



---

The Space Congress® Proceedings

1976 (13th) Technology For The New Horizon

---

Apr 1st, 8:00 AM

## Shuttle Payload Processing At KSC

James D. Phillips

*Mechanical Design Division, NASA, Kennedy Space Center, Kennedy Space Center, Florida 32899*

Follow this and additional works at: <https://commons.erau.edu/space-congress-proceedings>

---

### Scholarly Commons Citation

Phillips, James D., "Shuttle Payload Processing At KSC" (1976). *The Space Congress® Proceedings*. 2.  
<https://commons.erau.edu/space-congress-proceedings/proceedings-1976-13th/session-4/2>

This Event is brought to you for free and open access by the Conferences at Scholarly Commons. It has been accepted for inclusion in The Space Congress® Proceedings by an authorized administrator of Scholarly Commons. For more information, please contact [commons@erau.edu](mailto:commons@erau.edu).

**EMBRY-RIDDLE**  
Aeronautical University™  
SCHOLARLY COMMONS

## SHUTTLE PAYLOAD PROCESSING AT KSC

James D. Phillips  
Mechanical Design Division  
NASA, Kennedy Space Center  
Kennedy Space Center, Florida 32899

### ABSTRACT

This paper presents the current baseline concept for processing payloads and payload elements at the Shuttle launch site. Processing flows for various payloads will be presented from arrival at KSC/CCAFS through installation into the Shuttle Orbiter. Horizontal installation in the Orbiter Processing Facility and vertical removal and/or installation at the Pad will be presented.

Special emphasis will be given to facilities/equipment required for payload handling, transportation and access. Support capabilities of the Payload Transportation Canister and the Payload Changeout Room will be included.

### INTRODUCTION

In the pre-Shuttle era, payloads were delivered to the launch site via truck or aircraft and checked out in a fashion suitable to the payload supplier and compatible with one of several launch vehicles. With the Shuttle planned as an economical, single configuration, reusable launch vehicle, future payload processing will be systematized for efficiency. The Shuttle launch capability will be available approximately every two weeks, therefore, the schedule makes it imperative that the payloads be ready for launch simultaneously with the launch vehicle. In addition, funding limitations are demanding that manpower be conserved by a simplified checkout system.

### PAYLOAD PROCESSING

The basic premise of the Shuttle concept is that it be a transportation system capable of supporting movement of material at rather large rates to and from earth orbit. This goal assumes two basic hypotheses: First, that large flows of material and transportation systems can be processed in the short turnaround times required, and second, support equipment can be designed common to accept the wide variation of payload sizes and requirements. The first hypothesis was satisfied by the concept of "off-line" processing, namely that many payloads undergo parallel preparation, and that if an unforeseen event causes delay in one payload, another can replace it without affecting the schedule of the transportation system. For example,

substituting other passengers from standby lists for the "no shows" on a commercial airline. The second hypothesis deals with the design of how this movement is to take place. Rather than have a multitude of payload peculiar Ground Support Equipment (GSE) which causes both traffic congestion and increases cost due to limited adaptability and usefulness, the decision was made to attempt to provide GSE which would be multipurpose and allow interfacing with virtually any payload configuration imaginable. Studies led to a concept which would not only allow universal payload adaptability, but would be compatible with the payload contingency changeout capability required at the pad and also with the main payload processing facilities, namely the Orbiter Processing Facility, the Upper Stage Facility, and the Spacelab Facility.

This paper will discuss two basic systems of payload processing and checkout that are presently planned for KSC. The first system is called "off-line" checkout. In this scheme, payload or segments of payloads are brought to the various laboratories at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS), checked out as individual units and then transferred to an integration facility where they are integrated or assembled into a total Shuttle payload. Final processing or checkout is performed in this integration facility and when the payload is determined to be ready for flight, it is transported to the Orbiter Processing Facility (OPF) for horizontal installation or to the launch pad for vertical installation into the Orbiter.

In the "off-line" scheme, all payload assembly and checkout is performed away from the Orbiter; any problems that may be encountered with these payloads will allow rescheduling another payload for flight and therefore not subjecting the Orbiter to delays in its recycling flow. The time expended having a launch vehicle on the launch pad awaiting resolution of payload related problems is very costly.

The second system of payload processing is called "on-line" checkout which employs a "Factory to Pad" concept. In this scheme, payloads and segments of payloads are delivered directly to the pad, placed in the Payload Changeout Room (PCR) where they are checked out and integrated and after completion of

servicing, are installed vertically into the Orbiter. The advantage of this scheme is that no off-line facilities are required and control of the manpower expended is easier because only one location is involved. The disadvantage of this scheme is that the launch pad is not usable until the particular scheduled payload is ready for flight and only one payload per pad can be processed at any one time. A combination of both off-line and on-line processing will be used to best meet all flight requirements.

