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Kennedy Space Center Processing of Shuttle Small Payloads

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ABSTRACT

There are many steps involved in preparing a payload for a mission into space on the Space Shuttle. Operations at the John F. Kennedy Space Center (KSC) are the last of those steps for the hardware before the payload is launched. To assure a successful and efficient KSC processing flow, a great deal of planning between the Robert H. Goddard Space Flight Center (GSFC) and KSC personnel is required before the payload arrives at KSC. After arrival, pre-flight operations occur between payload personnel, GSFC and KSC personnel for integration of the payload into its carrier (if required), in preparation for installation into a Orbiter. Once installed into a Orbiter, final test(s), checkout, and close-out of the payload is performed by GSFC and KSC personnel before launch. Mission support varies depending on the payload flying, but once the mission is complete and the Orbiter has returned to KSC, post-flight operations begin. This usually involves a reverse flow of the pre-flight operations. KSC operations conclude when the payload, its ground support equipment (GSE), and personnel depart KSC. A list of lessons learned is generated at the end of each payload flow, to avoid repeating the same mistakes (if any) for the next payload or for multiple repeat flights of the same payload. Always monitored are planned changes that may affect the payloads, GSE, KSC facilities, payload personnel, GSFC personnel, and/or KSC personnel.

INTRODUCTION

This paper will discuss KSC processing of mostly the Get Away Special (GAS) payloads and Complex Autonomous Payloads (CAP's), with some mention of Hitchhiker type payloads. The STS-57 GAS Bridge Assembly (GBA) KSC operational flow will be used to demonstrate a normal flow of GAS/CAP payloads. The STS-57 GBA containing 11 GAS payloads and 1 CAP payload (CONCAP-IV) was launched on the Space Shuttle Endeavour, June 21, 1993 and landed at KSC on July 1, 1993. A general layout of facilities at KSC is shown on Figure 1.

PLANNING PHASE

The planning phase begins when a GAS, CAP, or Hitchhiker payload is manifested to fly on the Space Shuttle. This can be many years into the future, as shown in Figure 2, which reflects that KSC is planning well into the future to support many payloads. From this figure it can be seen how changes in the Space Shuttle manifest can cause major impacts to KSC facility utilization flow for payloads. The actual experiments may not yet be selected, but knowledge of the number of GAS, CAP or Hitchhiker payloads manifested for a certain STS mission is used to start preliminary planning. KSC personnel are involved early in the design phases of Hitchhiker type payloads because of the extensive integration and testing that needs to be performed at KSC. The GAS/CAP payloads do not require this, but early knowledge of what each GAS/CAP payload contains and its function allows GSFC and KSC personnel to better prepare facilities and support. Design inputs from KSC will allow the designer to modify the payload design early enough to avoid any problem areas that may be encountered at KSC with the current design. An example may be the location of a connector required to support pre-flight testing. On a bench in the experimenter's laboratory, access to the connector is easy. Once the experiment is integrated with its carrier and the carrier installed into the Orbiter, access to that connector could be impossible.

As the payload matures, KSC personnel review all the documentation, drawings, schematics, and requirements associated with both the payload and the Shuttle. This assures the payload will be properly prepared for the Shuttle, that the Shuttle will be properly prepared for the payload, and that all the personnel, facilities and support are ready for payload operations at KSC. Many teleconferences, and working group meetings take place to solve any possible problems or conflicts. Again, this is performed well before the payload arrives at KSC. This STS-57 mission was the fifth flight of the GBA so much of the work that had been performed on past flights was repeated taking into account the different payload types. The planning phase ends and the operational phase begins once the payload, GSE, or personnel arrive at KSC. This does not mean "planning" ends because all through the processing flow planning continues to prepare for all upcoming activities.

OPERATIONAL PHASE

Figure 3 (reference 1) shows the standard processing flow of the GAS/GBA payload(s) at KSC. Each block represents a facility with operations performed at that facility listed below. Experiment personnel and GSE will usually arrive before the experiment in order to configure any equipment that may support the experiment. After the experiment(s) arrive at the GAS facility, the experimenter will spend between 1 to 4 days checking out the payload, Figure 4. At the same time, GSFC personnel are preparing the GAS canister for experiment installation. Then the installation of the experiment(s) into the GAS canister occurs. This is performed by using an overhead crane and GSFC lifting sling attached to the upper plate of the payload, Figure 5. The payload is raised from its work area and lowered into the GAS canister and secured. GSFC personnel electrically connect the lower plate GAS subsystem electronics to the experiment and perform a test. When the interface test is successful, GSFC secures the lower plate to the GAS canister, Figure 6. KSC personnel support as required. The GBA, some CAP, and most Hitchhiker payloads are not assembled in the GAS facility. A Payload Processing Facility (PPF) will be used because of the physical size of the payload or strict payload requirements like, special handling, servicing requirements, contamination concerns or use of a KSC control room is required.

The GBA missions require that the GAS/CAP payloads be installed on the GBA in a PPF. The PPF used is determined by the Facility Utilization Schedule, Figure 2, and payload requirements. While the payloads are being prepared, GSFC personnel are preparing the GBA for the payloads. The GAS/CAP payloads are then moved from the integration area to the PPF using KSC transportation (some payloads may be prepared in the same PPF as the GBA). From this point on, all transportation is performed using KSC equipment. Once in the PPF each payload is installed onto the GBA and final electrical connections are made. When all payloads are installed on the GBA, a final test of all payloads is performed, and the GBA is prepared for transportation to the Operations and Checkout (O&C) building, Figure 7.

If the GAS/CAP or Hitchhiker payload will be installed onto a GAS beam side mounted to the Orbiter sill it will be transported to the Orbiter Processing Facility (OPF) with payload GSE using KSC transportation. In the OPF, the payload is mounted onto the GAS beam that has been installed into the Orbiter by Shuttle personnel. Some Hitchhiker payloads may first go to the O&C and undergo an integrated test in the Cargo Interface Test equipment or CITE, before transportation to the OPF. This CITE test, under KSC control, is very extensive and requires a great deal of coordination between GSFC and KSC personnel. The CITE test emulates the Orbiter as closely as possible.

The PPF to O&C building move is performed using a security escort, due to the slow speed and flight hardware classification. Plus all security escort convoy operations can only be performed during non-peak traffic hours. This transport usually occurs 2 to 3 months before launch. Up to this point, GSFC has had the responsibility of the payload with KSC in the support role. After arrival at the O&C, the roles change and KSC is now responsible for the payload with GSFC in the support role. The GBA is removed from the KSC transporter and placed on the Highbay floor of the O&C building. The next operation at the O&C is a cleanliness check of the GBA before being installed into the Payload Canister. This is then followed by installation of the primary payload(s), Figure 8.

The Payload Canister is then moved to the OPF. Some missions require that the payloads be moved to the Vertical Processing Facility (VPF) to add more payload elements, for the launch, before the canister is moved to the launch pad for installation into the Orbiter. This will occur for the GBA on the STS-60 mission. Once at the OPF, all the payloads are installed into the Orbiter during one lifting operation, Figure 9 and Figure 10. This operation can take up to 16 hours with more than 200 persons involved. The electrical and mechanical connections are made between the payload and Orbiter and an Interface Verification Test (IVT) is performed on all payloads, with the primary payload(s) having priority. This is the last test performed on the GBA before launch. A sharp edge and cleanliness inspection of the GBA is performed by the Astronauts and Orbiter close-out operations are performed. If access to the payload is not planned on the launch pad, this will be the final inspection and last access of the GBA before launch. This can occur 1 to 2 months before launch. Again, this will be determined by the primary payload(s). All payload access equipment is removed and the Orbiter payload bay doors (PLBD's) are closed. The Orbiter is then moved to the Vehicle Assembly building (VAB), Figure 11, for mating of the Orbiter to the External Tank (ET) and Solid Rocket Boosters (SRB's). Then the integrated Shuttle launch vehicle is moved to the launch pad. No GAS/CAP or Hitchhiker operations are performed in the VAB or during roll out to the pad.

