettisoned over the Indian Ocean and is not recovered.[55] Most of it burns up upon re-entry.

The SRBs are the workhorses of the shuttle, providing approximately 71 percent of the thrust for achieving orbit. Thiokol Chemical Company designed the SRBs in the 1970s. The two SRBs are attached to either side of the ET and support 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'. When fully loaded with solid propellant, each booster weighs around 160 tons. Most of that weight is in the propellant.[56] The SRBs are comprised of four segments that when stacked together and ignited from the top of the uppermost segment will burn down the length of the booster like a gigantic Roman candle, beginning at the edge of the tube and working

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[55] 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, NASA History Web Curator. National Aeronautics and Space Administration, NASA History Office, http://history.nasa.gov/rogersrep/51lcover.htm), Chapter IV.

[56] Presidential Commission, *Report on Challenger Accident*, Chapter IV; Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 2.4-5; "SRB Complex Work Begins on Site North of VAB," *Spaceport News*, Volume 21, No. 17, August 19, 1982, p. 7; *NASA Facts: Solid Rocket Boosters and Post-Launch Processing* (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida; FS-2004-07-012-KSC, www.nasa.gov, Rev. 2006).

outward to the edge of the rocket casing, until the fuel is spent. By that point, two minutes into the flight, the two SRBs have driven the shuttle assembly more than twenty-six miles above the Earth's surface and have exhausted their fuel. The spent booster rockets are jettisoned from the ET and the orbiter and fall back to Earth, landing in the Atlantic Ocean.[57] The *Liberty Star* and *Freedom Star*, two ships designed for this purpose, retrieve the two boosters and return them to Cape Canaveral Air Force Station, Hangar AF Complex.

While in orbit on a typical mission, the shuttle crew completes their specific mission objectives, including deploying payload, conducting experiments, and performing extravehicular activities (EVAs). Space shuttle payloads have historically been 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 lands at KSC as the preferred landing site, although alternate landing locations include Edwards Air Force Base, California, and White Sands Test Facility, New Mexico, for emergency landings. NASA has 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.

II. STRUCTURAL/DESIGN INFORMATION

A. General Description:

1. Character. Canisters are unique structures designed for one very specific purpose – the transportation of fully integrated space shuttle payloads from one location to another, in an environmentally-controlled space identical in shape and size to the orbiter's payload bay, until it is transferred from the canister to the orbiter just prior to launch. As part of the *NASA-Wide Survey and Evaluation of*

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[57] *NASA Facts: Solid Rocket Boosters*. (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC, Revised 2006).

Historic Facilities in the Context of the U.S. Space Shuttle Program: Roll-Up Report, the two canisters were evaluated as eligible under Criteria A and C for their unique payload transport capabilities, as well as design and construction.[58] All historic resources at KSC were grouped by functional types under the study and the canisters were determined to be Type 1, "Resources Associated with Transportation and Type 12, "Resources Associated with Processing Payloads." The payload canister transporters were evaluated at the same time and determined not eligible.[59]

2. Condition of Fabric. The condition of both canisters is excellent and fully operational. Maintenance has been ongoing and some upgrades were completed in 2003 after the loss of *Columbia*.

B. Construction:

Belko Steel of Orlando, Florida, built Canister 1, while Specialty Maintenance and Construction, Inc. of Lakeland, Florida, built Canister 2. The canisters cost approximately $200,000.00 each and were based on plans provided to NASA by McDonnell Douglas Space Systems Company, Kennedy Space Center Florida.

C. Mechanical/Operation:

One of the critical functions of the space shuttle is to deliver payloads into orbit, either as satellites or as part of supporting, constructing, or repairing, an orbiting space station or observatory. The process of preparing, loading, and unloading shuttle payload is complex and involves many skilled individuals and unique equipment and facilities. Understanding this process is key to understanding the initial design of the canisters, as well as its revisions.

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[58] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 5-11.
[59] Deming and Slovinac, *Evaluation of Historic Facilities, Space Shuttle Program*, 4-14.

The following section summarizes the payload processing steps that have been in effect for the majority of the missions since the CRF was built in 1993 and since the mission shift to almost entirely ISS payloads.[60]

A canister begins preparations for a new payload mission in the maintenance high bay of the CRF[61]. This space serves as the maintenance area for the canisters and the transporters. Once a canister arrives at the CRF, it can be demated from the transporter and the transporter can be moved to the low bay. At this point, the canister bay doors can be opened using the pneumatic screws and any routine maintenance and or modifications can be made to the canister or the transporters.

When maintenance is complete, the canister is mated to the transporter and moved in the horizontal position to the CRF. From the horizontal position in the CRF, the payload fittings can be installed at the correct distances for attachment of the payload trunnions. These will be attached with fittings identical to those in the orbiter. This serves to ensure that the weight of the payload is distributed in the same manner it will be when it is attached to the orbiter's payload bay. This avoids placing stress on parts of the payload that were not intended for it. After the payload fittings have been configured for the next mission, the canister is ready to be cleaned.[62]

For the first stage of cleaning, the Multi-Mission Support Equipment (MMSE) team or Canister (Can) Crew closes the doors and then rotates the canister to the vertical position using the 100-ton crane (Figures 19-21). The doors are opened manually, not pneumatically, from the vertical position and the canister is ready for a vertical cleaning. First, the entire interior of the canister is cleaned with alcohol and approved clean room

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[60] NASA Facts: Canister Rotation Facility. IS-2004-09-014-KSC (Rev. 2006).
[61] The term Canister Rotation Facility (CRF) refers to both the single large, high-bay, clean room where rotation is complete and the complete facility, which includes the CRF and the attached offices, high and low maintenance bays, and maintenance buildings. In this document Canister 1 was photographed outside the CRF and in the CRF High Bay. Canister 2 was photographed inside the maintenance high bay of the CRF.
[62] NASA Facts: Canister Rotation Facility (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC (Revised 2006).

wipes. Next, using a lift, technicians use compressed air and vacuums to blow down all interior surfaces to remove dust and small pieces of debris (Figure 23).[63]

After cleaning, the staff completes a check to verify that the telemetry data is correct for the specific mission parameters. This test of the I&CS ensures that the accelerometers inside the canister have the correct parameters for g-force movements, fires, temperature, and any gases that are inside the canister.[64]

If the I&CS check is favorable, then the doors of the canister can be closed and sealed. Air inside the payload bay is then sampled and checked for particulates and hydrocarbons.[65] Once the configuration, cleaning, testing, and sealing of the canister is complete, it cannot be re-opened until it reaches the specific payload processing facility that is specified in the mission. The canister is now returned to the horizontal position.

The day before the canister is moved to the appropriate payload processing facility, the transporter is steam cleaned to prevent it from bringing contaminants into the clean room areas of the Space Station Processing Facility (SSPF).

Today, the Boeing payload team completes most payload processing horizontally at the SSPF (Figure 22). However in the past, payload processing was completed both vertically and horizontally at the Vertical Processing Facility (VPF) or at the Operations and Checkout Building (O&C)(Figures 7-9 and Figures 10-15, respectively).[66]

When it is time to load the payload, the transporter carries the horizontal canister to the SSPF. Once in place, the doors are

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[63] CRF Manager, Liz Boyd, Personal Communication, August 9, 2010.
[64] NASA Facts: Canister Rotation Facility (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC (Revised 2006).
[65] NASA Facts: Canister Rotation Facility (National Aeronautics and Space Administration, John F. Kennedy Space Center, Florida. IS-2004-09-014-KSC, (Revised 2006).
[66] Ragusa, James M. *Payload Processing at the Launch Site*, p. 72. This article discusses in detail vertical payload processing at the Vertical Processing Facility.

opened pneumatically. For most ISS missions, the payload is loaded using the payload strongback (Figure 15). This unique device is capable of lifting and supporting multiple types of payloads at multiple facilities.

Once the payload is loaded into the canister, the doors are closed and the appropriate environmental parameters are established inside the canister. This is done with the integration of three systems located partly on both the canister and the transporter. These systems are the I&CS, ECS, and F&GS. The transporter's ECS is on the front of the transporter, adjacent to the cab, while the I&CS and F&GS are located on the aft starboard corner of the transporter. Once the canister is disconnected from power and controls in the CRF, the canister interfaces with the systems on the transporter to maintain the necessary environmental parameters.

Payload is usually loaded into the orbiter from the Payload Changeout Room (PCR)(Figures 16-18). There is a PCR at both Launch Complexes 39A and B. In order for the payload to be loaded into the PCR, the canister must be in the vertical position.

Since construction of the facility in 1993, all canister rotations have been completed at the CRF. Before 1993, the canister was rotated in the VAB. In the CRF, rotation is accomplished using the 100-ton bridge crane attached to a spreader bar.[67] The hoist sling from the spreader bar hooks into the forward canister trunnion (Figure 19). As the crane lifts the canister from the forward end attached to the forward trunnions, the canister pivots around the aft trunnions until it is over its center of gravity (Figure 20). It is then lifted straight up vertically and placed gently onto the transporter (Figure 21). The bed of the transporter is then tipped to match the planarity of the canister and the canister's hold-down clevis is attached to the transporter's hold-down fittings.[68]

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[67] "Inside the Canister Rotation Facility," *Spaceport News*, January 11, 2002, p. 4.
[68] CRF Manager, Liz Boyd, Personal Communication, August 9, 2010.

The process of completing a rotation in the CRF, from set-up to break down, takes approximately six hours.[69] Before the construction of the CRF, rotation involved two cranes and difficult manual manipulation of heavy cables and hooks.[70]

Worker History

NASA has always used contractors and subcontractors in the day-to-day operation of the canister at the CRF, as well as at most of its other operations at other facilities within KSC. Since the first shuttle launch in 1981, Boeing crews (initially McDonnell Douglas employees) have been responsible for all payload processing for the SSP.[71] Up through 2002, Boeing completed this work under the Payload Ground Operations Contract (PGOC), which was responsible for the processing of more than two million pounds of payload at KSC. In 2002, NASA awarded Boeing the Checkout, Assembly, & Payload Processing Services (CAPPS) contract, which included mission cargo preparations, payload processing, testing for launch vehicle compatibility, post-mission payload extraction, and operation and maintenance of associated facilities and ground facilities.[72]

The number of crewmembers varies for different tasks associated with the canister. For example, moving a canister in the horizontal position out of the CRF requires a number of trained staff members. There are individuals in the cab, spotters on each stanchion, spotters on the ground at each corner, and someone in front of the vehicle. Other types of moves, each of which would have a specifically tailored Boeing staffing plan, include: transporting the canister to the SSPF in the horizontal position; returning to the CRF, rotating the fully-loaded canister to the vertical position, and moving the canister to the launch pad to transfer the payload to the PCR. Specific staff assignments are proprietary to Boeing.

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69 "Inside the Canister Rotation Facility," *Spaceport News,* January 11, 2002, p. 4.
70 "Inside the Canister Rotation Facility," *Spaceport News*, January 11, 2002, p. 4.
71 *Boeing Backgrounder,* January 2010. Boeing's Role Processing NASA Payloads.
72 *Boeing Backgrounder,* January 2010. Boeing's Role Processing NASA Payloads.

