Space Shuttle Cargo Processing at the Kennedy Space Center

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ABSTRACT

This paper will discuss the various activities involved in processing the two basic types of cargo being prepared for launch by the Space Transportation System. An overview will be presented describing the independent processing systems used to ready the Spacelabs and other horizontal cargo as well as upper stages and other vertical cargo. The interrelationship of these two types of preparations with the main line Space Shuttle test and checkout operations will be shown.

In the explanation of each process, the ground support equipment and facilities of the Kennedy Space Center will also be described.

INTRODUCTION

The planned rate of up to 40 Space Shuttle missions per year will have a major impact on cargo processing at the Kennedy Space Center. The high launch rate is predicated on a turnaround time of two weeks on the ground for each orbiter vehicle, a factor that requires a matching payload processing capability that is both efficient and economical.

Spacecraft checkout is traditionally a slow, methodical and cautious process. Experience has shown that the developer/builder team that produces a given spacecraft can prepare it for launch better than anyone else. Such teams now accompany each spacecraft to Kennedy and participate in the launch. We plan to enlarge and expand on this proven technique to handle the greatly increased workload expected at Kennedy over the next decade.

Payloads to be launched from Kennedy are divided into two basic types, horizontally integrated and vertically integrated. Both are processed off-line from the Shuttle vehicle flow. Figures 1 thru 4 show the standard flow of both horizontally and vertically integrated payloads and a pictorial overview of KSC and Cape facilities.

CARGO INTEGRATION

Personnel at the Kennedy Space Center will prepare an integrated ground operations flow for each Shuttle flight. The integration planning will determine whether the payload will be installed in the Orbiter at the Orbiter Processing Facility (OPF) or at the launch pad. One consideration in making this determination is the type of hazardous operations to be performed. Certain hazardous operations cannot be performed in the OPF, consequently, some payloads must be installed at the launch pad.

In order to obtain the shortest Shuttle turnaround flow, KSC will perform simulated Orbiter-to-cargo interface verification of the entire cargo prior to installation into the Orbiter. Cargo Interface Verification will be conducted in one of two facilities -- the Operations and Checkout (O&C) Building or the Vertical Processing Facility (VPF).

Payloads which are to be integrated vertically in the VPF are normally installed at the launch pad. Payloads which are to be integrated horizontally in the O&C Building will normally be installed in the OPF.

HORIZONTAL CARGO FLOW

Horizontally integrated payloads will be received, assembled, and checked out in the O&C Building. Upon arrival of the payload, KSC provides support for movement of the payload from its arrival point to the O&C Building for processing (Figure 5).

Our prime payloads for horizontal integration are Spacelab payloads. The Spacelab train of pallets and racks are assembled in the O&C Building (Figure 6 & 7). Following build-up of the payload train, the Spacelab elements will be transferred to the Spacelab Integration Test Stand for integration with the Spacelab Module or Igloo. Spacelab systems testing is then conducted and the Spacelab moved to the horizontal Cargo Integration Test Equipmtnt (CITE) stand (Figure 8). The simulated Orbiter-to-cargo interface testing is then conducted.

The Spacelab, along with other payloads, is then installed into the environmentally controlled payload canister and transported to the OPF and installed into the Orbiter cargo bay (Figure 9). Tests are completed in the OPF, and the Orbiter, containing its cargo, is towed to the Vehicle Assembly Building, mated with the Space Shuttle External Tank on the Mobile Launch Platform, and readied for its trip to the pad.

Upon completion of mating and interface verification with the Mobile Launch Platform, the stacked vehicle is rolled out on the crawler transporter to the launch pad.

After the launch platform has been installed at the pad, interface verification tests are run to verify integrity and serviceability of the payload/Shuttle system interfaces. Access to payloads at the launch pad is not currently planned. However, the capability to open the payload doors and access the payload exists.

VERTICAL CARGO FLOW

For vertical payloads, existing Payload Processing Facilities on Cape Canaveral and Kennedy will be used. Some of these can process two spacecraft simultaneously. Most of these facilities are currently used as spacecraft checkout areas for unmanned launches.

On a maximum schedule of 40 launches per year, the non-Spacelab launches alone will require the processing of over 50 major spacecraft, plus a number of smaller ones. The assembly, checkout, and launch of this many spacecraft within a year has not previously been attempted by NASA.

Most vertical payloads are automated spacecraft, designed to operate in higher orbits than the Orbiter can reach. A typical payload will consist of two spacecraft, each with an attached solid propellant upper stage and a built-in apogee kick-motor. The Orbiter might also carry one or two small "payloads of opportunity" if the upper weight limit permits this.

A typical automated spacecraft will arrive at Kennedy and be met by its developer/builder team, already on site (Figure 10). The team moves it to a Processing Facility and begins assembly and checkout operations. The time involved can vary from 30 days for a simple communications satellite to four months for a complex interplanetary explorer. The facility selected is dedicated to that particular spacecraft until after its processing is completed.