If the PLBD's are opened at the launch pad, Figure 12, usually only a sharp edge and cleanliness inspection of the GAS/CAP payload(s) is performed. Hitchhiker payloads may require an extensive amount of servicing, testing and close-out operations. Access to the payloads in the payload bay must be completed 64 hours before launch (reference 2). This allows all the Orbiter operations to be completed before launch.

The Shuttle is launched, the mission takes place, and landing should occur at the Shuttle Landing Facility (SLF) at KSC. During this time, KSC is preparing for the payloads post-flight operations. If the Shuttle lands at Edward's Air Force Base (EAFB), it requires 5-7 days before the Shuttle returns to KSC. After arrival at KSC, no access to payloads is possible until 4-5 days after arrival, because of the time required to tow the Orbiter from the SLF to the OPF, jacking, leveling and deservicing of the Orbiter before the PLBD's are opened. Payload operations can then begin. All the payloads that span the width of the Orbiters payload bay are removed from the Orbiter in one lifting operation, Figure 13 and Figure 14, and installed into the payload canister, Figure 15. This occurs 5-7 days after the Orbiter arrives at KSC. The GAS/CAP and Hitchhiker payloads mounted to GAS beams are removed after the major payloads and installed into the experimenters GSE. From this point, post-flight GAS/CAP and Hitchhiker KSC operations are usually the reversal of pre-flight operations, except no CITE test is performed post-flight.

LESSONS LEARNED

A list of lessons learned, during ground processing, is generated after each Shuttle mission. Major lessons learned from all KSC operations that apply to GAS/CAP and Hitchhiker payloads are stated below:

1) COMPLETE THE SAFETY REVIEW PROCESS EARLY! The Flight safety review process is required for the on-orbit mission, but the Ground safety review process must be completed before any work can be performed at KSC. Most payloads should plan to complete the process 3-6 months before payload arrival. This allows time to satisfy concerns stated during the review process. Also, for GAS payloads, completing the safety review process early could be used to enhance the possibility of being selected as a back-up payload. Many GAS payloads have lost their chance to fly a scheduled mission because they did not complete the safety review in time. It should be noted that the KSC safety office considers GAS payload ground safety just as important as all other payloads. When it comes to safety, all payloads are treated the same. Please contact the GSFC safety office early!

2) Plan to have most of the preparation work on the experiment completed before arrival at KSC. The experiment should only require minimal checkout before integration into the GAS canister. Extensive work could be performed at KSC if required, but it is not desirable. It should be noted that a 12 hour/day work constraint is strictly imposed at KSC. Also use of any kind of chemicals is strictly controlled at KSC. Experimenters should plan to have all samples/chemicals installed on the experiment or contained in protective containers, with no planned work at KSC. Before payload arrival to the launch site, experimenters must provide the Launch Site Support Managers (LSSM), Process Waste Questionnaires (PWQ's) for "any" chemicals or materials brought to the launch site to support ground operations. Material Safety Data Sheets (MSDS) for these chemicals or materials must be maintained at their location of use. Contact GSFC representative for more details on these requirements

3) The experimenter should bring any required support or equipment with the experiment. KSC can supply almost any kind of support desired but the equipment may not be the same as used by the experimenter off-site and may not satisfy experimenters' requirements. If support from KSC is required, plan early! All experimenters need to coordinate through GSFC for any KSC support.

4) Experimenters should use long life batteries. If a launch slips, the experiments could sit for up to 5 months without access for battery changeout. Silver-Zinc batteries are recommended because they have been proven and flown inside may GAS cans. Nickel-Cadmium is not recommended because of their short life span.

FUTURE ACTIVITIES

The Autonomous Payload Controller (APC) is currently used to operate the GAS/CAP payloads. Future plans call for the use of the Payload Ground Support Computer (PGSC) to control operations. This will increase the time to perform pre-flight checkout due to use of this hardware.

Environmental requirements at KSC will become more strict in the future, so plans should be made to use the most benign chemicals possible if they are to be handled at KSC.