Until recently, as the program has begun to come to fruition, there have been three shifts of workers at the CRF, which included engineers and technicians. This allows the canister to be turned around for the next mission quickly and also allows the team to complete some of the work at night when temperatures are cooler. Transfer of the canister and payload to the PCR is frequently done at night as it is easier to maintain temperature parameters inside the canister and lightning and high winds are less of a risk.

Weather is a factor in when the canister can be transported to various locations at KSC. Lightning and high winds are the main concerns. Wind limits are lower when the canister is in the horizontal position. The KSC Weather Officer is involved in all decisions concerning canister moves outside of building facilities.

D. Site Information:

As the canisters are mobile structures and generally found with their transporters, this section briefly describes the most common locations for the canisters (Figures 1 and 2). The canisters are predominately used in the KSC Industrial Area and the Launch Complex 39A and B areas. However, there have been occasions where the canisters have been transported to other locations on KSC or Cape Canaveral Air Station (CCAS), including trips to pick up classified DoD payloads (Figure 1).

Within the Industrial Area, the primary location for the canisters is the CRF (Figure 2). As mentioned earlier, this area serves as the rotation site, as well as the storage and maintenance site for the canisters. The SSPF also lies within the Industrial Area along with the O&C Building and formally the VPF was located here as well (Figure 2). The VPF was demolished in 2010.

In the Launch Complex 39 Area, the canisters may be found at the VAB and at Launch Pads 39A and B, where the payloads are transferred to the shuttle orbiters at the PCRs (Figure 1).

III. Sources of Information:

A. Engineering Plans and Drawings

The construction plans for the canisters are housed at KSC, administered by NASA. While initial plans were completed by McDonnell Douglas Space Systems Company, Kennedy Space Center Division, later plans list Boeing (who purchased McDonnell Douglas in 1997), as the designer. A total of 112 plans detail the structure of the canisters. These 112 plans are the only plans available for the canisters. The plans date from January 17, 1977, and show the approximate current state of the canisters by including a number of modifications between 1978 and 2010. These modifications are noted on the title block for each plan. Some specify what change was made in the title block, while other minor changes are noted only by EO number.

As part of this study, the canisters' lead structural engineer and the author selected ten of these engineering drawings for reproduction in this documentation. They show the important facets of the canister's plans, including elevations, floor plans, details, and sections. The remaining two plans reproduced in this documentation are of the transporter and were included to illustrate how the canister connects with its transporter.

B. Early Views and Historical Data

KSC maintains a large and rich collection of historic photographs that show the canisters in use at various locations within KSC. Some of these views are included in the Appendix along with maps showing locations where the canisters are frequently used. All views are captioned and dated as available. The other historical data comes from a variety of sources cited in the Bibliography below.

The historic photographs and most of the historical data used in this documentation came from sources within KSC, specifically the KSC Archivist, Elaine E. Liston, whose office and data files are in the main Headquarters Building. Another source was the Photograph Archivist, Vera Van Hooser, of IMCS Photo and Media

Services, also located in the KSC Headquarters Building. Other more current imagery was obtained from the online KSC Media Archive.[73]

C. Interviews:

The following knowledgeable employees, working for NASA through the Boeing contract, were interviewed for this documentation. Each provided a significant amount of information about the design, operation, and history of the canisters. Most of the canister-specific information was obtained from a series of walking tours and personal interviews from the CRF Manager, Elizabeth Boyd, as well as other engineers, and technicians working in the CRF.[74] Dr. Hui-Han (Hank) Liu, the Structural Engineer who designed the canisters, also provided much useful information and suggested which plans were the most important to illustrate the overall and unique features of the canisters.[75]

D. References

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[73] *NASA, Kennedy Space Center Online Media Archive*. Accessed September 2010 at http://mediaarchive.ksc.nasa.gov/

[74] Boyd, Elizabeth, Canister Rotation Facility Manager. Personal Interviews, August 9-13, 2010

[75] Liu, Hui-Han, Lead Engineer, Boeing, Personal Interview, August 10, 2010.

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E. 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 the offices of Belko Steel of Orlando, Florida, and Specialty Maintenance and Construction, Inc. of Lakeland, Florida.

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

Part IV. PROJECT INFORMATION

NASA determined that the canisters were eligible to the National Register of Historic Places under Criteria A and C in the areas of Space Exploration and Transportation, and Engineering. This determination was made by NASA's "Shuttle Transition Historic Preservation Working Group" or HPWG, which looked at 335 facilities at thirteen NASA Centers.[76] 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

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

canisters were identified as falling within Types 1 and 12, which are Resources Associated with Transportation and Resources Associated with Processing Payloads, respectively.[77] NASA completed this evaluation as the SSP is 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, and the Florida State Historic Preservation Officer, dated May 2009, and the Statement of Work provided to New south Associates by KSC/Innovative Health Applications (IHA) as part of the Task Order Contract dated February 2010, the documentation package for the Orbiter Payload Canisters 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 canisters.

New South Associates, under contract with IHA, a subcontractor to NASA, conducted the HAER documentation and historic research for this project in August 2010. With the end of the SSP, the canisters or payload canister transporters may be adapted and modified for future space missions. Therefore, NASA is completing HAER documentation of the canisters and other KSC properties to record these as they appear and as they existed during the SSP. David Diener served as the project photographer. J. W. Joseph served as Principal Investigator, while Julie Coco served as Project Historian. Historian Mark Swanson authored portions of the historic context.

In order to complete the project, New South Associates personnel were allowed full access to the facility, under the supervision of Mark Mercandante, an Environmental Engineer with IHA, and Liz Boyd and Steve Kelly of the Canister Rotation Facility staff of KSC. Photographs were taken of the canisters outside the CRF, as well as, in the CRF and in the Maintenance high and low bays.

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

Shannah Trout, also of IHA, assisted with early coordination efforts and editing.

Julie Coco conducted a limited number of oral interviews and otherwise compiled the historic documentation required for the project. Among the people interviewed for this project were: Liz Boyd, Canister Rotation Facility Manager and Systems Engineer, and Dr. Hui-Han (Hank) Liu, lead engineer with Boeing, at the Kennedy Space Center. These individuals provided much of the historical information used in this project. Elaine Liston and Vera Van Hooser also provided much information through their offices in the KSC Headquarters Building.

Appendix- Location Map and Historical Views

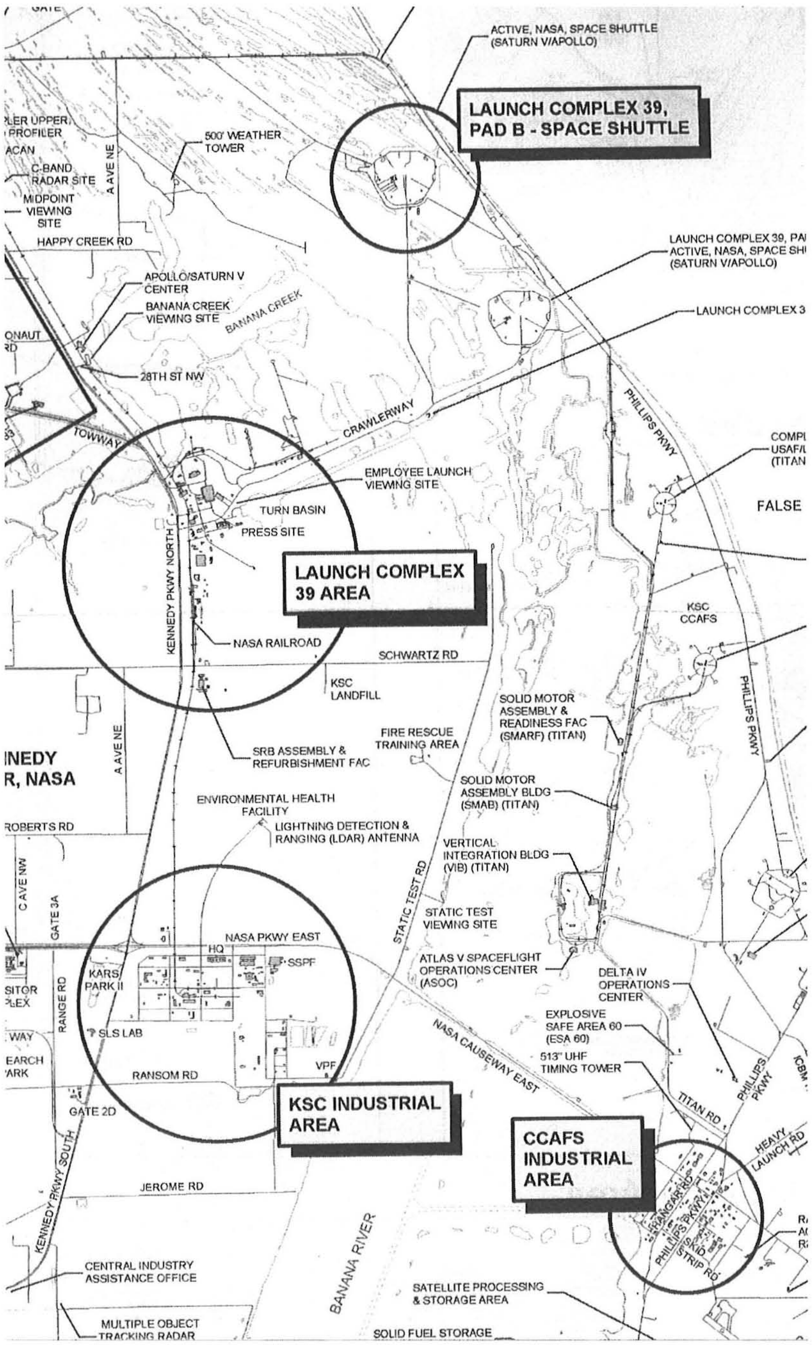

Figure 1. Map of Kennedy Space Center showing use locations for the orbiter payload canisters. (Courtesy of Kennedy Space Center)