#### OFF-LINE PROCESSING

Figure 1 and 2 show an overview of the Shuttle facilities at CCAFS and KSC. The payload customer has the responsibility of delivering his payload to the launch site. These deliveries may be made by practically every mode of transportation; air, rail, barge, trucks, etc. Figure 3 shows air delivery of a payload or payload segment to either the skid strip at CCAFS or the new Shuttle landing facility at KSC. After the payload has been off-loaded, as shown in Figure 4, it is ready for processing through whichever scheme is applicable, off-line or on-line. A typical candidate for off-line processing is the Spacelab as shown in Figure 5. Spacelab is made up of various configurations of personnel habitable modules and experiment pallet trains. The off-line facility chosen for horizontal integration and checkout of Spacelab is the existing Operations and Checkout Building. Figures 6, 7 and 8 show the checkout of Spacelab segments on workstands and Figures 9 and 10 show the assembly of these segments into the proper flight configuration in the integrated Spacelab checkout stand. Upon completion of the installation of experiments and final checkout of Spacelab in preparation for launch, it is placed inside a canister, to preserve its cleanliness and environmental integrity, for transport to the OPF located adjacent to the Vehicle Assembly Building (VAB) at Launch Complex 39 (see Figure 11). The OPF is an environmentally controlled area used for the recycle processing of the Orbiter for its next flight. When the Orbiter has been configured for the particular scheduled flight it is prepared for installation of the payload. The Orbiter payload bay doors are closed and the OPF doors are opened to allow the canister with the payload to be positioned alongside the Orbiter workstands. After the canister is in position, the OPF doors closed and the environmental conditions reestablished, the Orbiter payload bay doors and the transport canister doors are opened. Figure 12 shows the payload being removed from the canister, hoisted over the Orbiter workstands and installed inside the Orbiter payload bay. Access to the payload after installation is depicted by Figure 13; access is required to connect and verify the payload-to-Orbiter umbilicals. Subsequent to interface verification tests and final checkout, the Orbiter is towed to the VAB for stacking, as shown by Figure 14. The trailing vehicles behind the Orbiter shown in Figure 14 provide umbilical services to the Orbiter during transit between facilities. These services will include electrical

power, instrumentation, environmental conditioning, purges, etc. These service vehicles will be used to support Orbiter and possible payload requirements during tow from the OPF to the VAB and, upon return from flight, between the Landing Site and the OPF.

In the VAB, the Solid Rocket Boosters (SRB's) are stacked on the Mobile Launch Platform (MLP) in the integration cell and the External Tank (ET) is mated to the SRB's prior to the arrival of the Orbiter. The Orbiter is towed into the transfer aisle of the VAB where it is rotated to the vertical position and hoisted into the integration cell and mated to the ET to complete the assembly of the totally integrated Shuttle flight configuration. The Orbiter payload bay doors will not be opened in the VAB; therefore, any necessary access to the payload will be accomplished through an environmentally protected access room to the Orbiter crew hatch, through the on-board airlock and into the Orbiter payload bay. Any access equipment that may be required that is unique to specific payloads will be supplied by the individual payload customer (see Figure 15).

The MLP with the fully integrated Shuttle vehicle is next transported to the Launch Pad by the Crawler Transporter (Figure 16), placed on its supports and pad electrical and mechanical facilities are connected. The PCR is rotated into position and on-pad servicing for launch preparation begins, shown in Figure 17.

The PCR provides many services. In normal launch flows, it provides any necessary on-pad access to the Orbiter payload bay area and fluid and electrical umbilical servicing to the Orbiter and its payload. As a contingency, the PCR provides the capability to permit unscheduled on-pad changeout of payloads or scheduled installation of certain vertically processed off-line payloads and all on-line payloads.

Should the situation ever exist for on-pad payload changeout, due to emergency conditions or failure of a payload or payload component that could not be repaired or replaced in a timely fashion without significantly delaying the launch and thereby impacting the entire launch schedules, the following changeout sequence will occur. The installed payload will be prepared for removal from the Orbiter; it will be deserviced, if applicable, and the Orbiter-to-payload umbilicals will be disconnected. Payload changeout is accomplished using the Payload Ground Handling Mechanism (PGHM) in the PCR.

The Payload Ground Handling Mechanism (PGHM) is a structural steel assembly, shown in Figure 18, suspended from an overhead bridge that rolls on rails mounted in the top of the PCR. The PGHM is capable of handling, installing and removing payloads or payload segments up to 15 feet in diameter, 60 feet in length and weighing up to 65,000 pounds. The vernier fittings shown are capable of being bolted to the longeron beam of the PGHM strongback at the same vertical locations as the handling

fittings on the payloads and the retention fittings on the longeron beam of the Orbiter. There will be a vernier fitting on the PGHM for each handling fitting which exist on the particular payload. All payloads must have these handling fittings at identical horizontal locations to be compatible with the Orbiter and the vernier fittings mounted on the PGHM. For payloads of a smaller diameter than the full 15 feet, a payload support structure or cradle will be required around the payload. The cradle will have handling fittings located at the identical horizontal locations as the PGHM vernier fittings and the Orbiter retention fittings.

Adjustments required to align the PGHM with the handling fittings on the payloads are provided as shown on Figures 18, 19 and 20. Figure 19 shows a detail view of a typical proposed vernier fitting. It is a gear box device that allows the lifting arm of the vernier fitting to be adjusted vertically and horizontally. The strongback portion of the PGHM, with all the vernier fittings mounted on it, is adjustable as shown in Figure 20. Jack screw mechanisms provide adjustments of the PGHM strongback vertically and horizontally.

A standard payload interface trunnion has been established and is as shown in Figure 21. This payload trunnion provides both a handling interface for the GSE and a retention interface for attachment to the Orbiter for flight. The dimension for the centerline of the retention interface of the payload fitting is 94 inches on either side of the payload longitudinal centerline; the dimension of the handling interface is inboard of the retention interface and is at 90.125 inches on either side of the payload longitudinal centerline. These dimensions and the configuration of the trunnion has been standardized for all Shuttle payloads and is compatible with the locations of the Orbiter retention fittings and thus the pick-up point of the lifting arm of the vernier fittings located on the PGHM.