When the spacecraft is ready, the test and checkout team takes it to one of two Explosive Safe Areas, ESA 60 or the Delta Spin Test Facility (Figure 11). The explosives, pyrotechnics, and certain volatile propellants are added here. Upper stages of the Delta class (SSUS-D) are also attached in Delta Spin Test, and the assembly is spin-tested for balance. Upper stages of the Atlas/Centaur (SSUS-A) or Inertial Upper Stage (IUS)--both of which are larger--are mated with the spacecraft in the Vertical Processing Facility.

From Delta Spin Test or ESA 60 a spacecraft moves to the Vertical Processing Facility at Kennedy (Figure 12). Those with an upper stage already attached go directly into one of the two workstands in this building. Those that are to be mated with an Atlas/Centaur upper stage are attached to it in the high bay prior to installation in a workstand. A spacecraft that is to be mated with an Inertial Upper Stage will find it already installed in the workstand (Figure 13). The spacecraft is attached on arrival.

Each of the two workstands can support an entire Shuttle cargo, and designated integrated payloads are assembled in one. The complete cargo--two or more spacecraft, attached upper stages, and any in-flight support equipment--is then checked for mechanical fit and electrical compatibility with the Shuttle cargo bay. The integrated payload is then loaded into the Payload Canister (Figures 14 and 15).

The Payload Canister is taken directly to the pad by a specially designed transporter (Figure 16). There is becomes part of the on-line Shuttle processing flow, though it normally arrives ahead of the Shuttle. With the Rotating Service Structure in the retracted position, the Canister is positioned below the spacecraft handling room. The Canister is then hoisted to the door, the room seals are inflated, both sets of doors are opened, and the payload is removed. After the doors are closed again the Canister is lowered back to its transporter. Figure 17 depicts this activity.

The RSS rotates on its track until the room doors contact the Orbiter Cargo Bay, and the seals again provide environmental protection. The payload is transferred into the Orbiter and attached for launch (Figure 18).

CONCLUSION

The Kennedy Space Center approach requires the developer/builder field teams, working with their own mission-unique ground support equipment, to be responsible for the first and most lengthy steps of payload processing. It provides for the off-line assembly and checkout of up to eight vertical and two horizontal spacecraft simultaneously. This plan should ensure an efficient, minimum-cost payload processing operation that will equal the efficiency of the automated Space Shuttle ground turnaround operation.

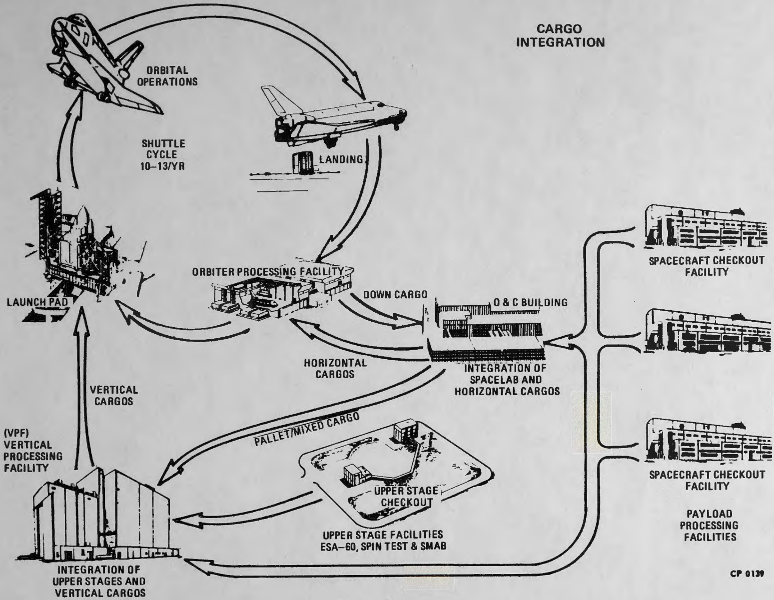
CARGO
INTEGRATION
ORBITAL
OPERATIONS
SHUTTLE
CYCLE
10–13/YR
LANDING
LAUNCH PAD
ORBITER PROCESSING FACILITY
DOWN CARGO
O & C BUILDING
HORIZONTAL
CARGOS
INTEGRATION OF
SPACELAB AND
HORIZONTAL CARGOS
SPACECRAFT CHECKOUT
FACILITY
SPACECRAFT CHECKOUT
FACILITY
PAYLOAD
PROCESSING
FACILITIES
VERTICAL
CARGOS
(VPF)
VERTICAL
PROCESSING
FACILITY
PALLET/MIXED CARGO
UPPER STAGE
CHECKOUT
UPPER STAGE FACILITIES
ESA–60, SPIN TEST & SMAB
INTEGRATION OF
UPPER STAGES AND
VERTICAL CARGOS
CP 0139

Figure 1.