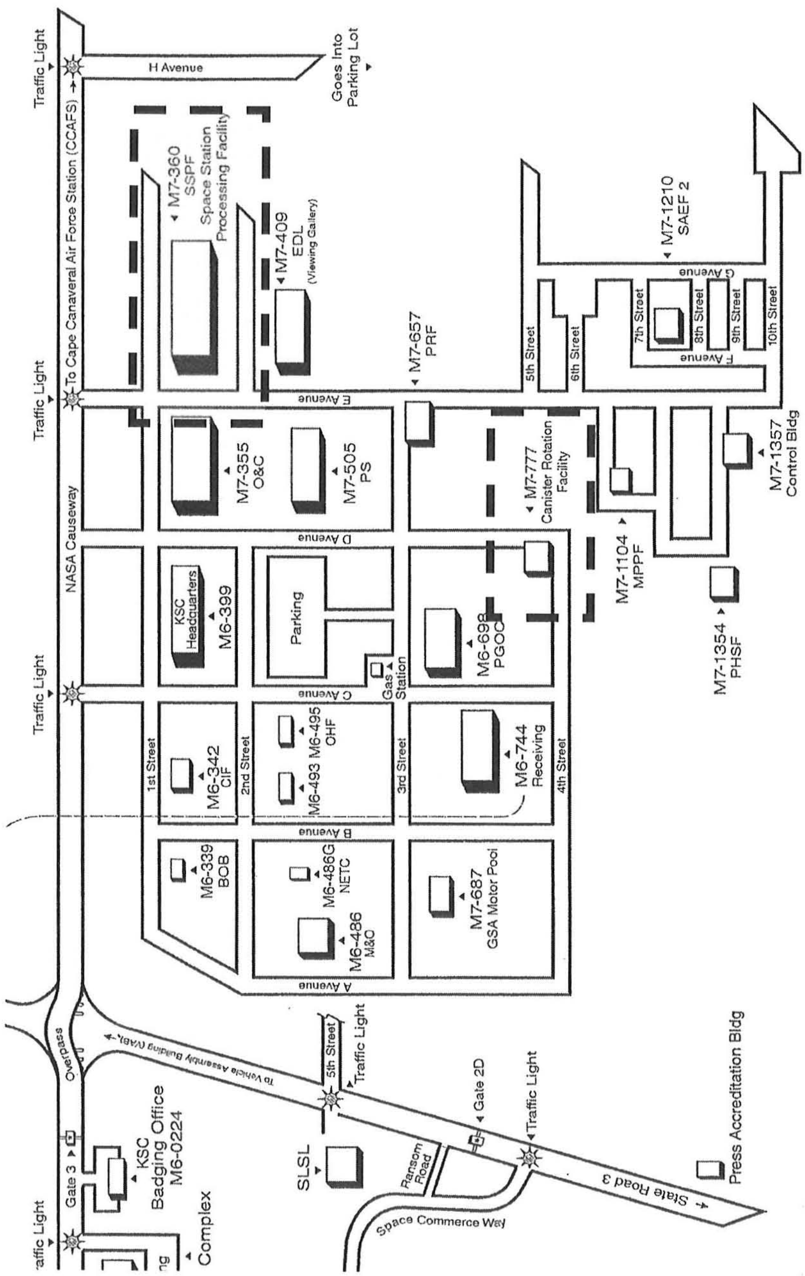

Figure 2. Map of Kennedy Space Center Industrial Area showing locations for the Canister Rotation Facility (CRF) and the Space Station Processing Facility (SSPF). (Courtesy of Kennedy Space Center).

Figure 3. Original appearance of the orbiter payload canister before painting, view to north, August 13, 1980 (Courtesy of Kennedy Space Center, Image 108-KSC-380C-2150 FR07.jpg).

Figure 4. Payload canister exiting the Vehicle Assembly Building (VAB), undated. (Courtesy of Kennedy Space Center, Image 108-KSC-80P-367.jpg).

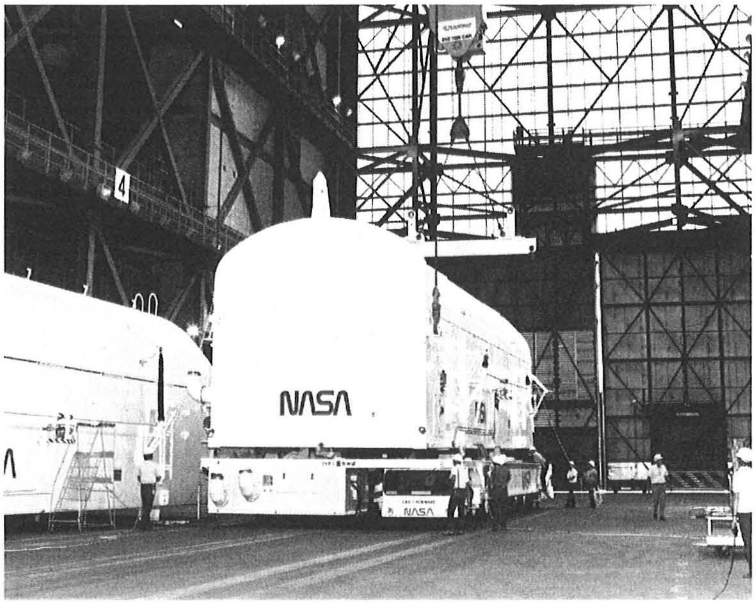

Figure 5A. Canister 1 and canister 2 inside the VAB, undated. (Courtesy of Kennedy Space Center, Print 001.jpg).

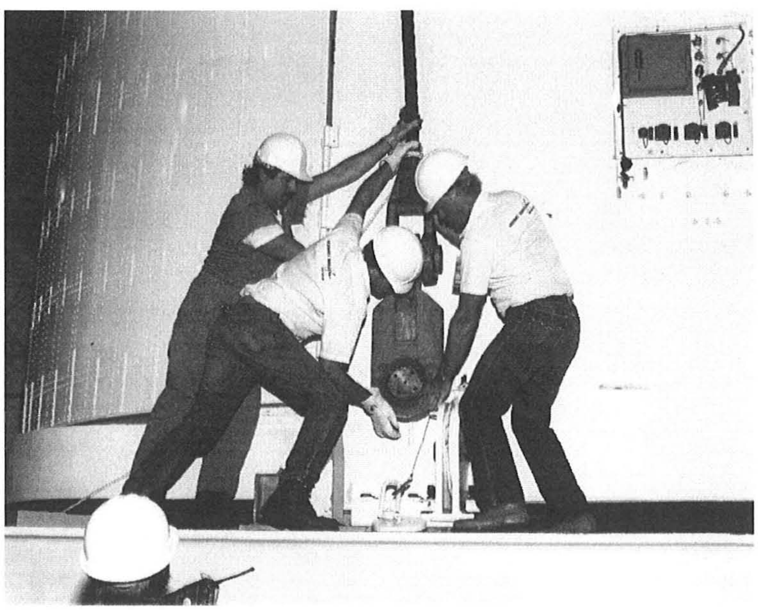

Figure 5B. Manual manipulation of the cables during canister rotation in the VAB, undated. (Courtesy of Kennedy Space Center, Image Print 004.jpg).

Figure 6. Canister rotation in the VAB, undated. (Courtesy of Kennedy Space Center, Print 002.jpg).

Figure 7. Canister in the VPF. March 30, 1984. (Courtesy of Kennedy Space Center, 108-KSC-380-851 FR07.jpg).

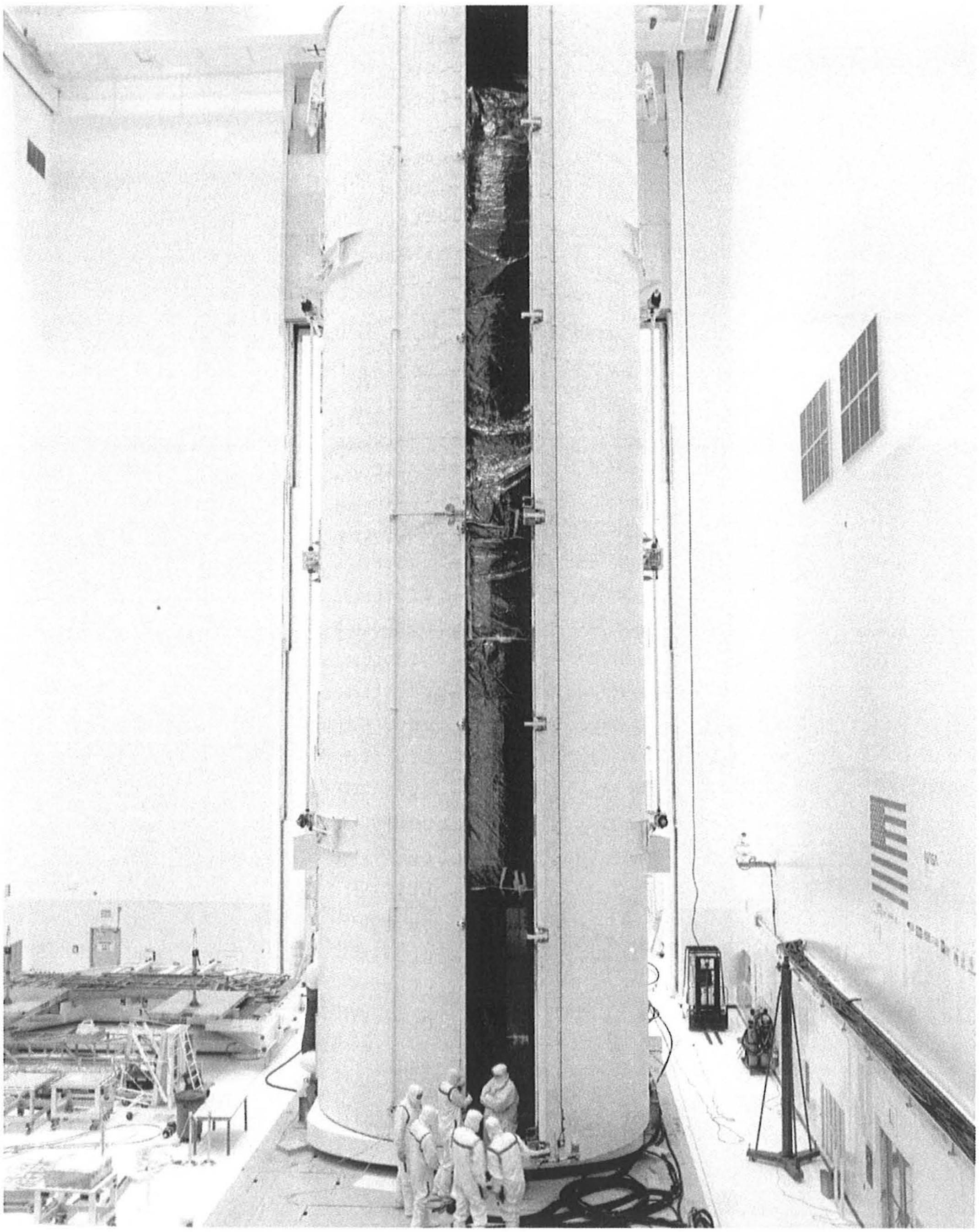

Figure 8. Canister inside clean room of VPF with doors partially open and payload visible, undated. (Courtesy of Kennedy Space Center, KSC-390-2721_08.jpg).