To accomplish removal of a payload, the PGHM is rolled forward on the rails toward the payload installed in the Orbiter. As it approaches the payload, the lifting arm of each vernier fitting is aligned with its corresponding handling/retention fitting on the payload. A vernier fitting will be mounted on the longeron beam of the PGHM for each handling fitting that is on the particular payload. This alignment will position the vernier fittings just beneath each payload handling fitting. The strongback portion is next raised vertically to pick up the payload from the Orbiter retention fittings and the PGHM is rolled back into the PCR extracting the payload from the Orbiter bay. This sequence is shown in Figures 22 and 23. Figure 24 shows a typical payload on the PGHM. The installation and removal of payloads from the Orbiter by the PGHM is a highly complex load transfer problem. Ideally, the payload should be exchanged from one to the other without physically tying the two together to avoid Orbiter damage from differential motion caused by load, wind, and thermal stress. The forklift type of load transfer as described above, is one of the concepts being

studied to solve this problem.

With the payload on the PGHM and the PGHM positioned at the back of the PCR, the Orbiter payload bay doors and the PCR doors are closed, respectively, to preserve the cleanliness of both the Orbiter and the payload. The PCR is now rotated approximately 120° to its fully retracted position.

Simultaneous to the previous operations, an empty payload changeout canister has been transported to the VAB and rotated to a vertical position by the VAB overhead cranes as depicted by Figures 25, 26 and 27. This payload changeout canister is transported vertically to the launch pad and positioned beneath the retracted PCR as indicated in Figure 28. The payload changeout canister will be designed to match the same configuration as the payload bay portion of the Orbiter fuselage, in order to be compatible with the seals of the PCR that provides the environmental seal between the room and the Orbiter. The canister simulates the Orbiter both externally and internally; externally to dimensionally mate with the environmental seal of the room and internally to provide longeron beams and retention fittings to support the payload during changeout and transportation between facilities. It will also be capable of providing necessary requirements such as fluids, power, instrumentation, and environmental control to the payload during transit.

After the canister has been properly positioned under the PCR, it is hoisted by a 90 ton crane as shown in Figures 29, 30 and 31. The outriggers on the sides of the canister fit with guide rails on the PCR. When the canister is hoisted to the proper elevation, it is locked into position and the environmental seals of the room are inflated to seal against the sides of the canister. The space between the closed doors of the PCR and the canister will be washed down with clean air to ensure the required cleanliness prior to opening the doors of the PCR and the canister.

After opening the doors of the PCR and the canister, the PGHM with the payload is rolled toward the canister and, by the same methods of alignment as previously discussed, the attach/handling fittings of the payload are aligned with the prepositioned retention fittings mounted on the longeron beams of the canister. The payload is transferred from the PGHM into the canister and the PGHM is retracted into the PCR. Since the canister is rigidly mounted to the PCR the payload transfer is simpler than with the Orbiter. The payload is secured by the retention fittings and the canister doors and the PCR doors are closed as shown in Figures 32 and 33. The environmental seal is deflated and the canister with the payload is lowered onto the transporter and taken to the off-line facility. If necessary, the canister is taken to the VAB for rotation to a horizontal position to travel to the off-line facility.

Another alternate payload that has been prepared for launch will be transported vertically to the pad in another canister and will be installed onto the PGHM in the PCR and subsequently into the

Orbiter in the reverse sequence as the previously removed payload.

The payload support capabilities that are available inside the PCR are provided for on-line processing of some factory-to-pad payloads and to provide access to areas of payloads after they are installed in the Orbiter. Figure 34 shows some of these support facilities of the PCR. Work platforms providing approximately 2300 square feet of space for payload checkout and servicing equipment, are shown as five permanently mounted platforms approximately 10 feet apart on either side of the PCR extending to within several inches of the PGHM. Fluid services, such as gaseous nitrogen, gaseous helium, shop air, etc., and electrical power outlets are provided on each level of these platforms and are located against the PCR wall. This allows flex line and cable connections to provide these services, as required, to the payload while it is in the PCR.

Hoisting provisions are available by the two fixed mounted 5-ton hoists on either side of the bridge structure of the PGHM and two 1-ton jib cranes mounted on the top forward corners of the PGHM. Larger pieces of GSE may be brought into the PCR through the 10' x 12' x 12' airlock located at the back corner on the tower side of the PCR and lifted to the required working level by one of the 5-ton hoists. The jib cranes are used to handle GSE and also to position the vernier fittings as they are being bolted along the longeron beams of the PGHM strongback.

Access around 360° of the payload, when it is installed on the PGHM, is provided by extendable metal planking that telescope from under each of the GSE storage platform levels. These extendable planks are approximately 12 inches wide and are driven outward toward the payload to conform to the exposed surface configuration of the particular payload. Access to the exposed surface of a payload installed in the Orbiter may be provided from the PGHM in a similar manner, as shown in Figure 35.

#### OFF-LINE PROCESSING OF INTERIM UPPER STAGES AND SPACE TUG

The Interim Upper Stage (IUS), which is being developed by the Department of Defense as part of the Shuttle program, is a booster of one or more stages which is carried in the payload bay of the Orbiter. It is used to boost payloads to a higher orbit than the Orbiter can alone provide, and also for interplanetary flights. The IUS will be a solid fueled vehicle of up to 3 stages with a fourth or kick stage as required.

A permanent upper stage called Space Tug will be developed in the early 1980's as a reusable replacement for the IUS. This vehicle will use liquid hydrogen and liquid oxygen as propellants.