REFERENCES

1. Dean Zimmerman, "Get-Away Special Payloads Launch Site Support Plan", NASA K-PSM-11.3 Revision D, July 1991

2. System Description and Design Data-Ground Operations, NSTS 07700, Volume XIV, Appendix 5, Revision K.

3. Photographs, Bionetics Corporation, Kennedy Space Center, 1993

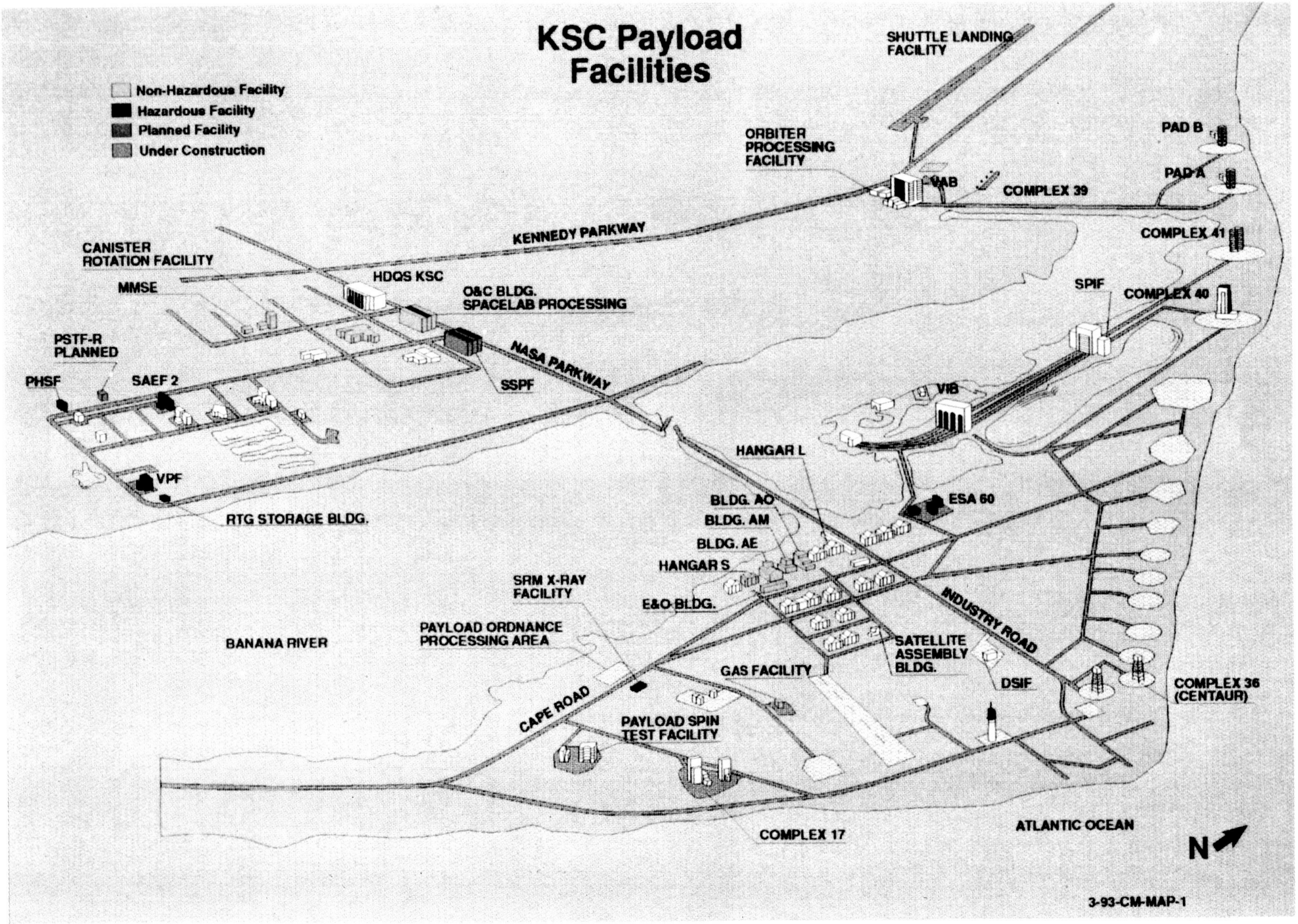

Figure 1 - Kennedy Space Center Facilities

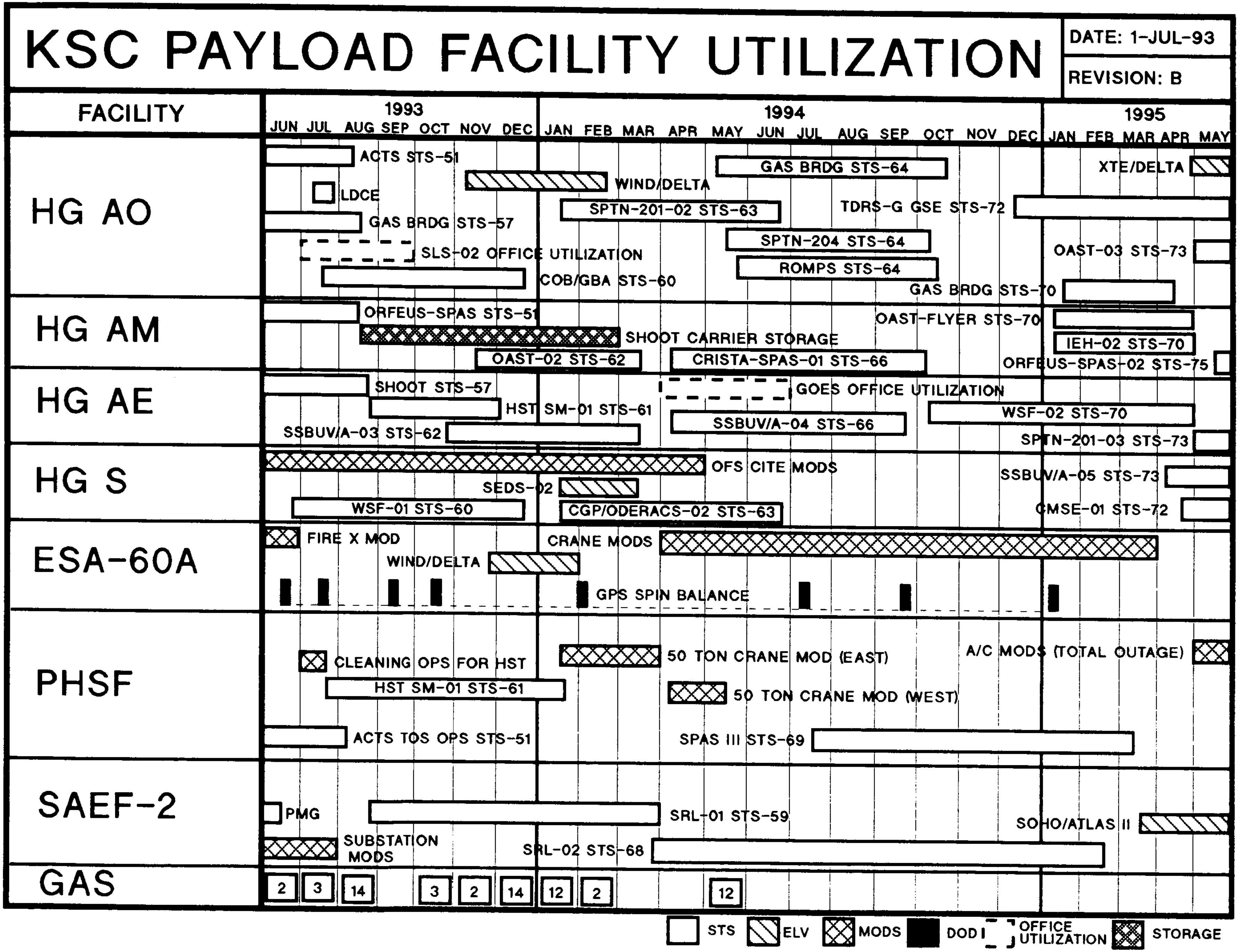

Figure 2 - KSC Payload Facility Utilization

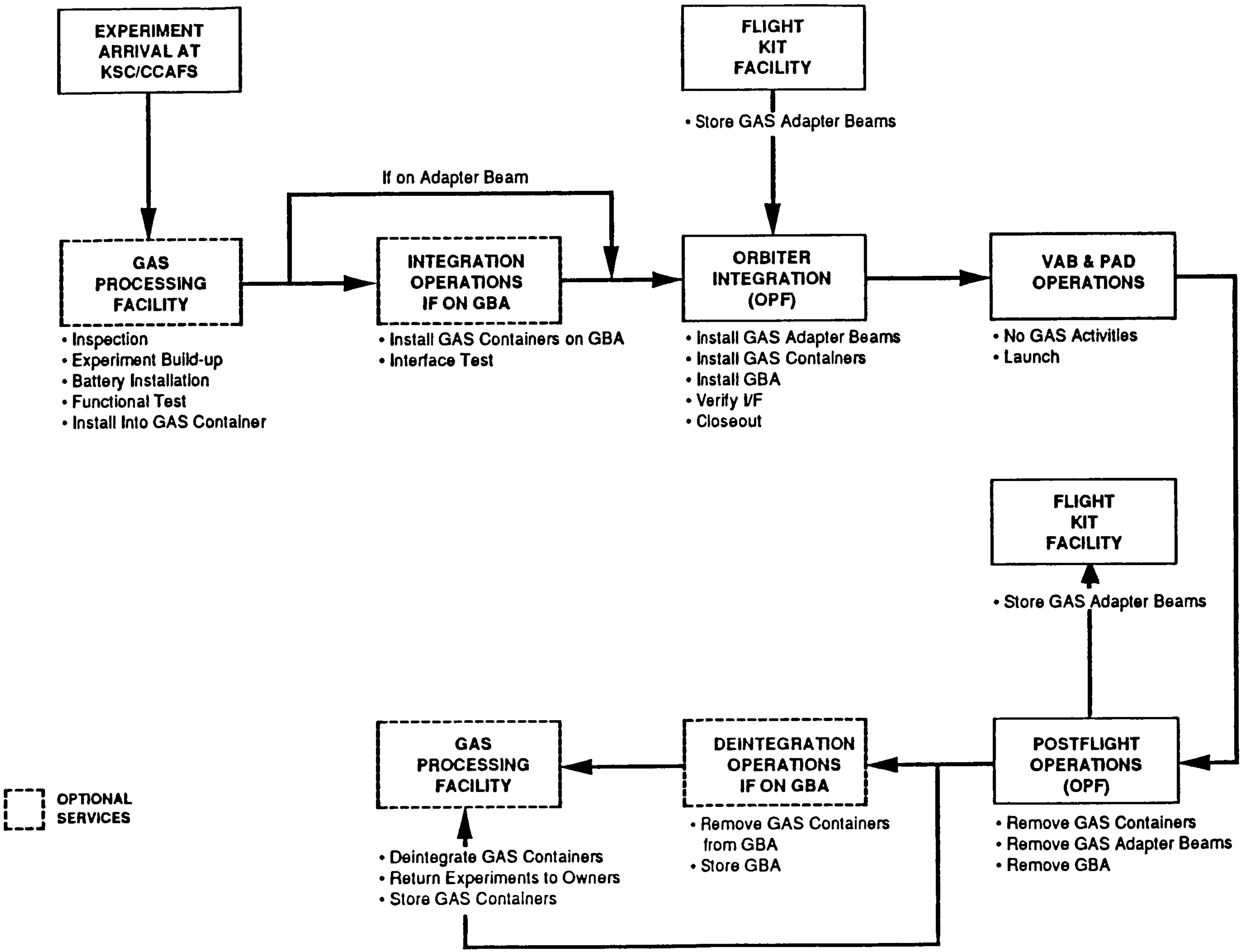

Figure 3 - Process Flow for Horizontally Installed GAS/GBA

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Figure 4 - STS-57 G-535, LERC Pool Boiling Experiment at GAS Facility