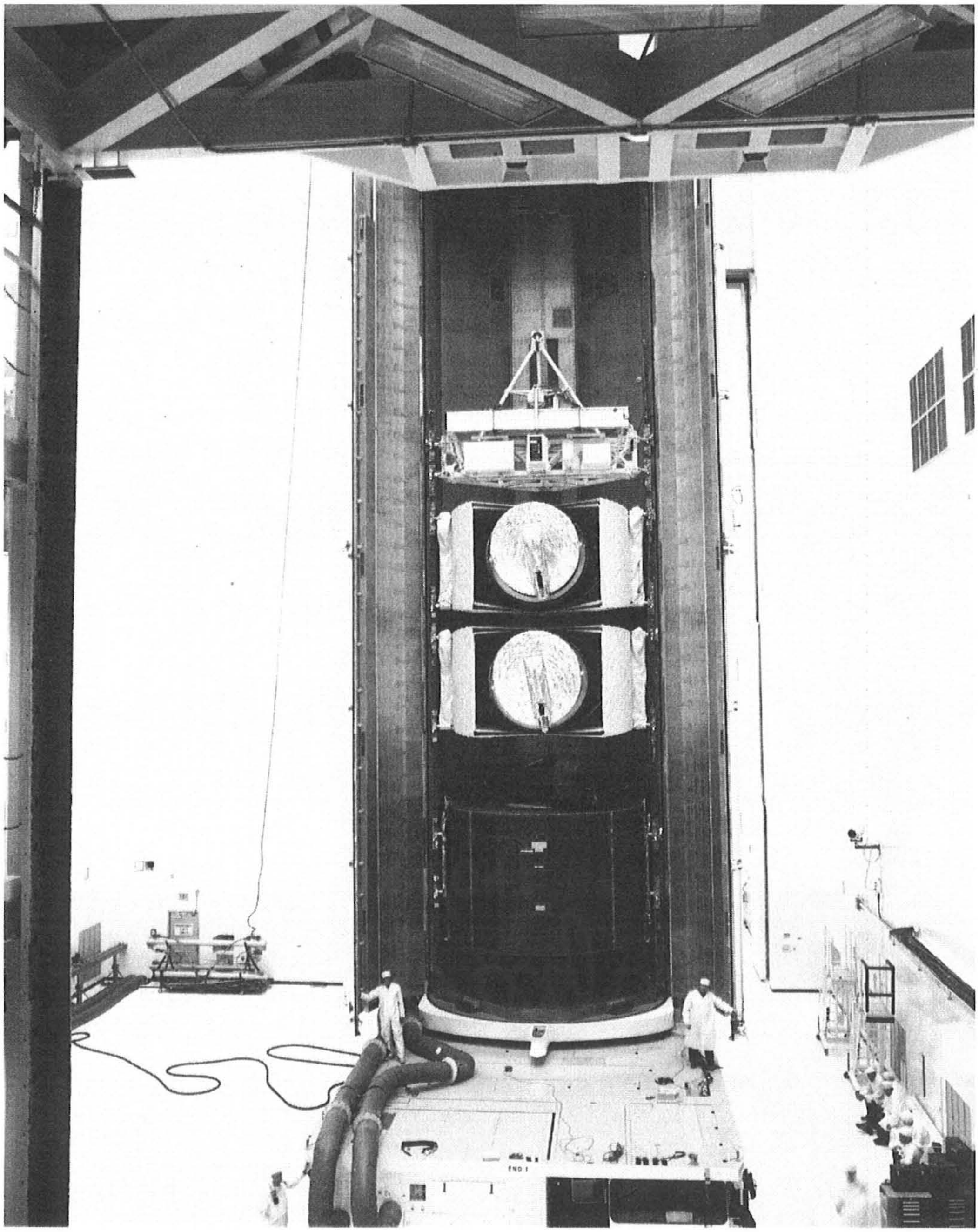

Figure 9. Canister open in VPF. Payload for STS-5, SBS-3 and Anik C-3, being loaded into canister, undated. (Courtesy of Kennedy Space Center, 108-KSC-84PC-541.jpg).

Figure 10. Payload canister with the original rain cover en route from the Operations and Checkout Building (O&C) to the VAB. November 11, 1980. (Courtesy of Kennedy Space Center, 108-KSC-380C-3307 FR06.jpg).

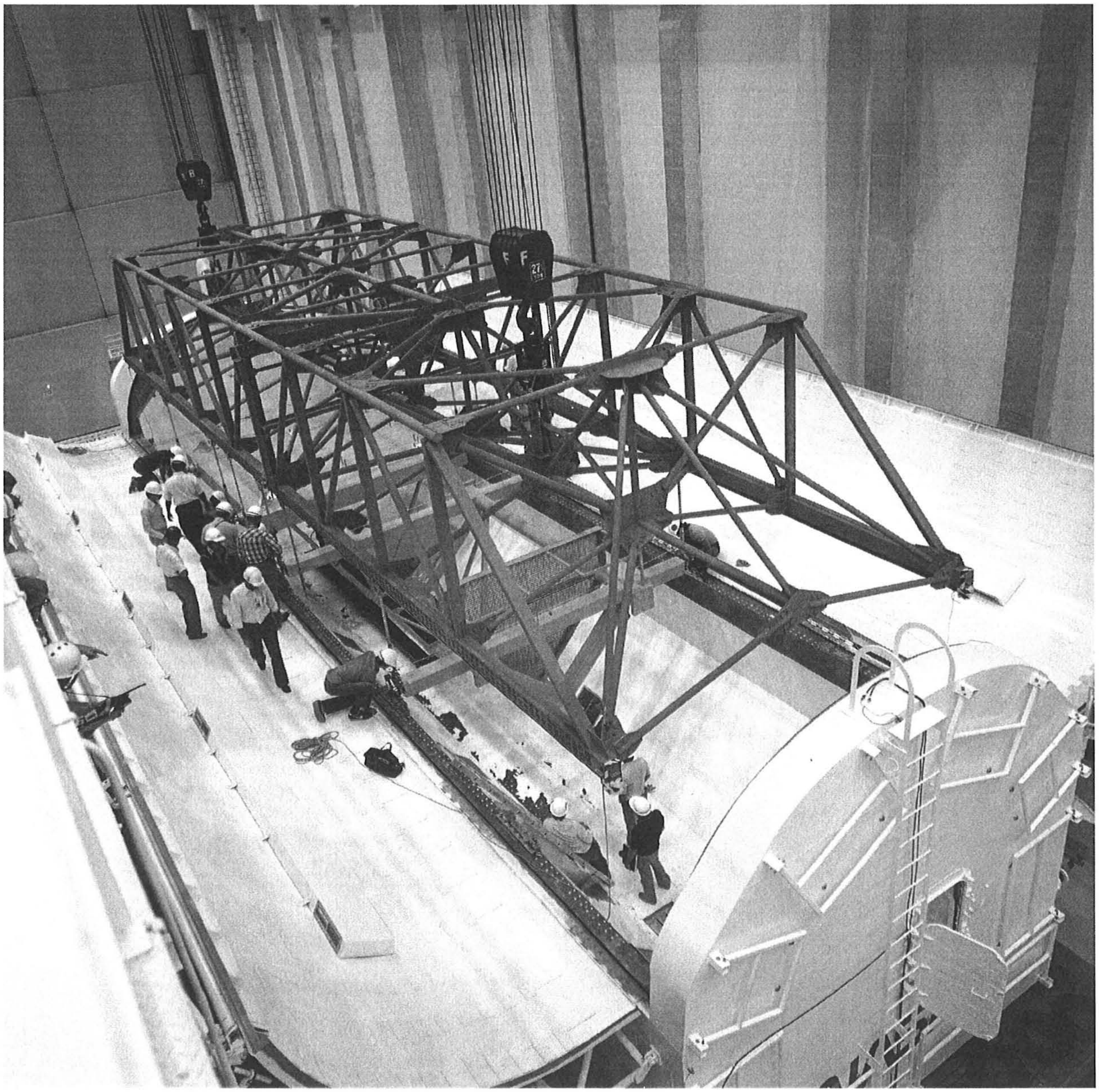

Figure 11. Horizontal loading and unloading of orbiter payload canister with test weights in the O&C Building High Bay. November 12, 1980. (Courtesy of Kennedy Space Center, 108-KSC-380C-3392 FR07.jpg).

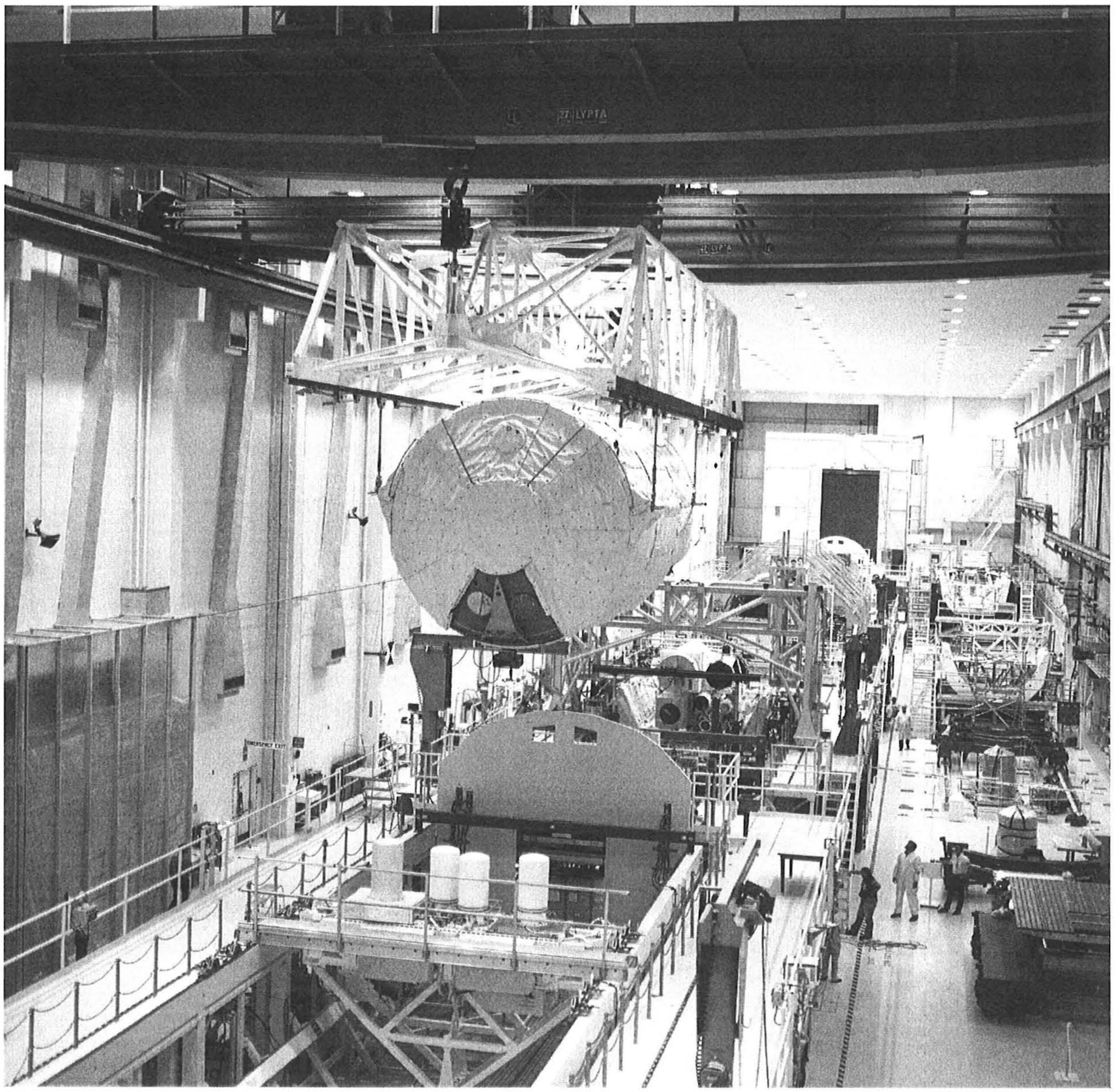

Figure 12. Removal of payload from the canister to the work stand in the O&C Building high bay. November 18, 1985. (Courtesy of Kennedy Space Center, 108-KSC-385C-5616 FR12.jpg).