The satellite and its IUS (or Tug) will each be checked out separately in its own facility. The

satellite processing and preintegration checkout will be performed in one of many off-line facilities such as buildings AE, AO, AM, etc. In these facilities payload owners will perform the required testing without impact to the on-line schedules of the Shuttle. In parallel with this operation the upper stage undergoes its buildup and preparation in the Spacecraft Assembly and Encapsulation Facility #1 (SAEF #1), which is planned to be converted to an upper stage checkout and integration facility.

SAEF #1 (see Figure 36) consists of a high bay area 71 feet wide, 143 feet long and 105 feet high serviced by a 25 ton traveling crane. The area is environmentally controlled to the Class 100,000 cleanroom level required by Shuttle payloads. Entrance and exit from the high bay is through an airlock (see Figure 37) which allows contamination control by cleaning items before they pass through the second doorway into the high bay proper.

One of the more interesting proposed concepts which might be used to prepare an upper stage, consists of twin cells located at the north end of the high bay. Each of the cells would consist of a stand on which the segments of the upper stage are connected together and tested, and a nest of access platforms surround it (see Figure 38). The stand itself (see Figure 39) consists of a tower similar in design to that which is planned for use at the launch pad, mounted on a base having wheels for mobility. The tower is a strongback with vernier fittings mounted on a structural frame, and which operates very similar to the PGHM used at the pad as shown in Figures 19, 20 and 21.

The flow begins with the arrival of subassemblies of the upper stage, in this case an early program IUS (see Figure 40). The road covers are removed in the airlock and the cleanliness level brought up to the Class 100,000 requirements. Then, by means of an electric tow cart, the items pass through the inner doorway and are prepared for assembly. Figures 41, 42, 43 and 44 show a theoretical assembly of a solid booster. It is not known if the stages will assemble in series as depicted or in parallel (i.e. side by side). In either event, the subsegments are assembled on a shelf-like platform. When the assembly has reached the point where the adapter (called the cradle, which adapts the smaller diameter IUS to the 15 foot diameter Orbiter bay) is attached, the total IUS is lifted by the use of the vernier fittings which have been aligned just below the trunnions on the cradle. The assembly platform is then removed and work proceeds on the IUS. At the prescheduled time, the spacecraft is brought to SAEF #1 from its checkout area. It arrives in the airlock and is cleaned and road covers, etc. removed (see Figure 45). Once this is completed, the spacecraft is towed into the high bay and hoisted via the 25 ton crane onto the adapter affixed to the IUS (see Figure 46). Once the spacecraft is mounted to its adapter, an integrated test is performed verifying union of the two elements.

As the time nears to transfer the payload to the Orbiter, a payload canister arrives, standing vertically atop the transporter (see Figure 47). After being washed down, the canister is taken into the airlock where further preparations take place, using the 10-ton monorail and the envisioned articulating-arm access (see Figure 48). Once the canister is ready, the transporter, switching to electric/hydraulic drive, moves into the high bay (see Figure 49) and using its very flexible and precise steering aligns itself with benchmarks in front of the cell and the canister doors are opened. The flip-up portions of the access stands are then raised allowing passage of the stand with its IUS/SC to the awaiting canister. The payload is deposited into the canister in very much the same manner that it occurs at the launch pad PCR. Once the payload is installed, the canister doors are closed and the transporter carries it through the airlock and out to the launch pad. Upon arrival, the canister is aligned under the retracted PCR, hoisted, and installed onto the PGHM and then into the Orbiter payload bay in the normal manner as depicted in Figures 28 through 31, and 50 through 52.

The Space Tug is predicted to operate in an identical manner. It is expected, however, to arrive virtually preassembled and as such the assembly platform may be phased out.

Other concepts being examined would utilize an uprated overhead crane, or special fixtures and stands which may use specially adapted canisters.

These same vertical cells will also provide the ability to process a payload which must be kept vertical at all times after checkout. These would be installed into the cell stand and then transferred via the canister to the PCR in the normal fashion.

#### ON-LINE PROCESSING

The portion of Interim Upper Stage flights which are scheduled to be dedicated to Department of Defense payloads are foreseen as requiring an on-line processing of the solid fueled upper stage and spacecraft, the so called "Factory-to-Pad" concept. Basically, this concept postulates that the segments of the solid fueled upper stage are brought together at the launch pad PCR directly from the factory. Once installed and assembled in the PCR on the PGHM, the spacecraft will arrive and be introduced into the PCR and installed onto the IUS. Once mated, the various systems verified by testing, the combined unit is then deposited in the payload bay of the Orbiter which has arrived at the pad in the meanwhile.

While these methods appear on the surface to be the same as the off-line processing and handling methods, closer study revealed the necessity of specialized equipment to handle the entry of payloads into the PCR and provide quick response to malfunctioning equipment since this would impact launch in serial time. The largest of these

specialized pieces of equipment is a unique canister, large enough and flexible enough to accommodate both the extra required access and the ability to allow the entry and departure of the payload elements. Thus, a new canister of much larger interior work area is required (see Figure 53). This larger area would provide access around an IUS or a spacecraft located within. An opening on the bottom would allow introduction of the IUS and SC. A 20 ton monorail crane placed at the top of the canister would operate along a mating track running between the centerline of the canister and the centerline of the payload on the PGHM. The bottom doors would open, and the monorail crane hook lowered to the pad surface. The covered IUS would then be lifted from its delivery vehicle, and hoisted up into the canister room (see Figure 54). The canister room, with its large vertical "Payload Bay" doors closed for contamination control of the PCR, contains the access required for cleaning the IUS to the 100,000 level, and for shipping cover removal. Once this is completed, the doors to the PCR and the large canister are opened, and the monorail travels into the room and positions the IUS onto the vernier fittings of the PGHM.