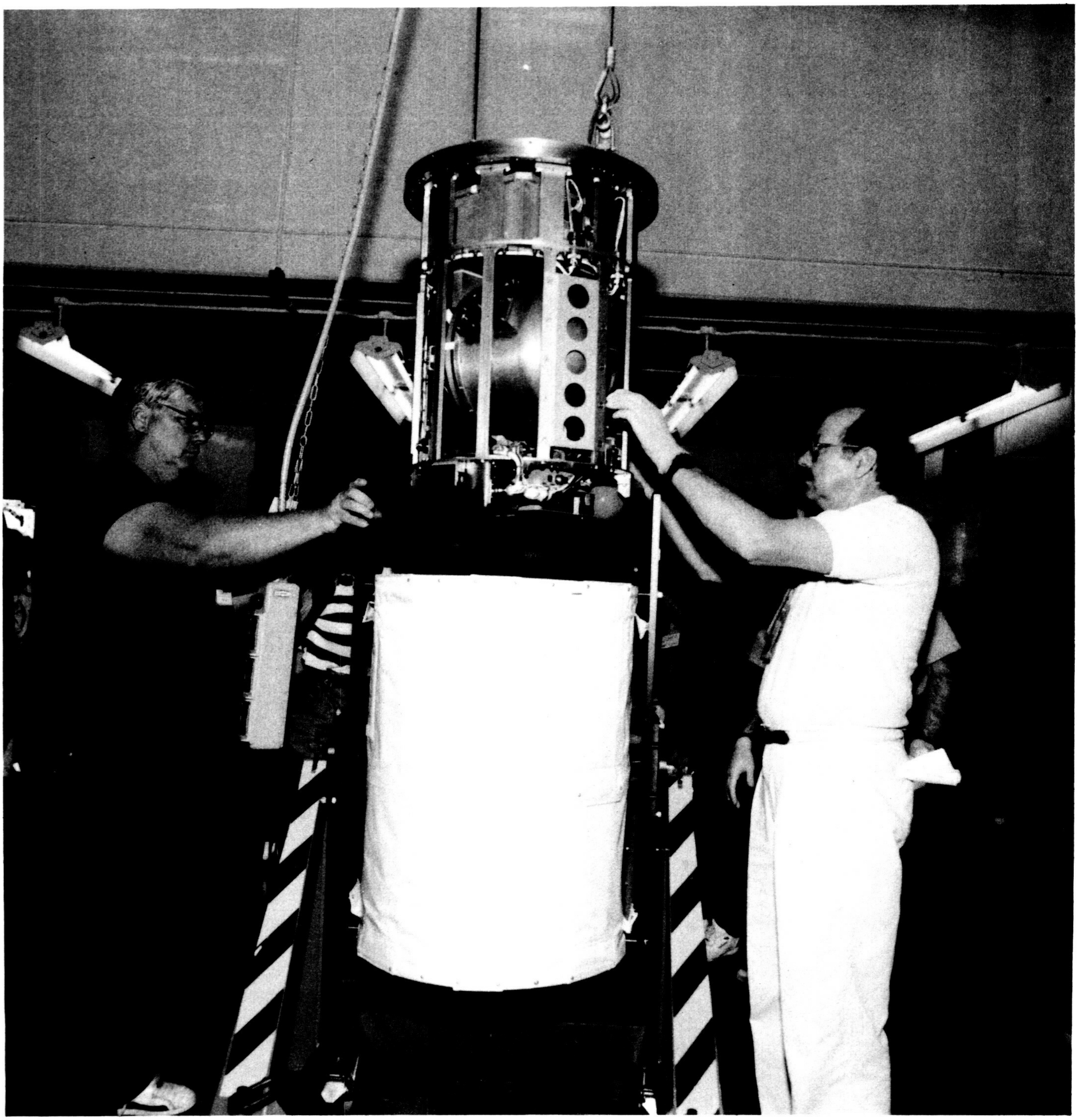

Figure 5 - STS-57, G-535 installation into GAS Canister at GAS Facility

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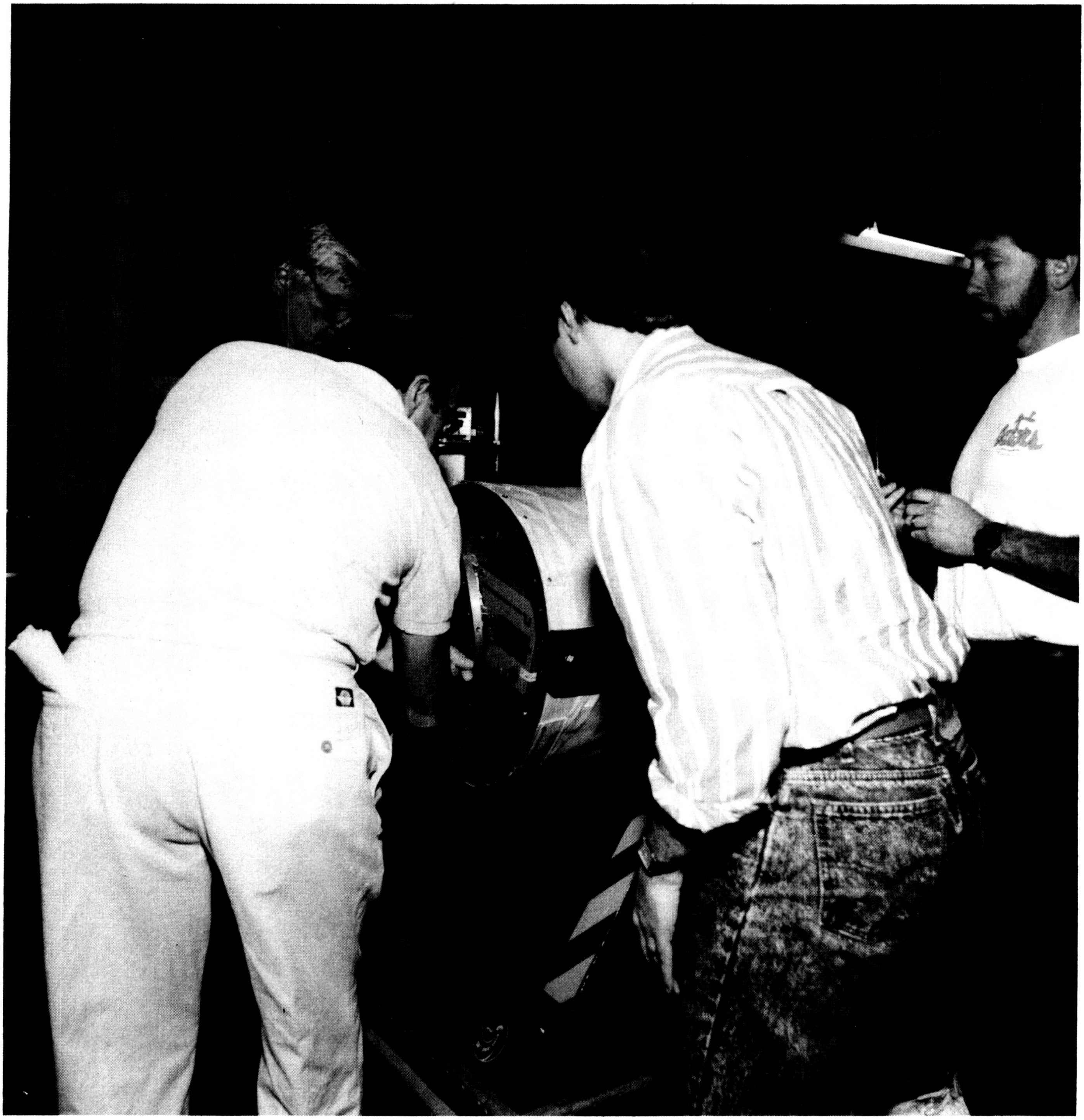