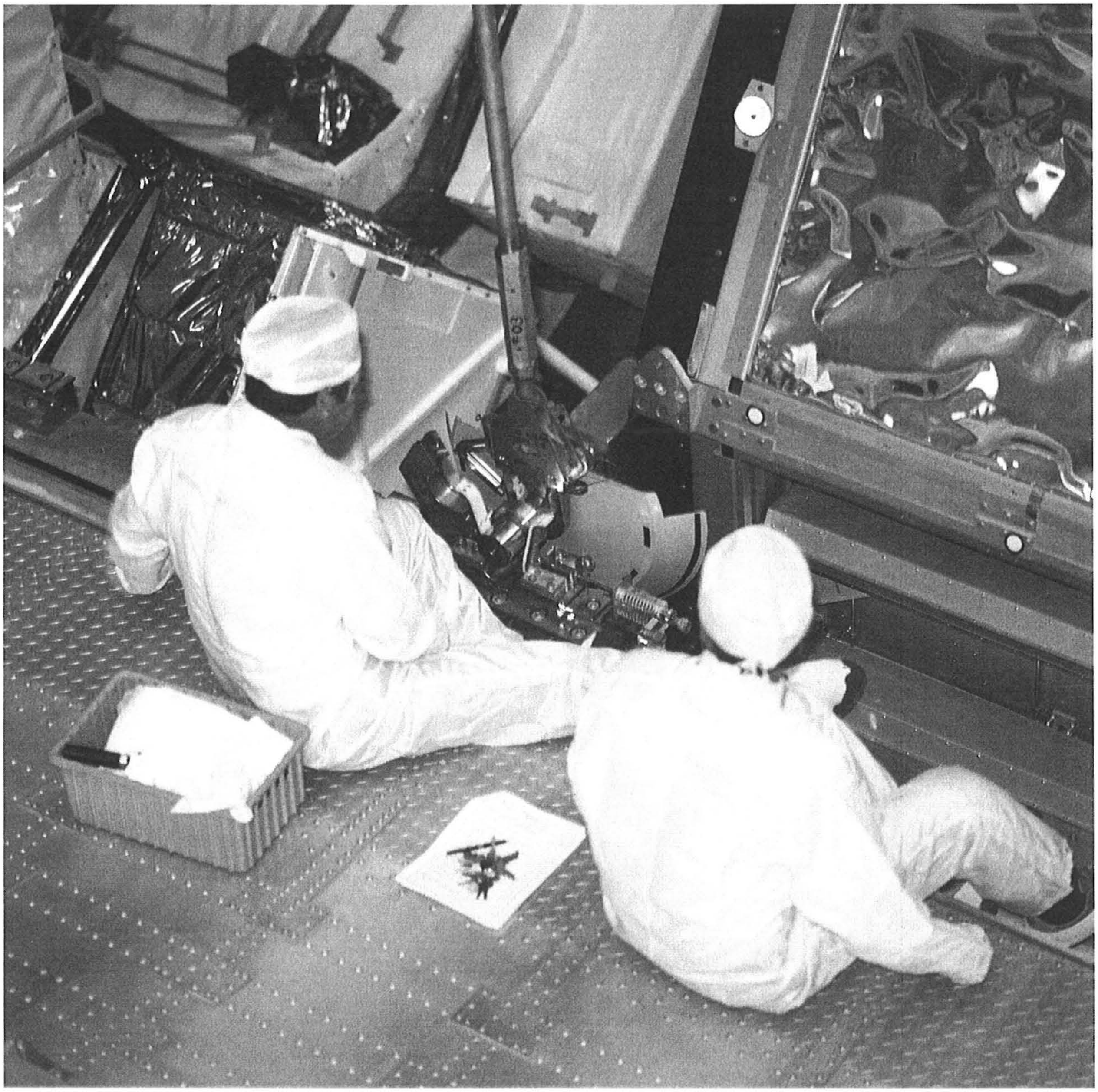

Figure 13. Loading payload trunnion into the payload canister fitting in O&C high bay. March 6, 1984. (Courtesy of Kennedy Space Center, 108-KSC-384C-941 FRr12.jpg).

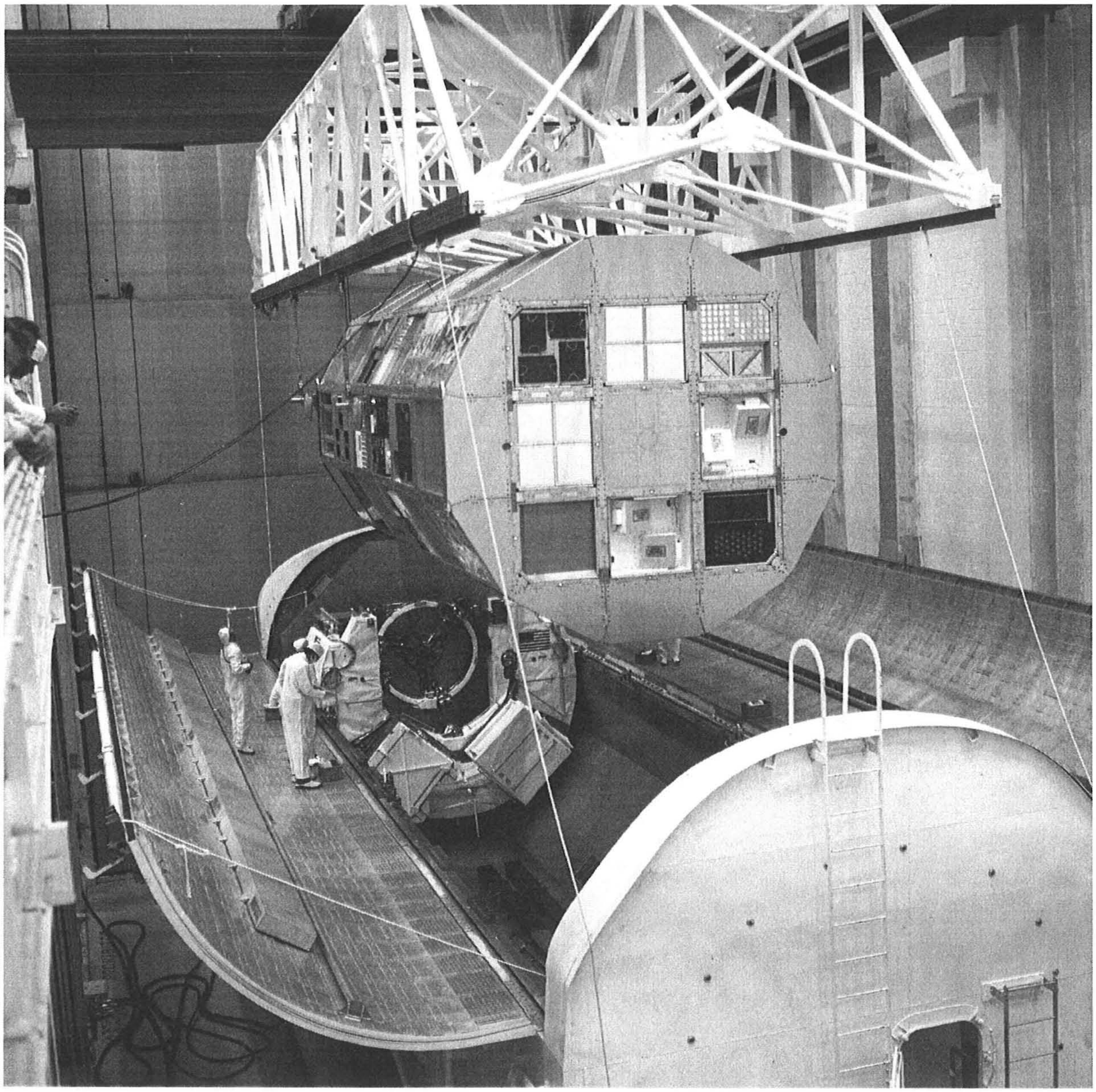

Figure 14. Transferring the Long Duration Exposure Facility (LDEF) into Canister 1 for the STS-41C Mission. O&C Building high bay. March 6, 1984. (Courtesy of Kennedy Space Center,108-KSC-384C-941 FR01.jpg).

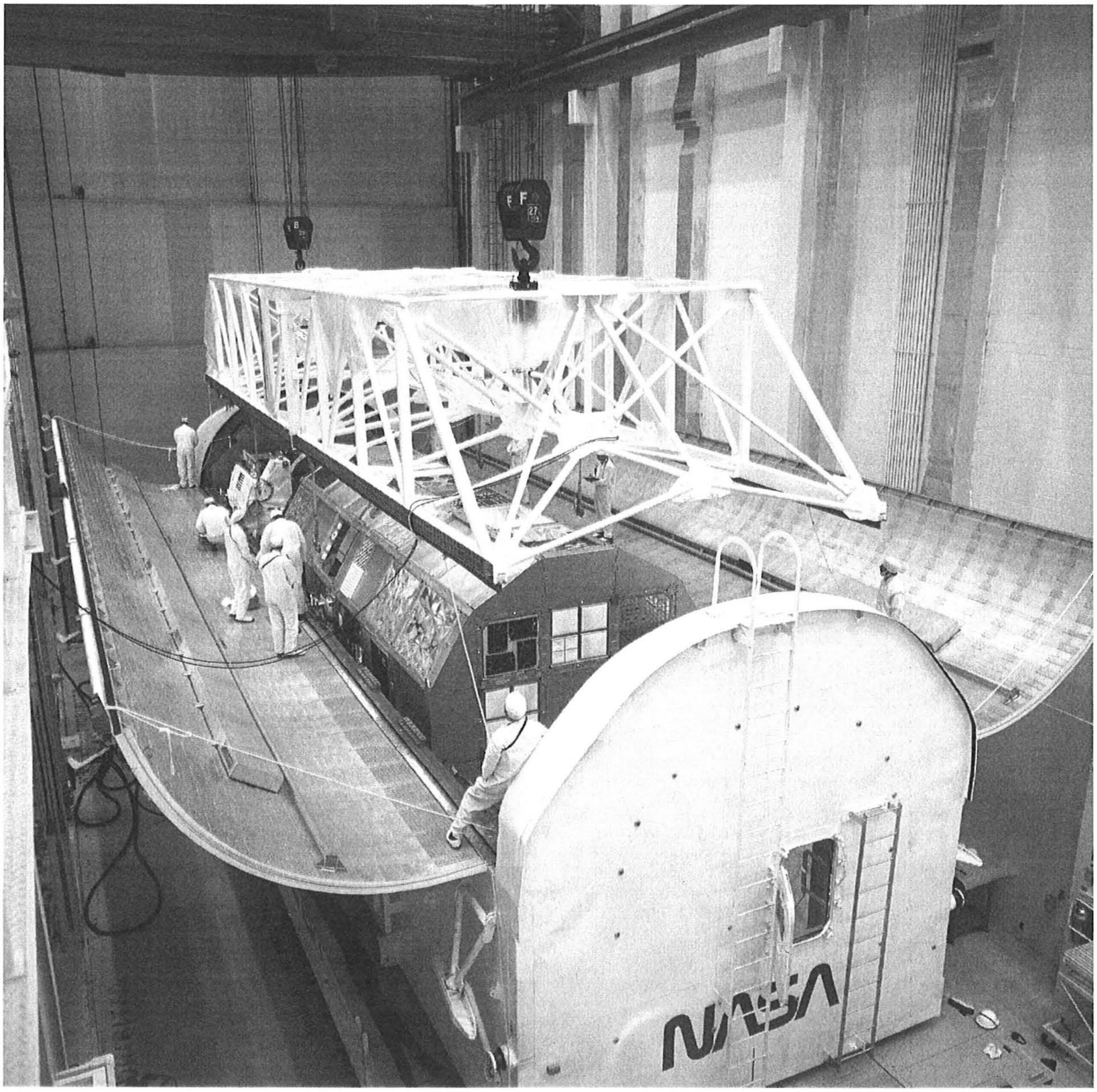

Figure 15. Installing the Long Duration Exposure Facility (LDEF), using the payload strongback, into Canister 1 O&C Building high bay. March 6, 1984. (Courtesy of Kennedy Space Center, 108-KSC-384C-941 FR01.jpg).