At the appropriate time, the spacecraft arrives and is positioned on the pad surface, as was the IUS. The canister bottom doors are opened and the canister mounted monorail hoist hook is lowered and the spacecraft hoisted into the canister room (see Figure 55). Once again canister provided access around the payload element allows cleaning and cover removal and the large doors opened. The monorail carries the spacecraft from the canister room to the mating interface of the IUS for assembly.

The mated spacecraft and IUS are then tested. The Orbiter which has been undergoing parallel preparation now arrives at the launch pad and is prepared to accept the payload. The canister is removed and the PCR is rotated to the Orbiter and a normal payload transfer takes place.

The special canister also provides the capability of removing segments of the spacecraft that have malfunctioned during testing, or are to be replaced by other preferred items. The segment to be replaced is lifted from the stack with the monorail hoist and positioned in the special canister where it is prepared for removal (or it may be repaired and reinstalled as the case might be). Once packaged, it is lowered through the bottom doors to the awaiting vehicle and the replacement brought up into the canister and deposited on the IUS spacecraft.

The size of the canister dictates that its mobility be limited to travel between the two launch pads. Thus, this canister would not be used for normal transportation between payload facilities.

After an on-line payload has been processed for launch in the PCR or any payload has been changed out, installation into the Orbiter is accomplished by the reverse order of payload removal as has



been previously discussed. The payload to Orbiter electrical and mechanical interfaces are connected and verified and any payload servicing commences. When the on-pad payload servicing has been completed, the Orbiter payload bay doors are closed and sealed for launch. Pad close-out begins, the PCR doors are closed, the PCR is rotated to the fully retracted position and the loading of the cryogenic propellants begins at approximately T-2 hours.

Subsequent to launch and after the Orbiter has achieved its proper orbit, the payload is either exposed to the outer space environment, by opening the Orbiter payload bay doors for the duration of the payload's performance, or deployed from the Orbiter bay and placed in orbit, depending upon the specific characteristics and mission plan for the particular payload. When a payload's mission has been completed, it is returned by the Orbiter to the landing site at KSC. The Orbiter is safed and prepared for tow to the OPF where final safing and deservicing is completed and the Orbiter payload bay doors are opened. the payload is removed and transported back to the off-line processing facility or directly to the air strip for return to the supplier.

#### ILLUSTRATIONS

- Figure 1. Overview of Payload Facilities at Cape Canaveral Air Force Station (CCAFS) and Kennedy Space Center (KSC)
- Figure 2. Overview of Facilities at Kennedy Space Center
- Figure 3. Air Delivery of Payloads or Payload Segments to the Launch Site
- Figure 4. Off Loading Payloads or Payload Segments from Aircraft
- Figure 5. Typical Flight Configurations of Spacelab Elements
- Figure 6. Work Stand for Spacelab End Cone
- Figure 7. Work Stand for Spacelab Racks and Panels
- Figure 8. Work Stand for Spacelab Pallets
- Figure 9. Assembly of Spacelab Elements in Checkout Stand
- Figure 10. Checkout of Integrated Spacelab
- Figure 11. Installation of Spacelab into Transportation Canister
- Figure 12. Installation of Spacelab into Orbiter at OPF
- Figure 13. Access Provisions to Payloads Subsequent to Installation into Orbiter Payload Bay
- Figure 14. In-Transit Services to the Orbiter During Tow
- Figure 15. Orbiter Crew Hatch Access Room in VAB
- Figure 16. MLP With Integrated Shuttle Vehicle in Transit to the Pad
- Figure 17. On Pad Servicing of Shuttle Vehicle, Payload Changeout Room Extended
- Figure 18. Payload Ground Handling Mechanism (PGHM)
- Figure 19. Vernier Fitting Mounted on PGHM Showing Adjustments of Payload
- Figure 20. PGHM Strongback Adjustment Mechanism
- Figure 21. Standard Payload Interface Trunnion
- Figure 22. Extracting Payload from Orbiter With PGHM
- Figure 23. Payload on PGHM in PCR With Doors Closed
- Figure 24. Typical Payload on PGHM
- Figure 25. Canister Rotation Sequence Using VAB Cranes
- Figure 26. Canister Rotation Sequence Using VAB Cranes
- Figure 27. Canister Rotation Sequence Using VAB Cranes
- Figure 28. Positioning Payload Transportation Canister Beneath the PCR
- Figure 29. Hoisting Sequence of Transportation Canister at PCR
- Figure 30. Hoisting Sequence of Transportation Canister at PCR
- Figure 31. Hoisting Sequence of Transportation Canister at PCR
- Figure 32. Installation of Payload into Canister by PGHM
- Figure 33. Payload in Transportation Canister With Room & Canister Doors Closed
- Figure 34. Payload Support Facilities of PCR
- Figure 35. Payload Access Platforms from PGHM
- Figure 36. Spacecraft Assembly & Encapsulation Facility No. 1 (PIF)
- Figure 37. SAEF #1 Floor Plan
- Figure 38. SAEF #1 Checkout Cell
- Figure 39. Checkout Stand