Figure 6 - STS-57, G-535 lower plate installation onto GAS Canister at the GAS Facility

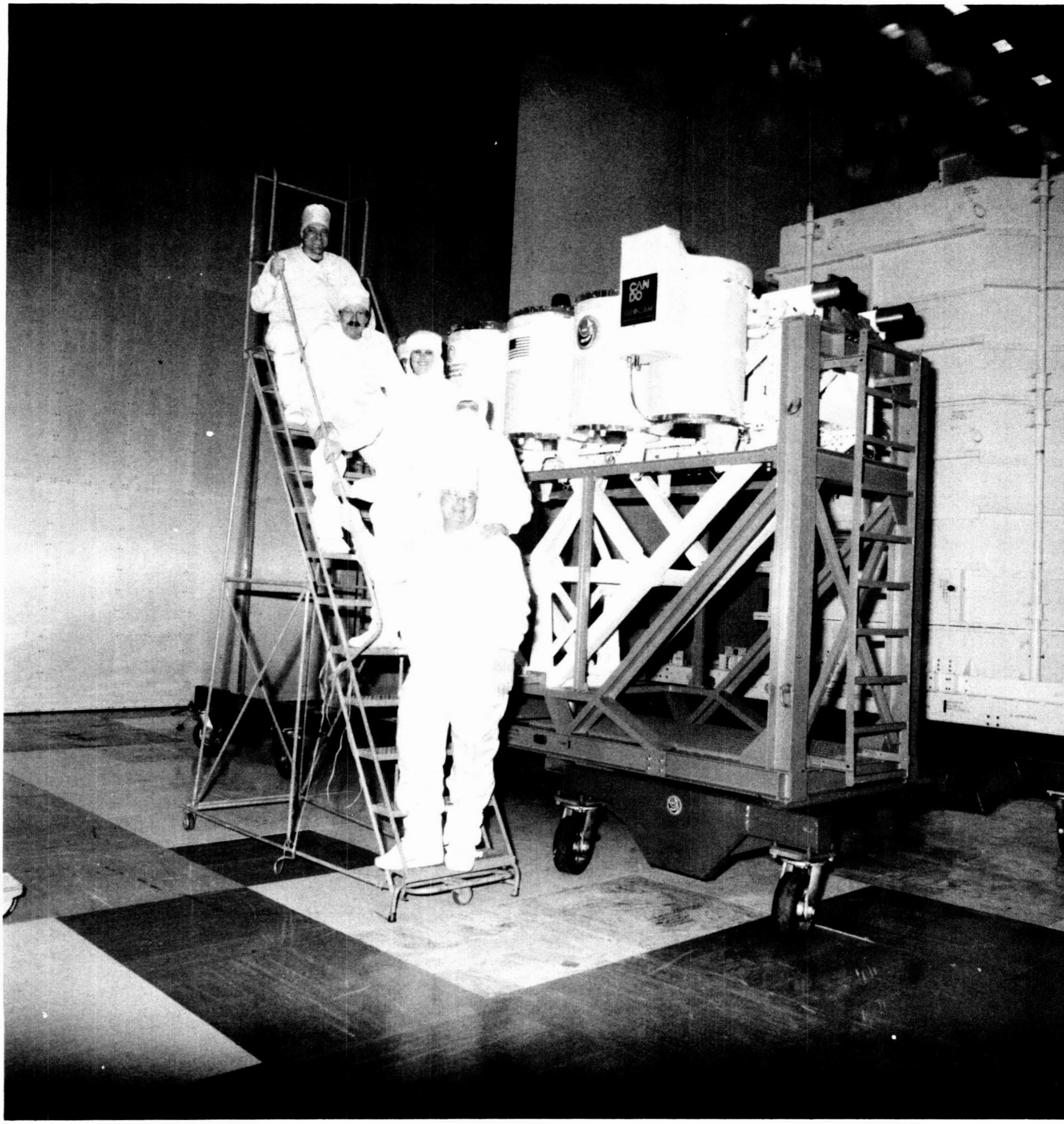

Figure 7 - STS-57 GBA Integration At Payload Processing Facility, Hanger AO

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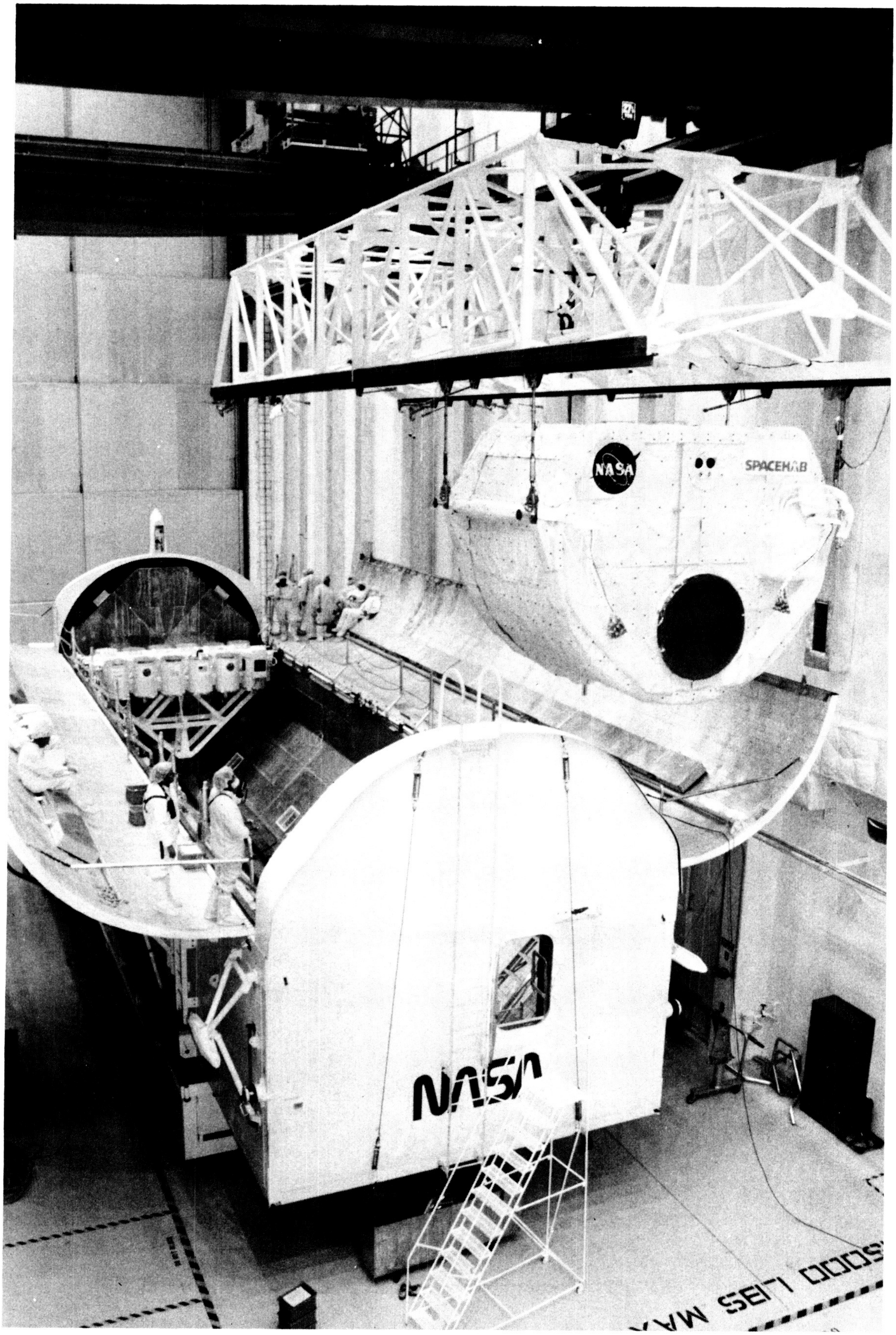