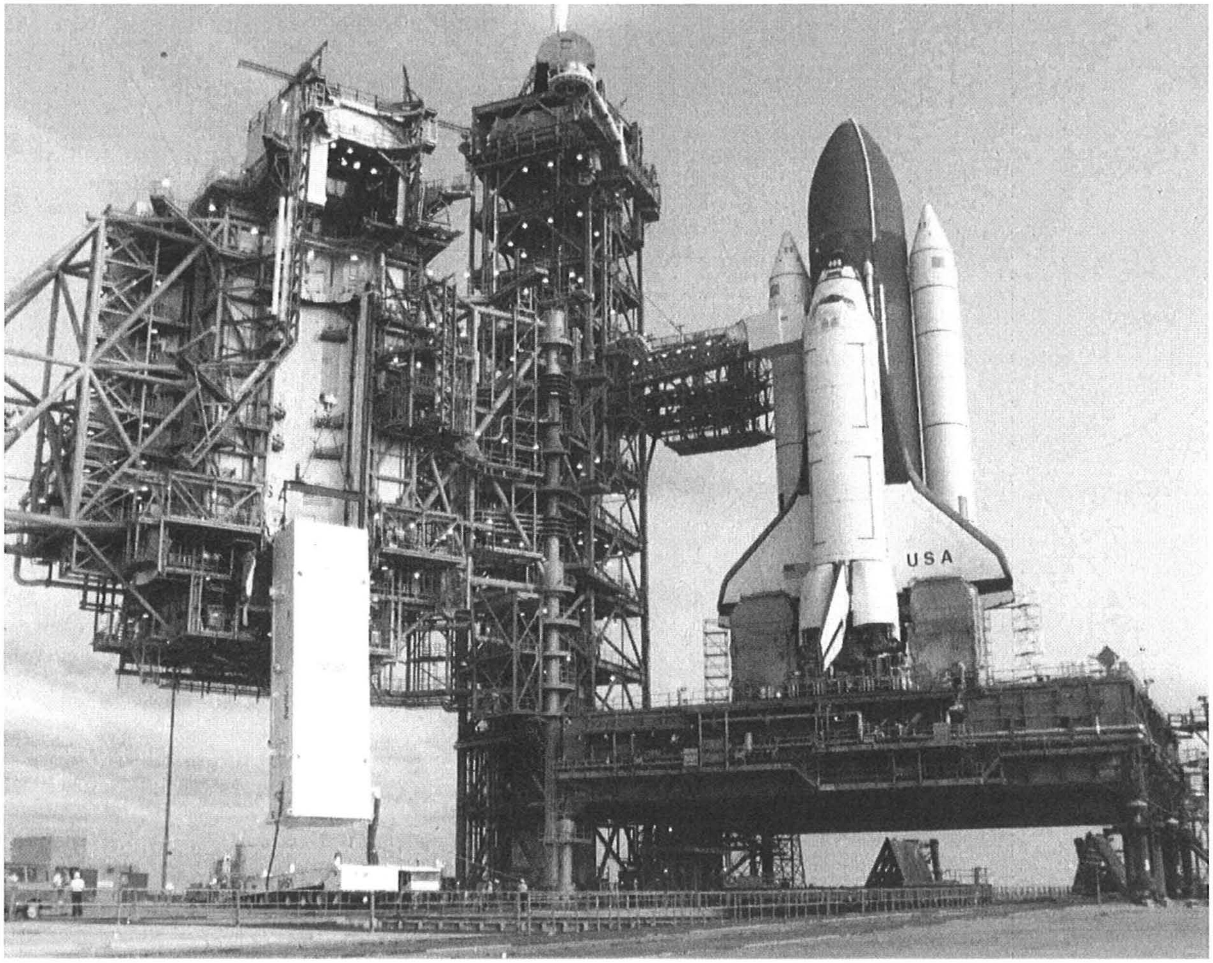

Figure 16. Orbiter payload canister being raised into the Payload Changeout Room (PCR) at Launch Pad 39A. 1982. (Courtesy of Kennedy Space Center, KSC-82PC-1148.jpg).

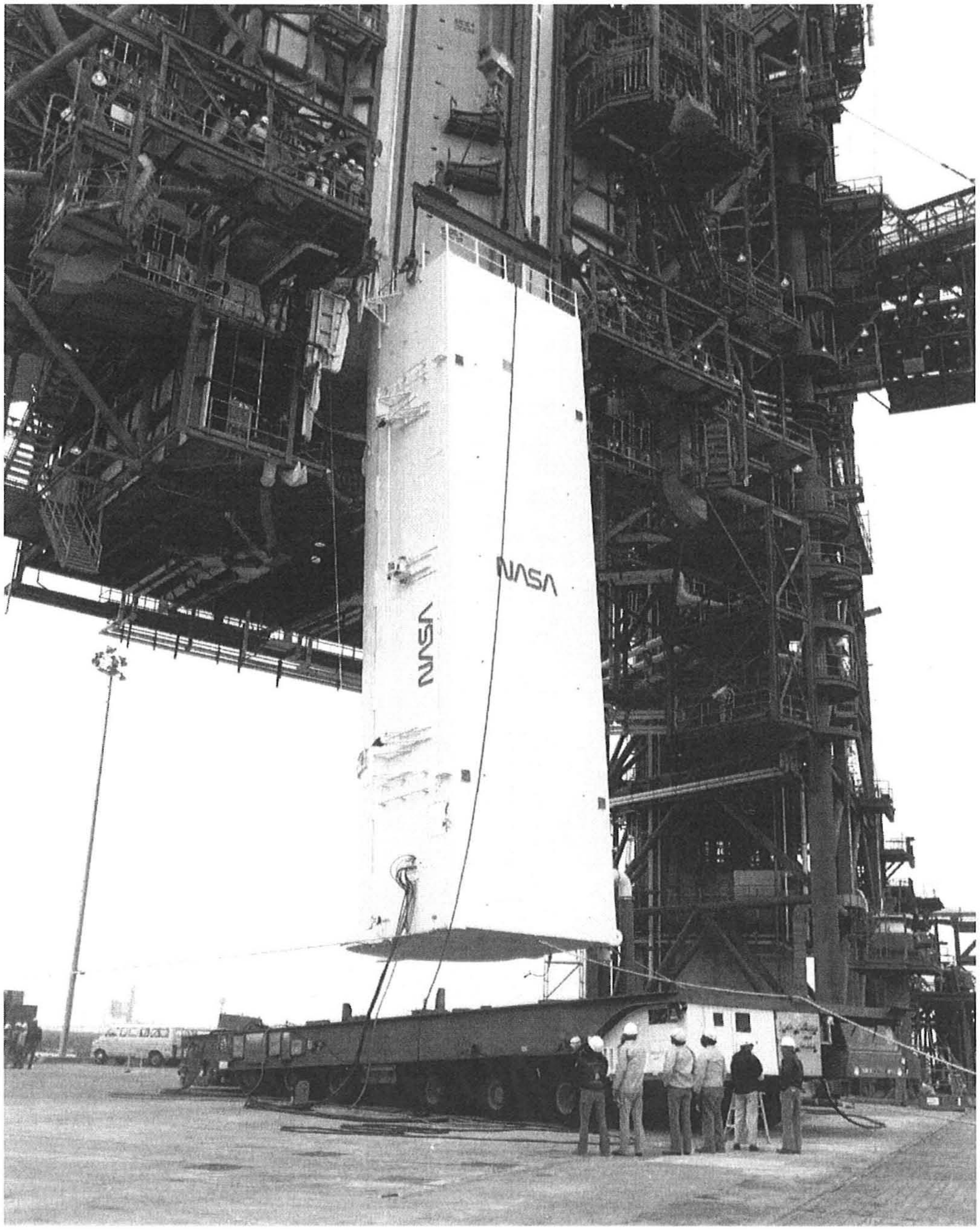

Figure 17. Orbiter payload canister being raised into the PCR at Launch Pad 39A. Note continued connection of ECS and I&CS to the Transporter. 1980. (Courtesy of Kennedy Space Center, 108-KSC-80P-369.jpg).