- Figure 40. Subassembly Arrival
- Figure 41. IUS Assembly
- Figure 42. IUS Assembly
- Figure 43. Plan View of Checkout Cells
- Figure 44. Elevation View of Checkout Cells
- Figure 45. Spacecraft Arrival in Airlock
- Figure 46. Placing the Spacecraft on IUS
- Figure 47. Washdown of Canister Outside Airlock
- Figure 48. Canister Preparations in Airlock
- Figure 49. Installing Payload in Canister
- Figure 50. Canister Installed onto PCR
- Figure 51. PGHM Picking Payload Out of Canister
- Figure 52. PGHM Retracted into PCR with Payload
- Figure 53. Elevation View of Canister with Internal Monorail Hoist
- Figure 54. IUS Lifted into Canister by Monorail Hoist
- Figure 55. Payload Being Lifted into Canister

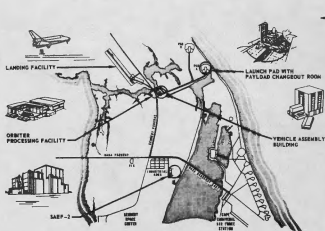


Figure 2.

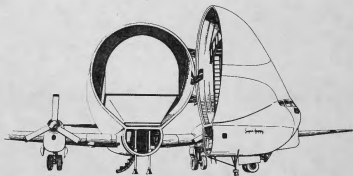


Figure 3.

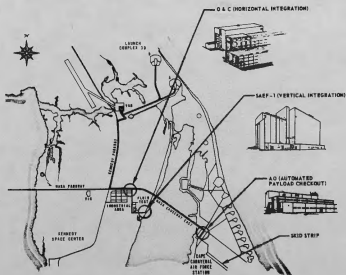


Figure 1.

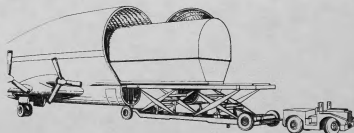


Figure 4.

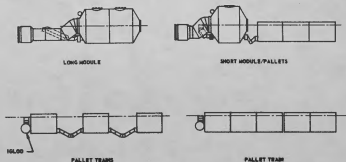


Figure 5.



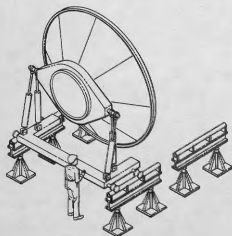


Figure 6.

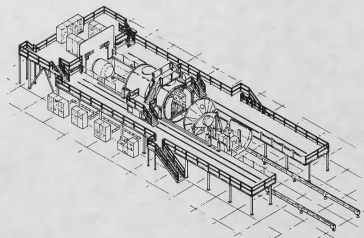


Figure 9.

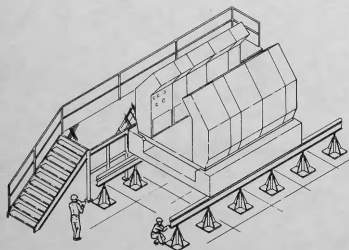


Figure 7.

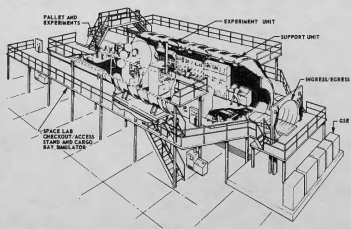


Figure 10.

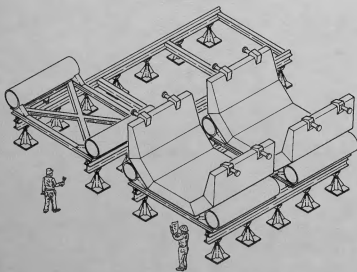


Figure 8.

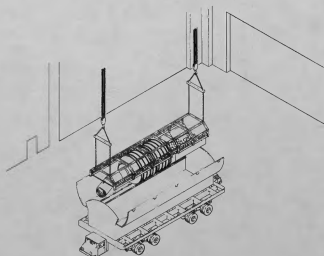


Figure 11.

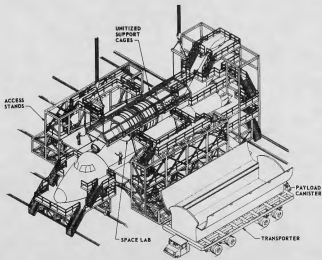


Figure 12.

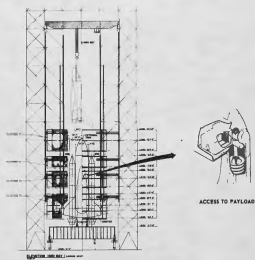


Figure 15.

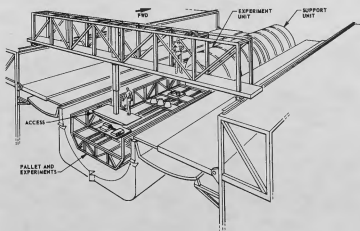


Figure 13.

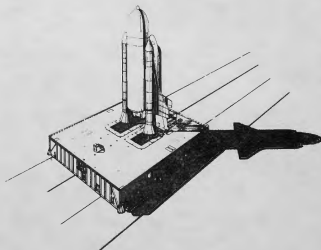
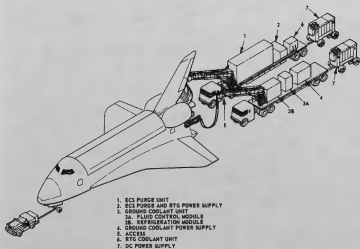


Figure 16.