Figure 8 - STS-57 Spacehab-1 Installation into Payload Canister containing GAS Bridge Assembly

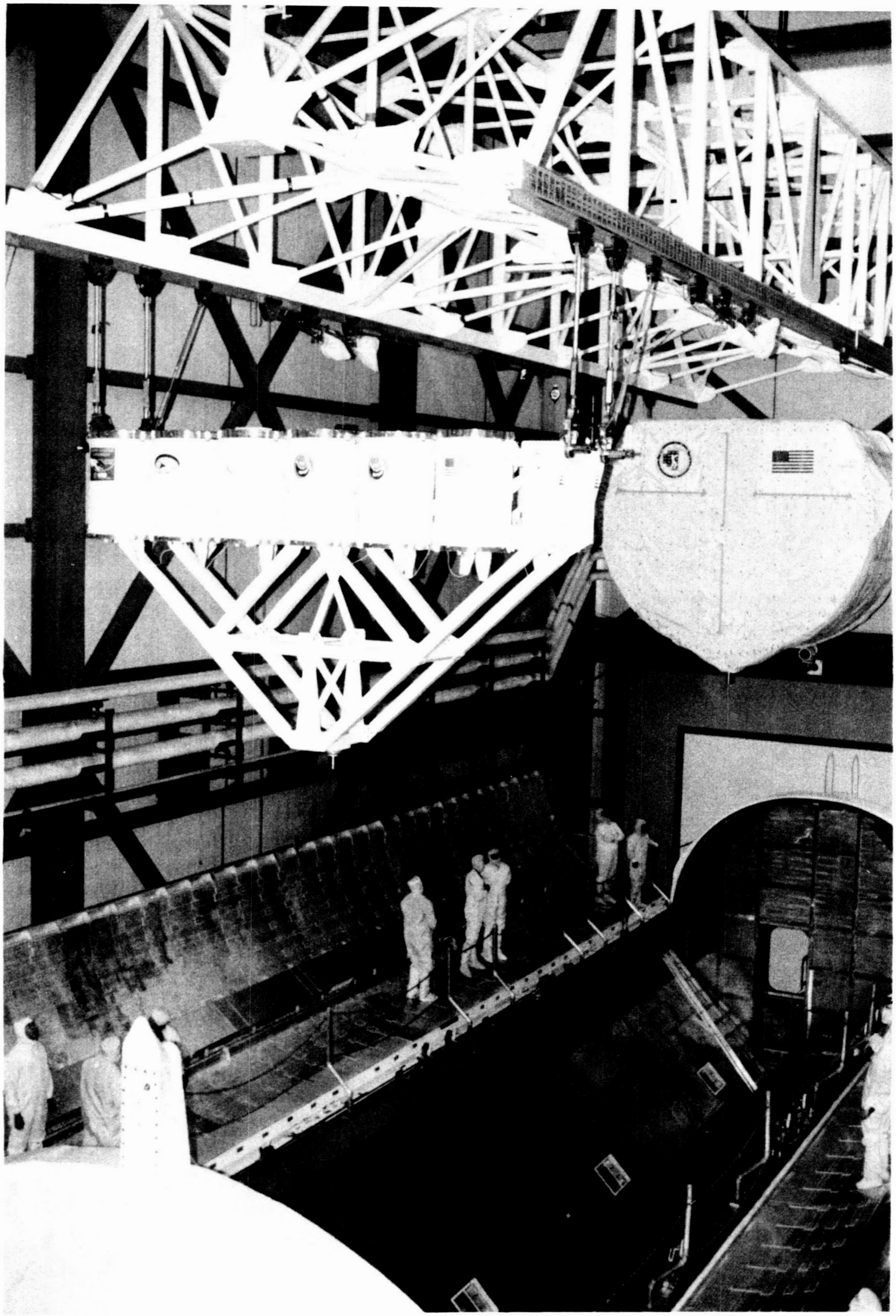

Figure 9 - STS-57 Payload Removal from Payload Canister for installation into Orbiter Endeavor, Orbiter Processing Facility

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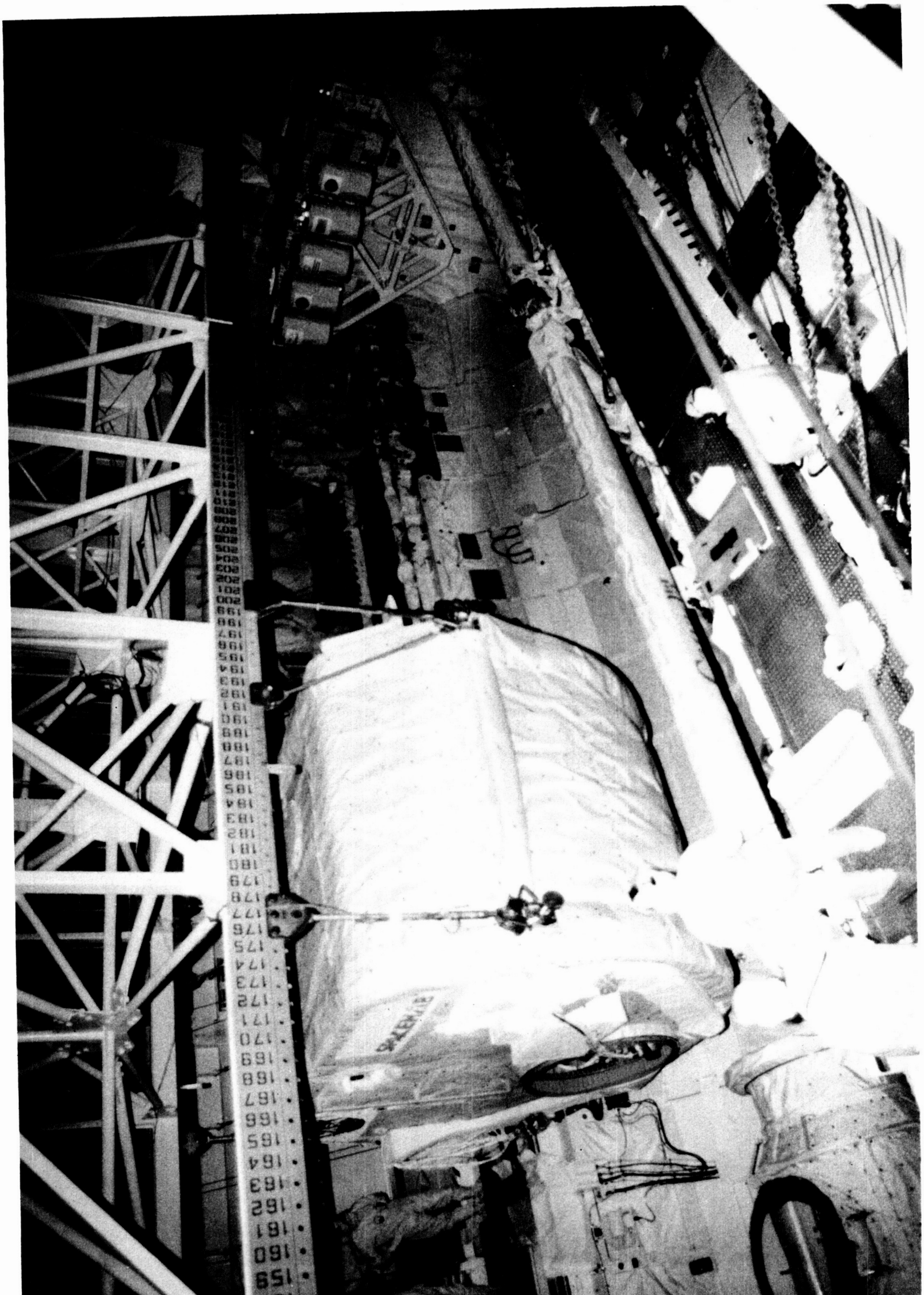