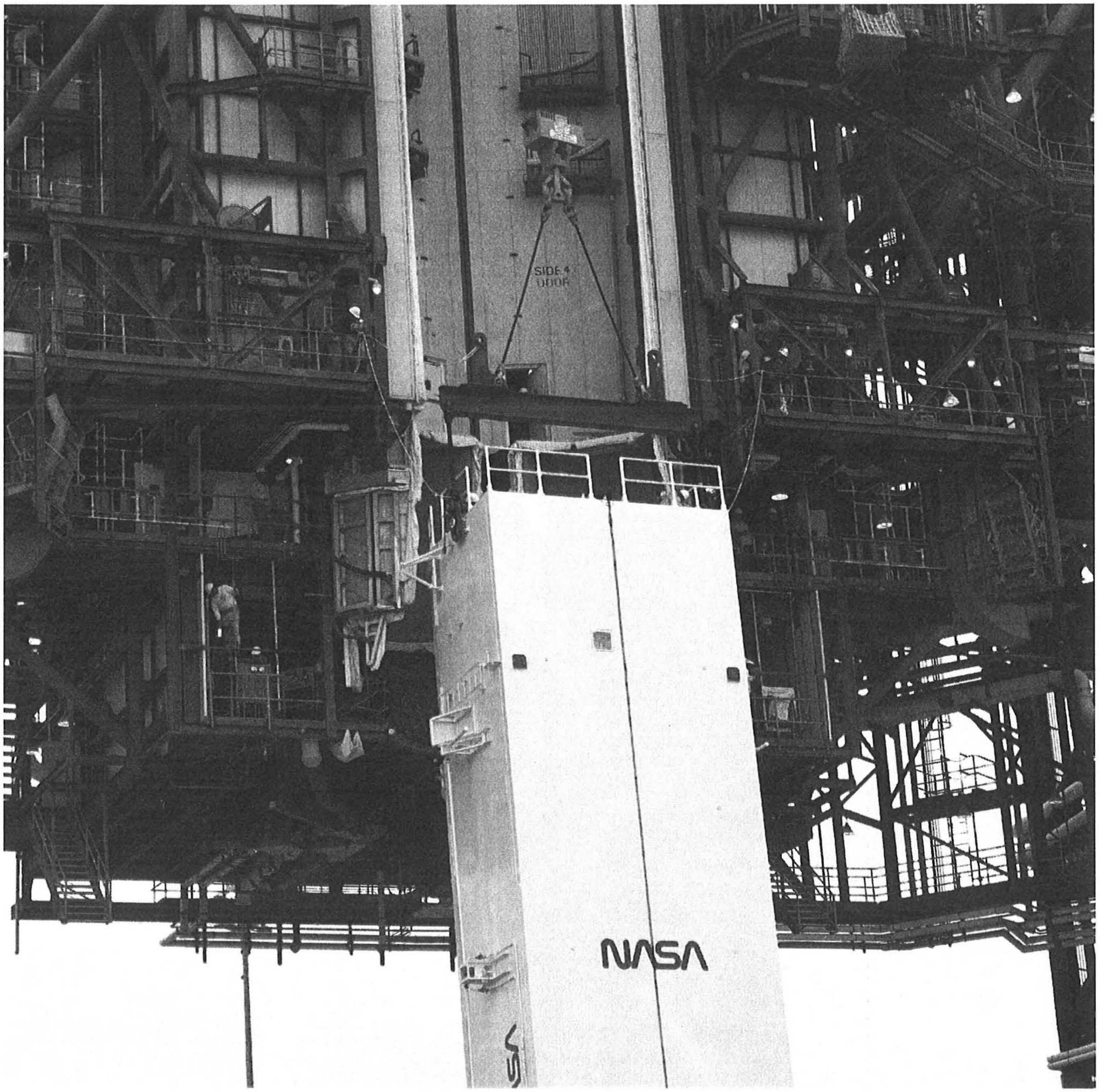

Figure 18. Orbiter payload canister being raised into the PCR at Launch Pad 39A. Note the outrigger guiding the canister as it is raised. December 9, 1980. (Courtesy of Kennedy Space Center, KSC-82PC-1148.jpg).

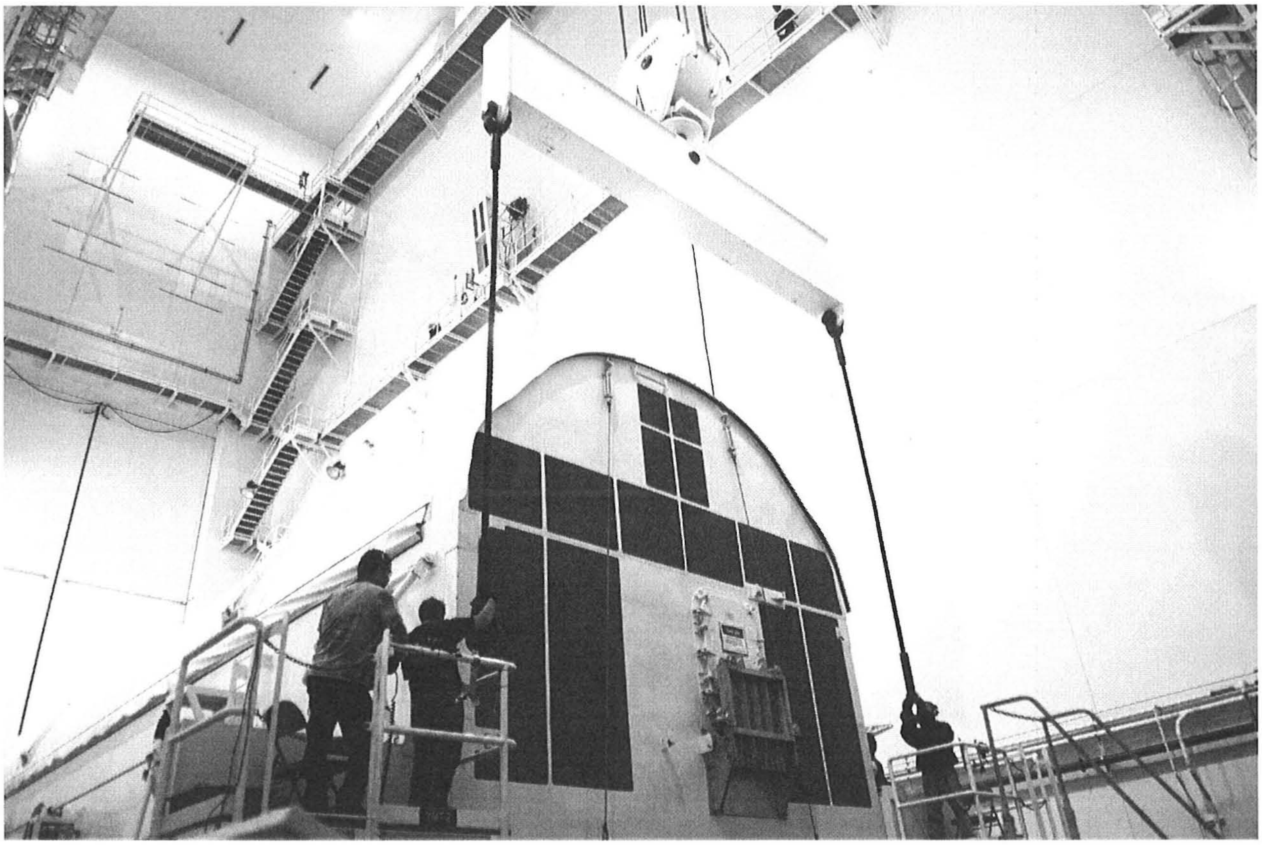

Figure 19. Attaching cables to the canister for rotation in the CRF. March 11, 2010. (Courtesy of Kennedy Space Center, KSC-2010-2267 3-11-10.jpg).

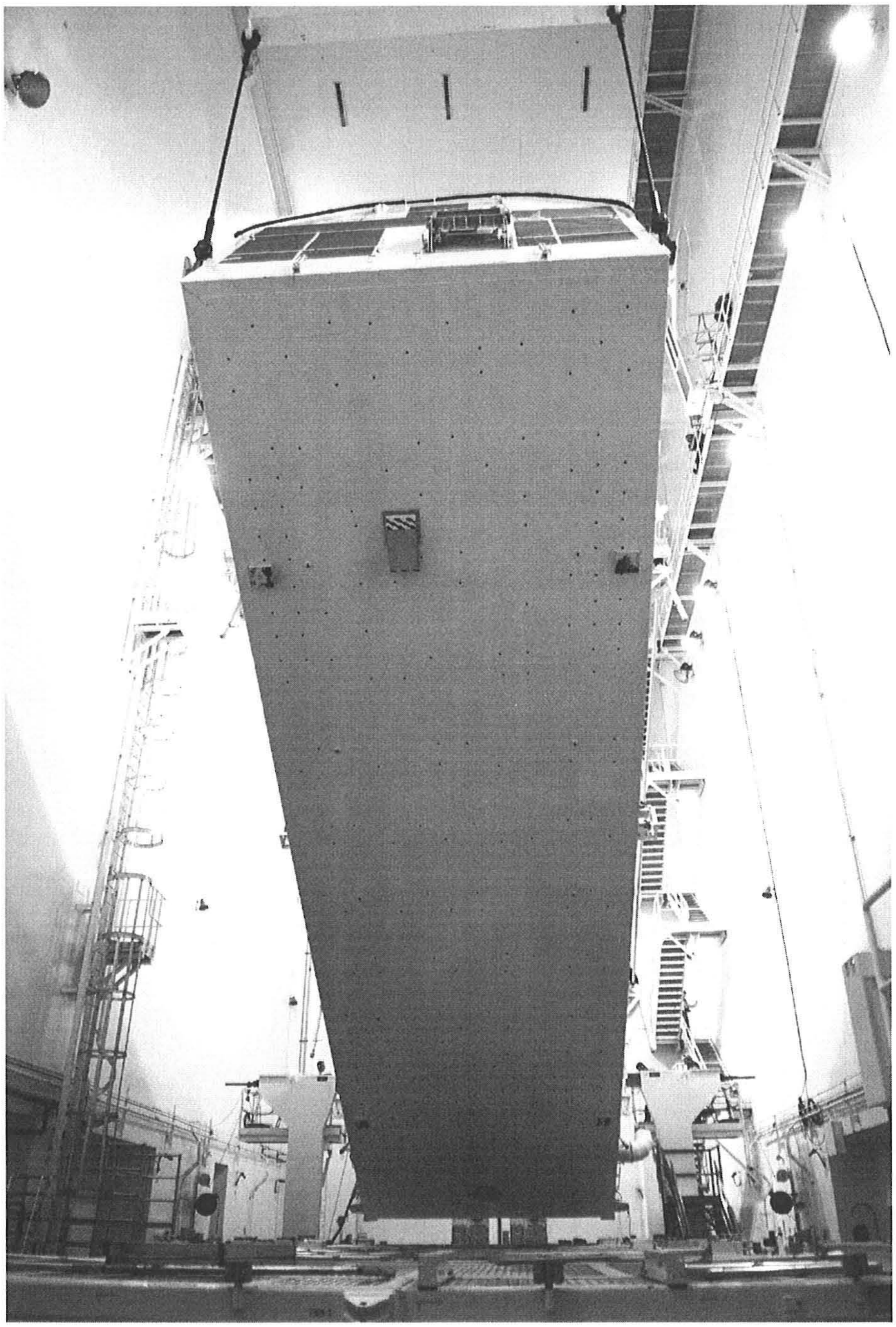

Figure 20. Rotation in progress at the CRF. April 13, 2010. (Courtesy of Kennedy Space Center, KSC-2010-2267-4_13_2010.jpg).