1. ECS PURGE UNIT
2. ECS PURGE AND BTG POWER SUPPLY
3. ORBAND COOLANT UNIT
- 3A. FLUID CONTROL MODULE
- 3B. REFRIGERATION MODULE
4. ORBAND COOLANT POWER SUPPLY
5. ACCESS
6. BTG COOLANT UNIT
7. DC POWER SUPPLY

Figure 14.

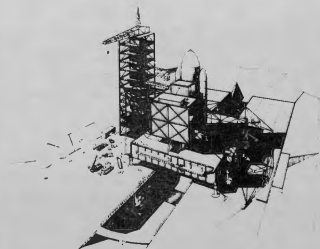


Figure 17.

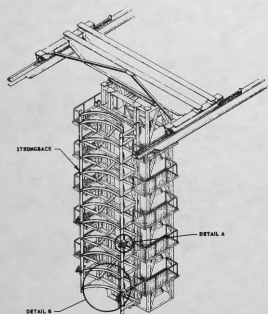


Figure 18.

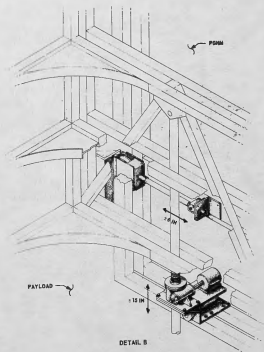


Figure 20.

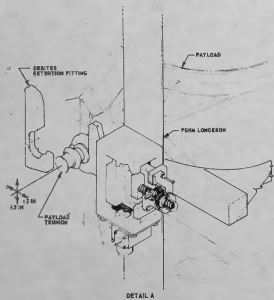
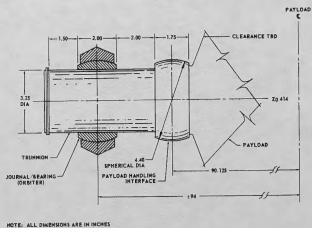


Figure 19.



NOTE: ALL DIMENSIONS ARE IN INCHES

Figure 21.

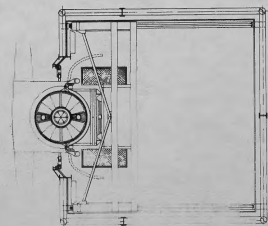


Figure 22.

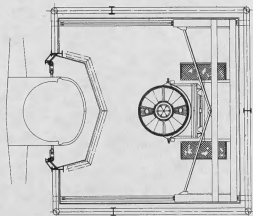


Figure 23.

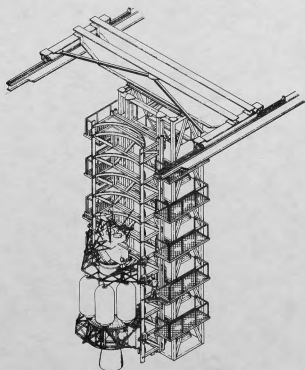


Figure 24.

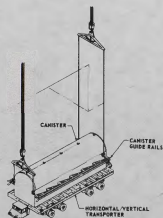


Figure 25.

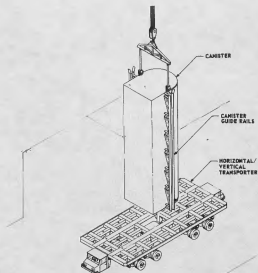


Figure 26.

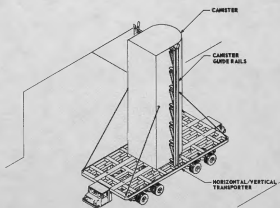


Figure 27.

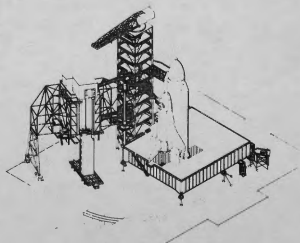


Figure 28.

Figure 29.

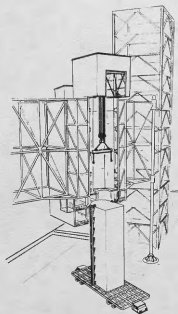


Figure 32.

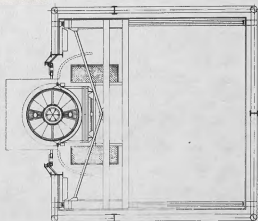


Figure 30.

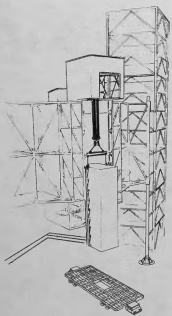


Figure 33.

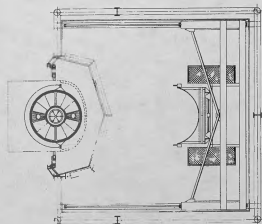


Figure 31.

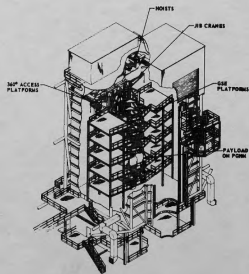
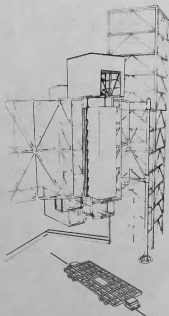


Figure 34.

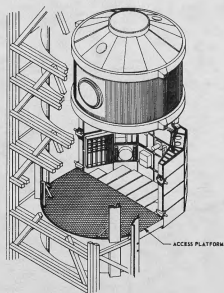


Figure 35.