Figure 10 - Installation of STS-57 payloads into Orbiter Endeavor

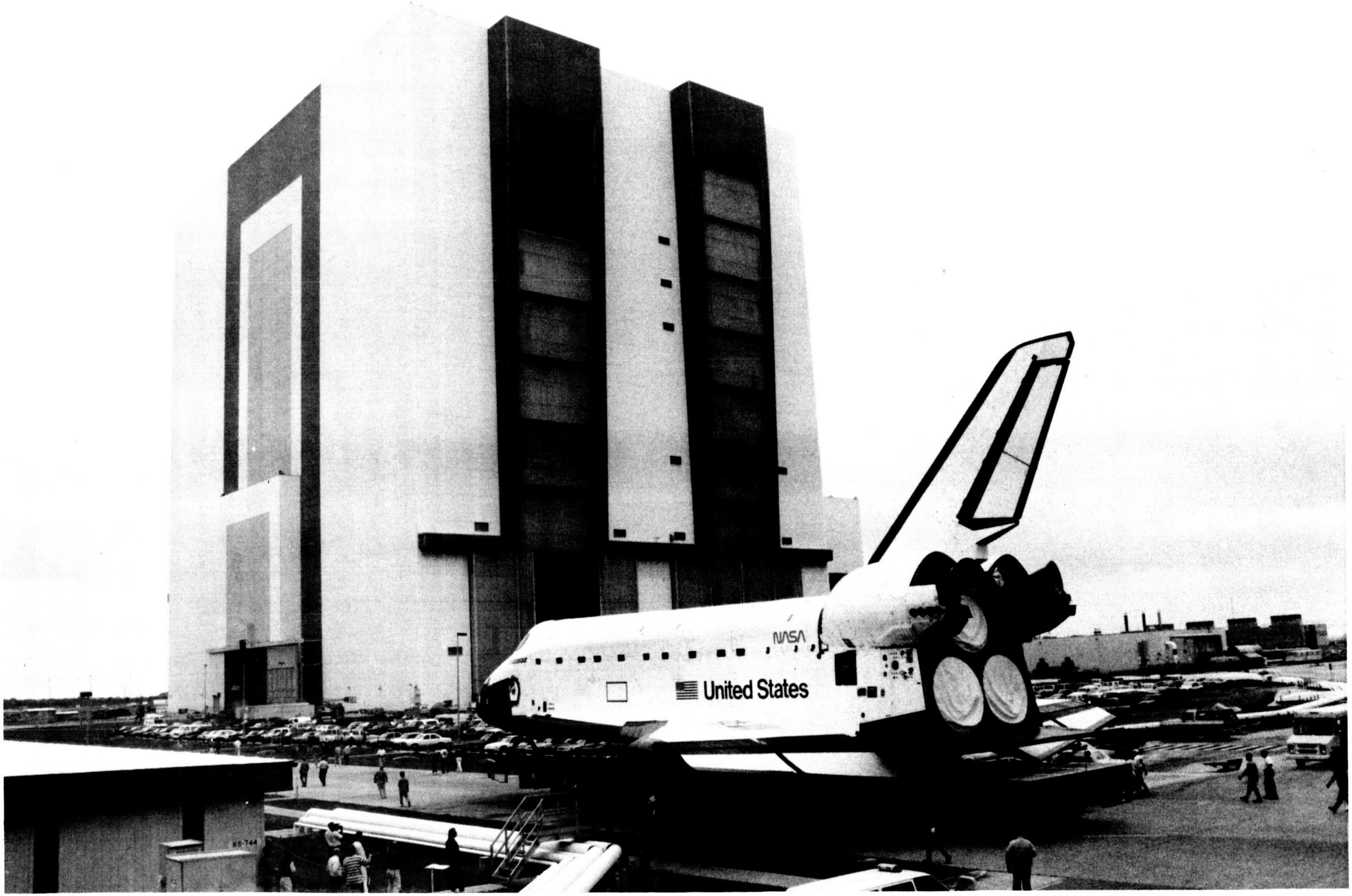

Figure 11 - Rollover of STS-57 Endeavor from Orbiter Processing Facility to Vehicle Assembly Building

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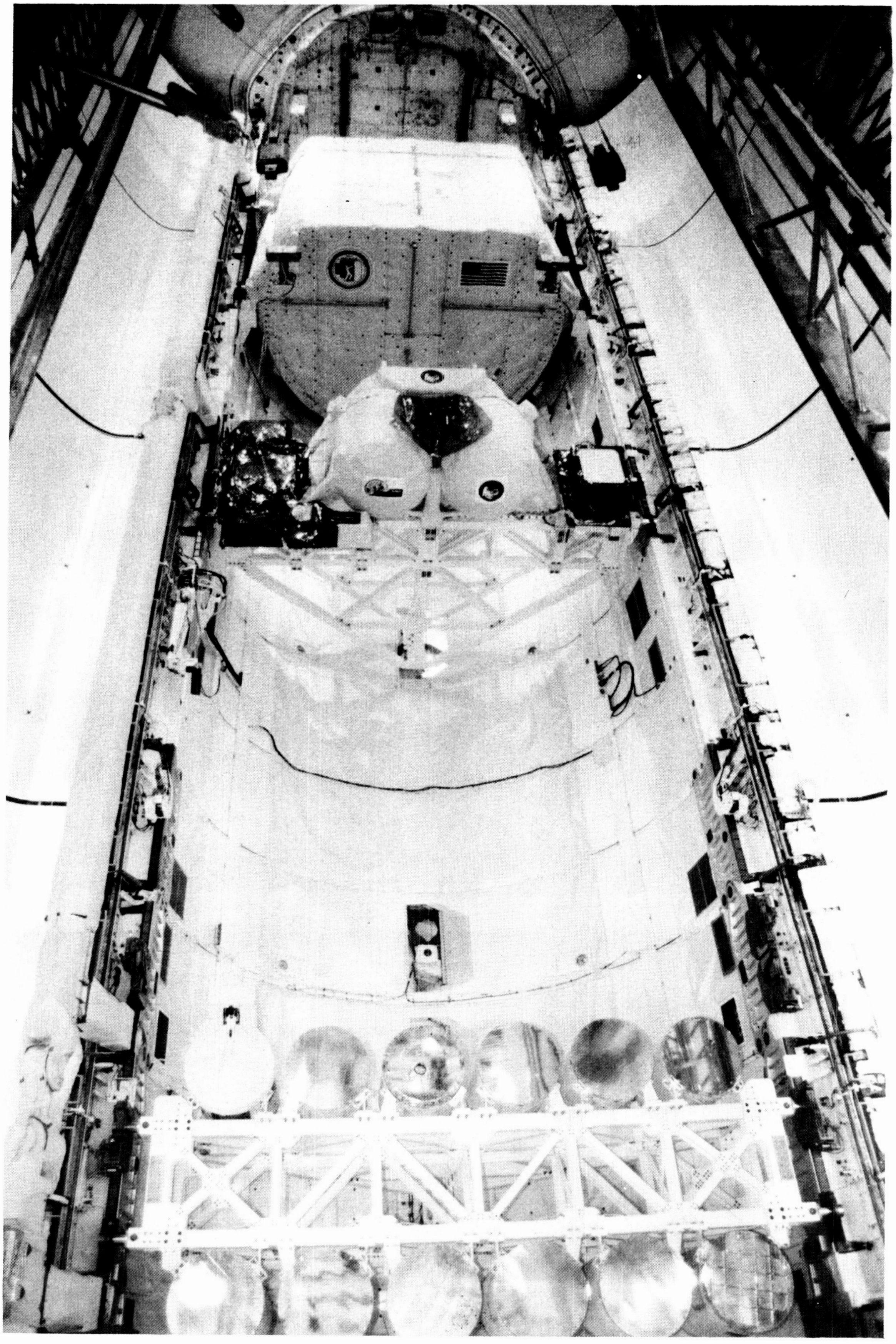