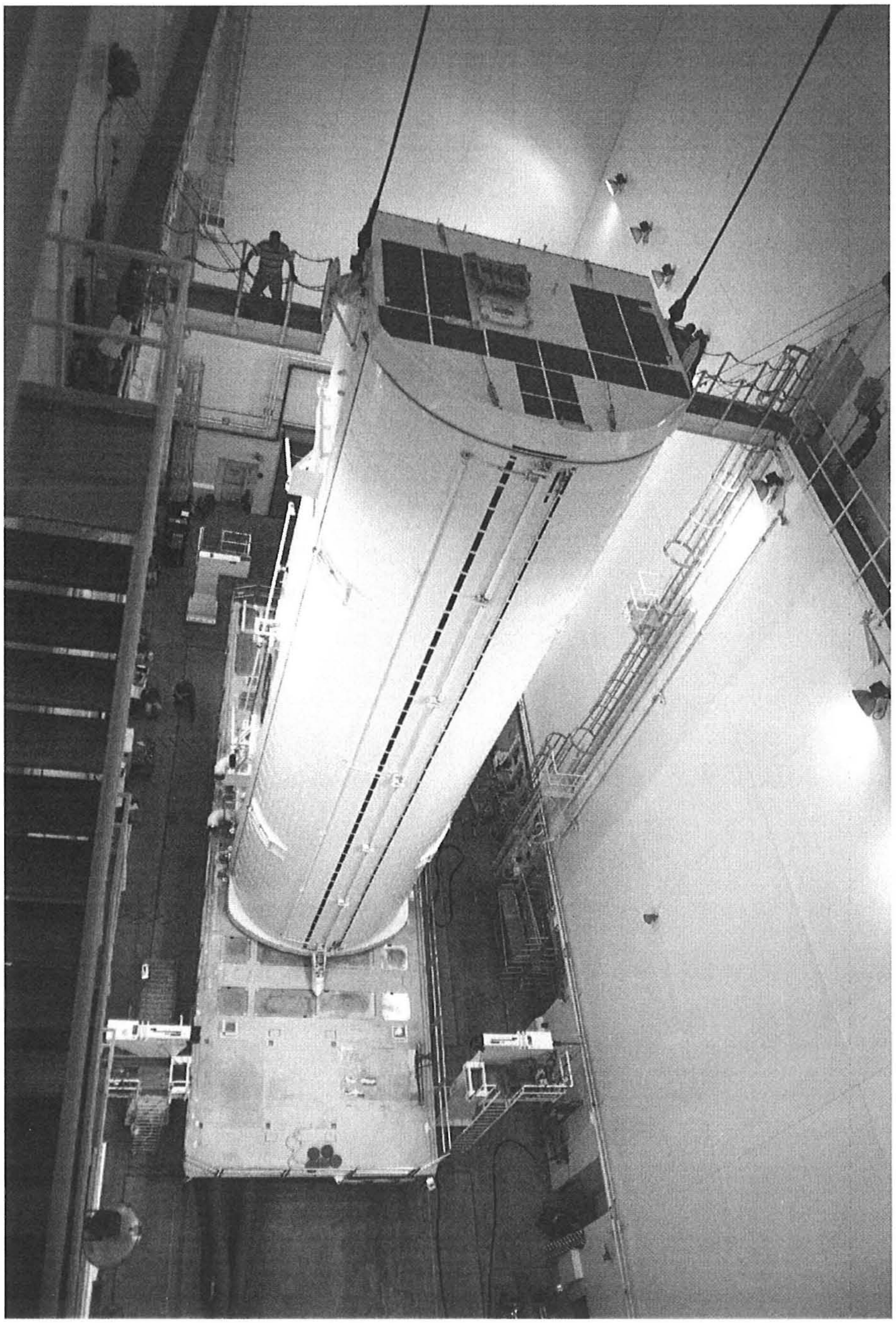

Figure 21. Lowering canister to the transporter bed in the vertical position at the CRF. April 13, 2010. (Courtesy of Kennedy Space Center, KSC-2010-2264-4_13_2010.jpg).

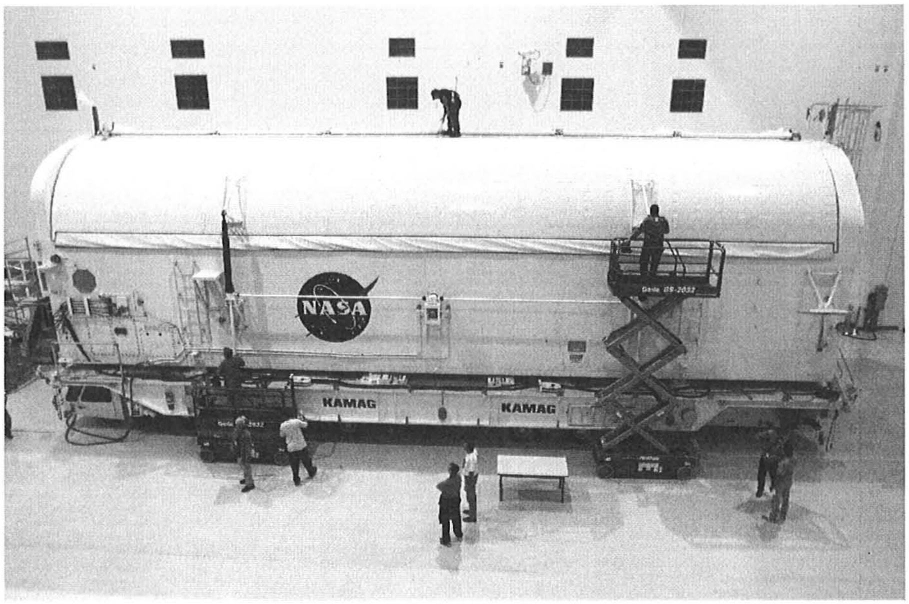

Figure 22A. Canister in the SSPF. October 21, 2008. (Courtesy of Kennedy Space Center, KSC-08PD-3303 10_21_20008.jpg).

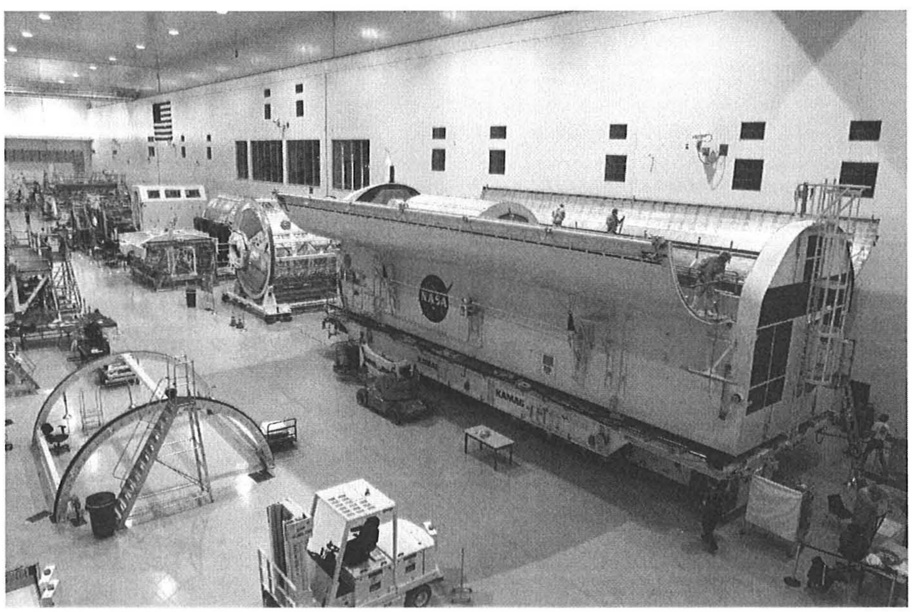

Figure 22B. Canister's doors open in the SSPF. October 21, 2008. (Courtesy of Kennedy Space Center,KSC-08PD-3300 10_21_08.jpg).

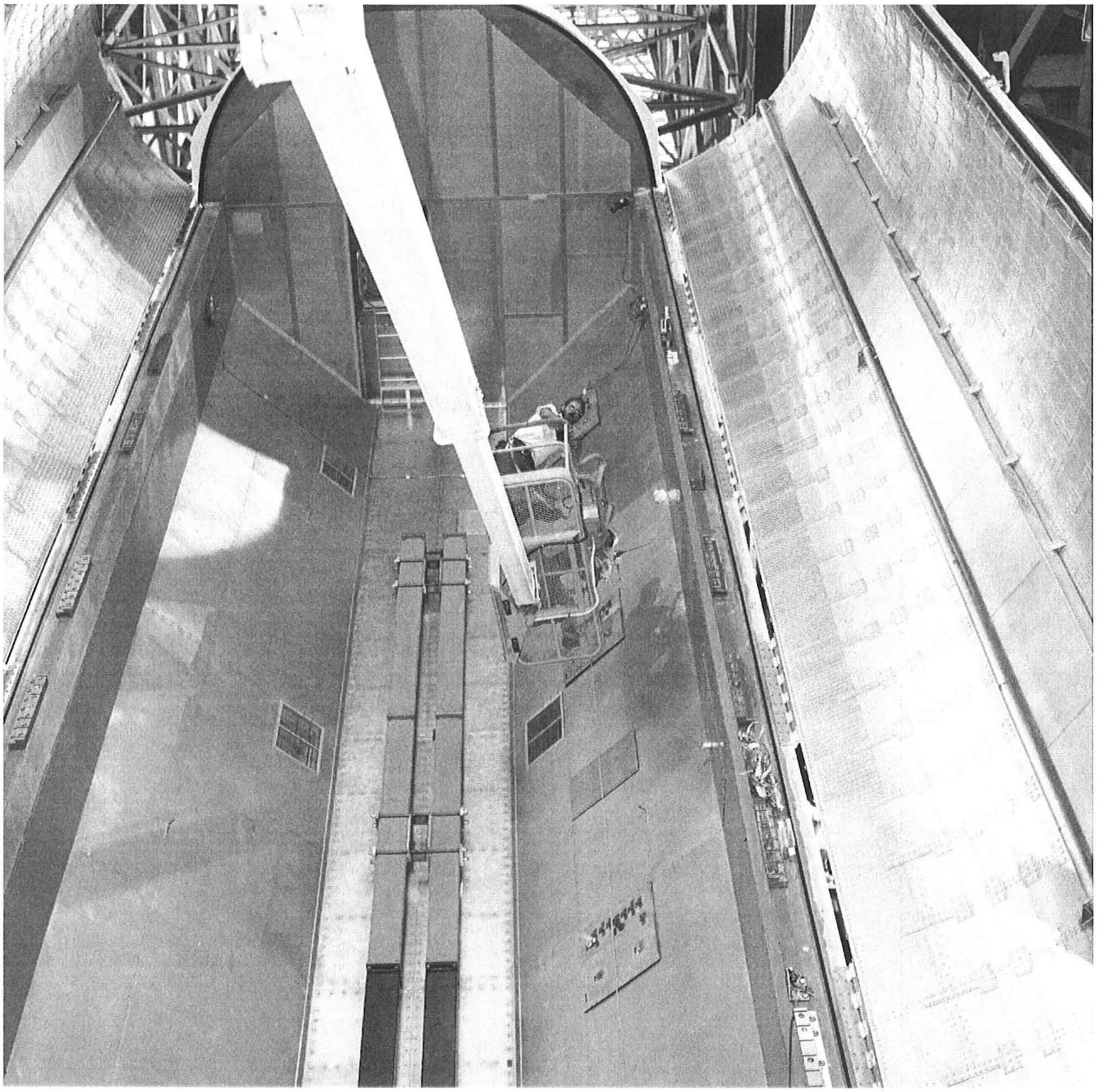

Figure 23. Vertical cleaning of the canister prior to payload processing, undated. (Courtesy of Kennedy Space Center, 108-KSC-384C-5134 FR10.jpg).