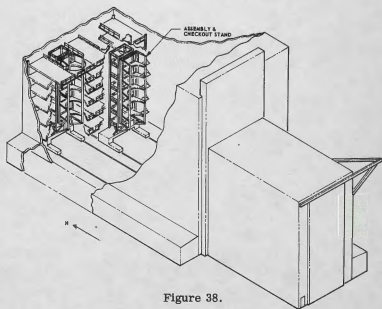


Figure 38.

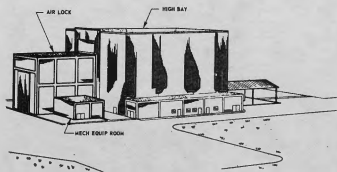


Figure 36.

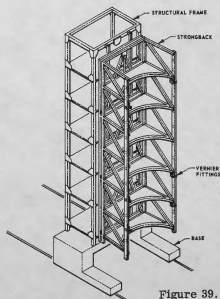


Figure 39.

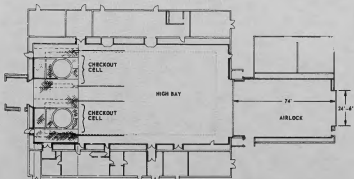


Figure 37.

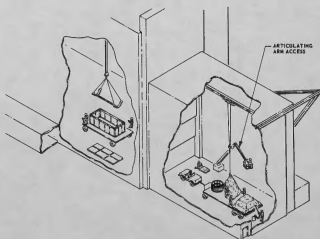


Figure 40.

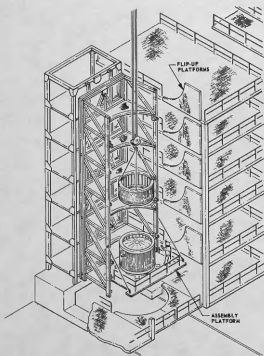


Figure 41.

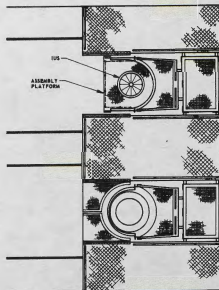


Figure 43.

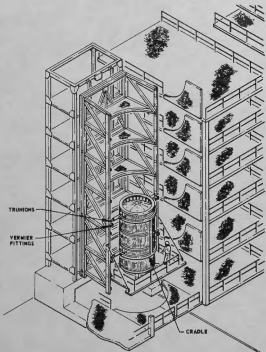


Figure 42.

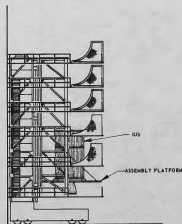


Figure 44.

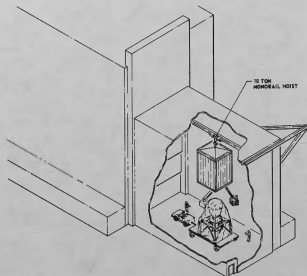


Figure 45.



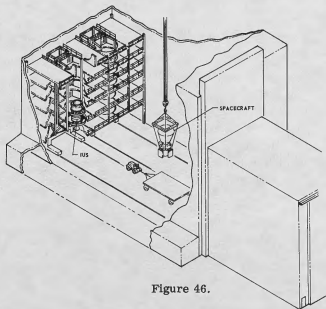


Figure 46.

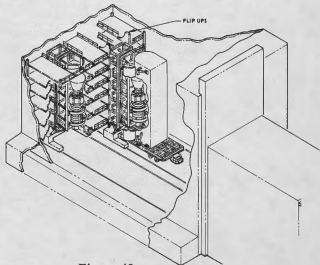


Figure 49.

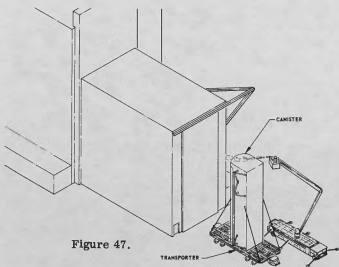


Figure 47.

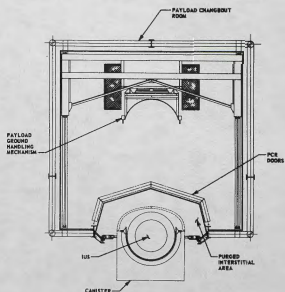


Figure 50.

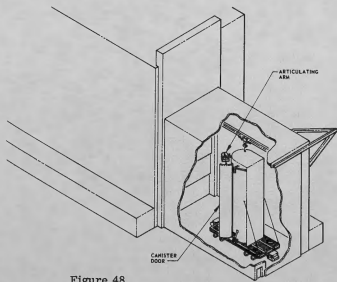


Figure 48.

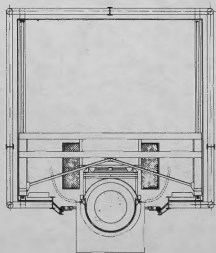


Figure 51.

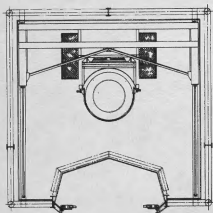


Figure 52.

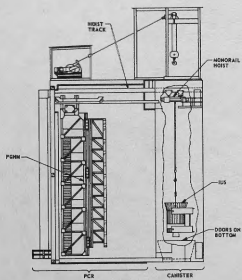


Figure 53.

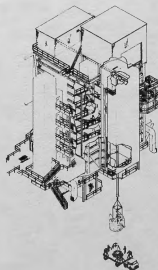


Figure 55.

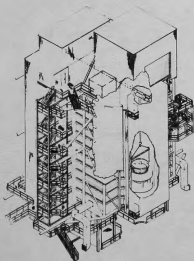


Figure 54.