Figure 12 - STS-57 Payloads at Launch Pad 39B

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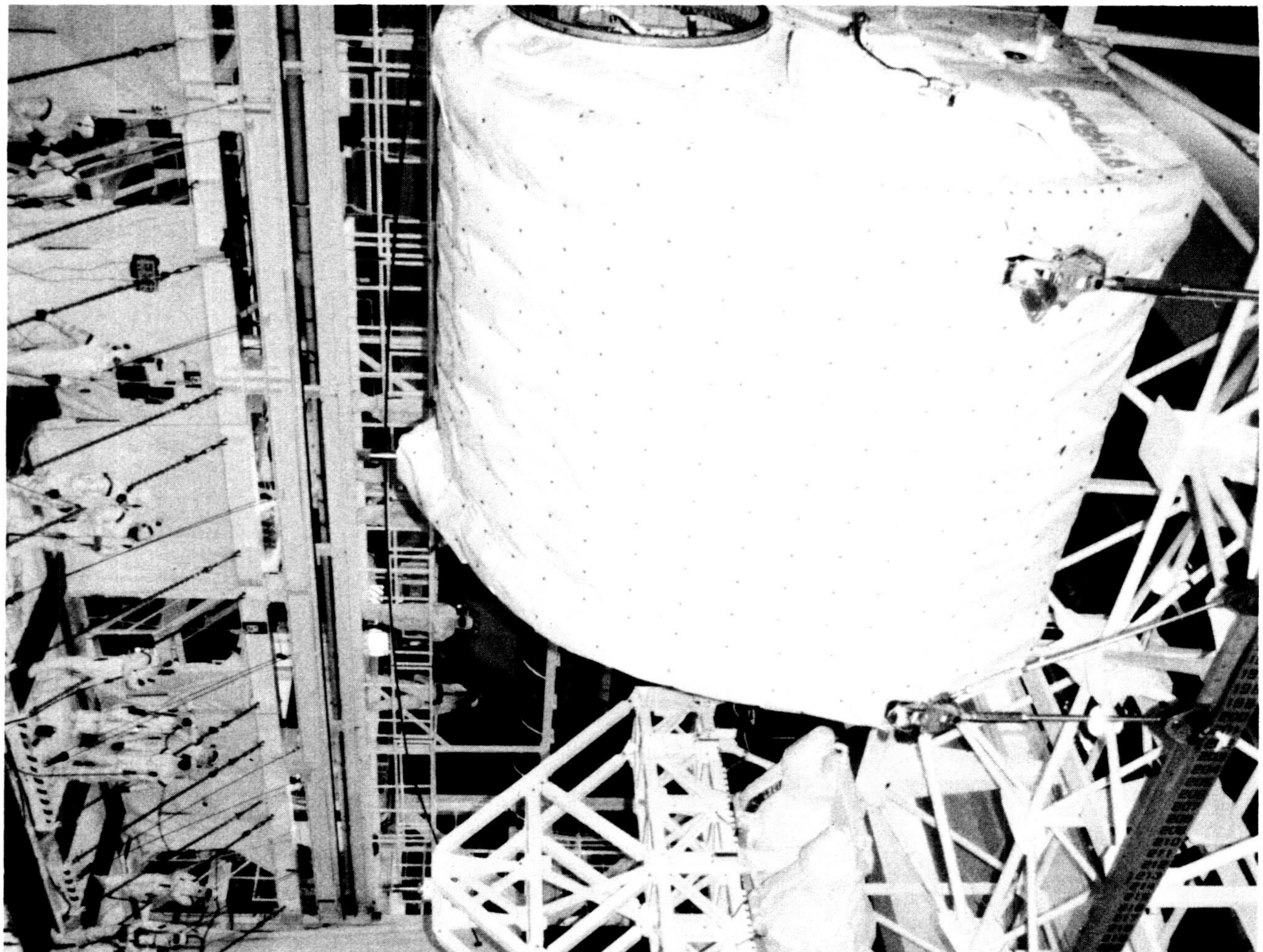

Figure 13 - STS-57 Payloads Removed from Endeavour at Orbiter Processing Facility, Post-Flight

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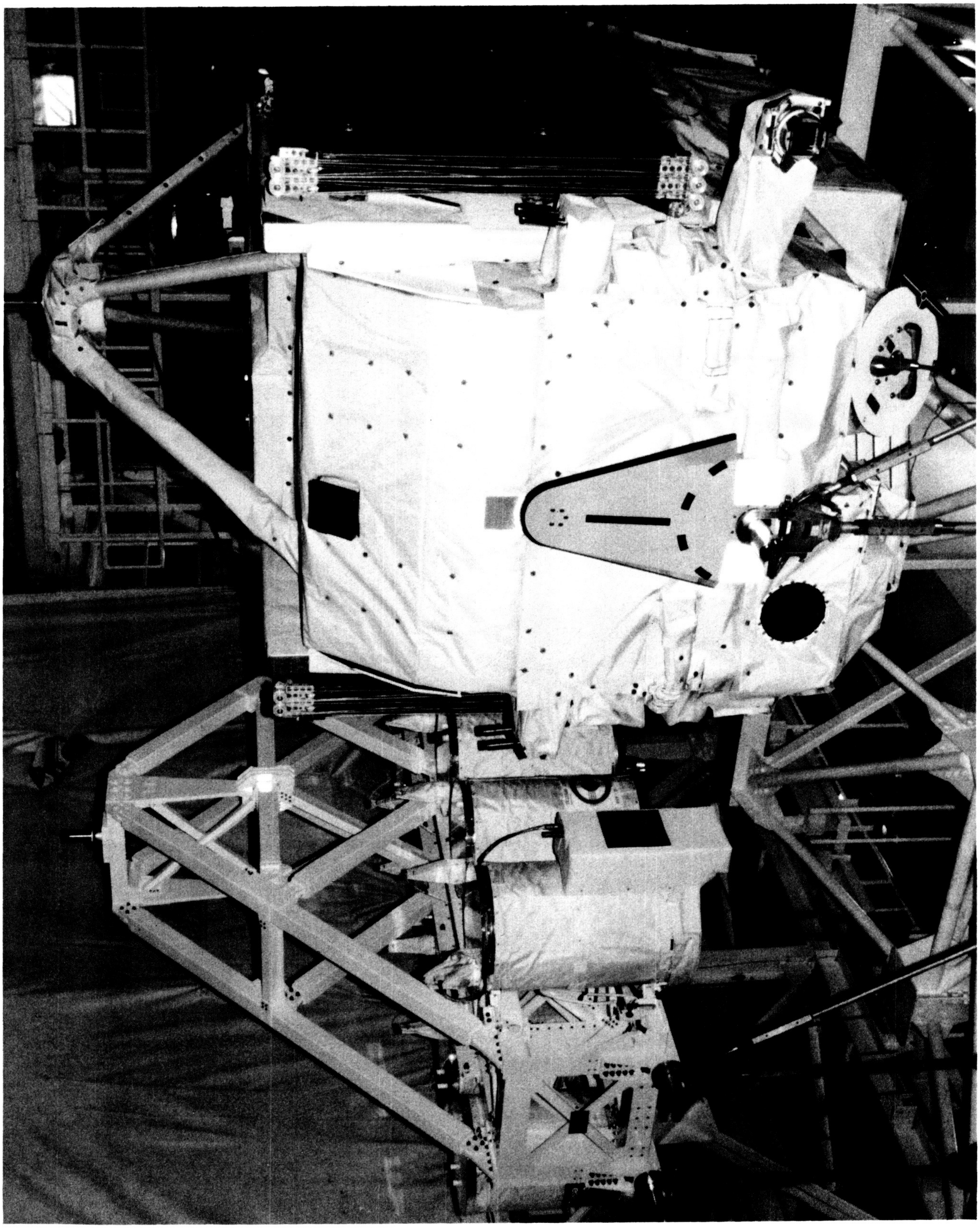

Figure 14 - STS-57 Payloads Removed from Endeavour, Close-up View of EURECA and GAS Bridge Assembly, at Orbiter Processing Facility, Post-Flight

Figure 15 - STS-57 Payloads Installed into Payload Canister at Orbiter Processing Facility, Post-flight