SHUTTLE AUTOMATED PAYLOAD PROCESSING FACILITIES

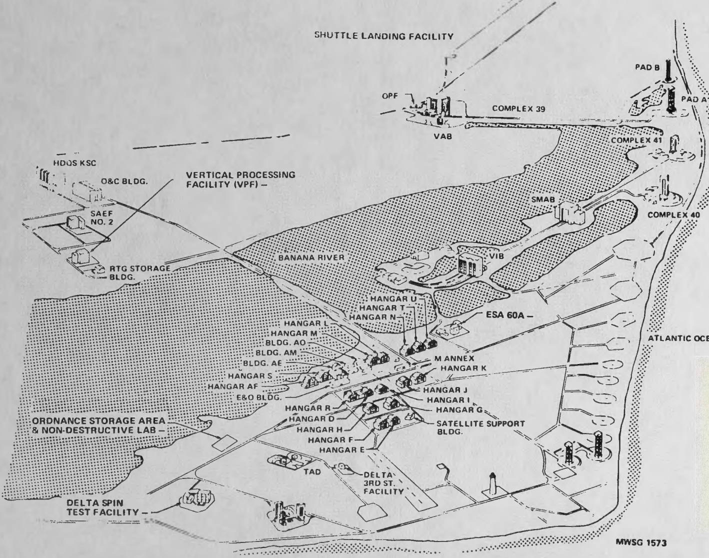

Figure 2.

Figure 3. Cape Industrial Area.

Figure 4. KSC Industrial Area

KSC CARGO PROJECTS	HORIZONTAL CARGO FLOW	J. J. NEILON

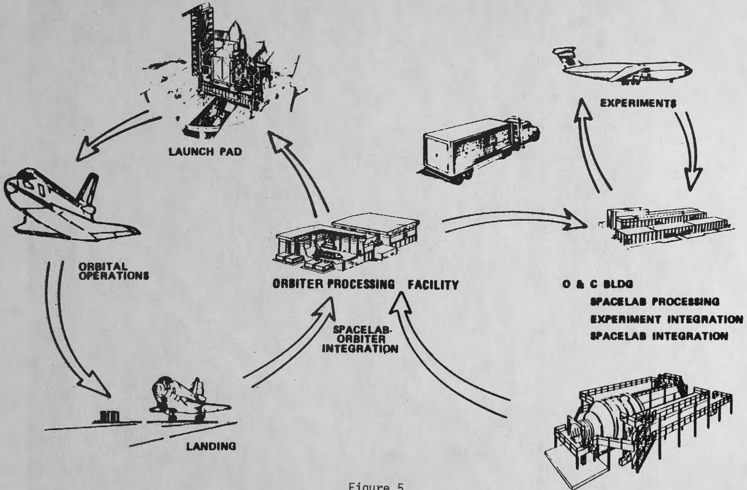

Figure 5

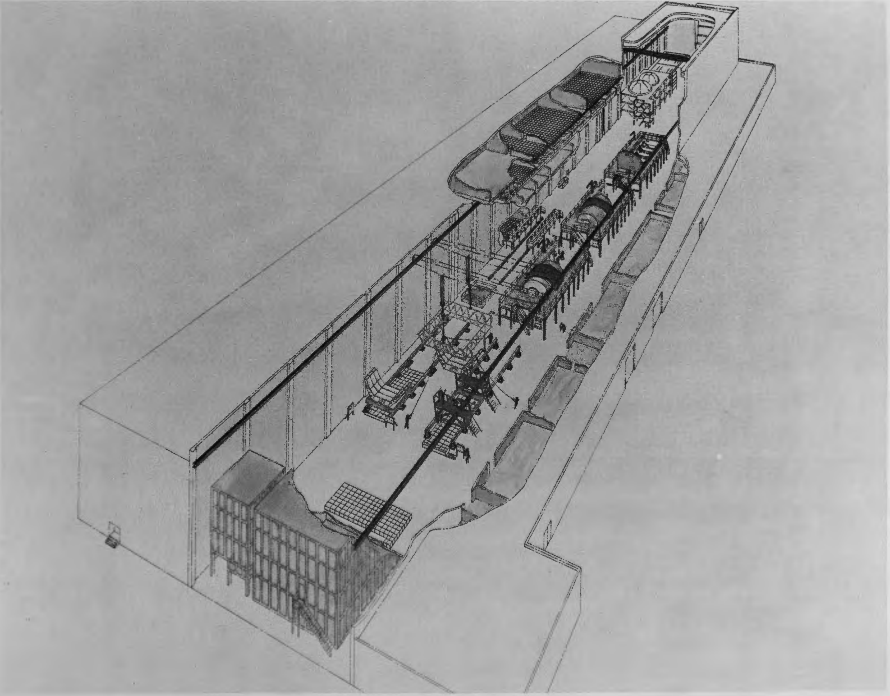

Figure 6. Artist Concept of O&C Workstands.

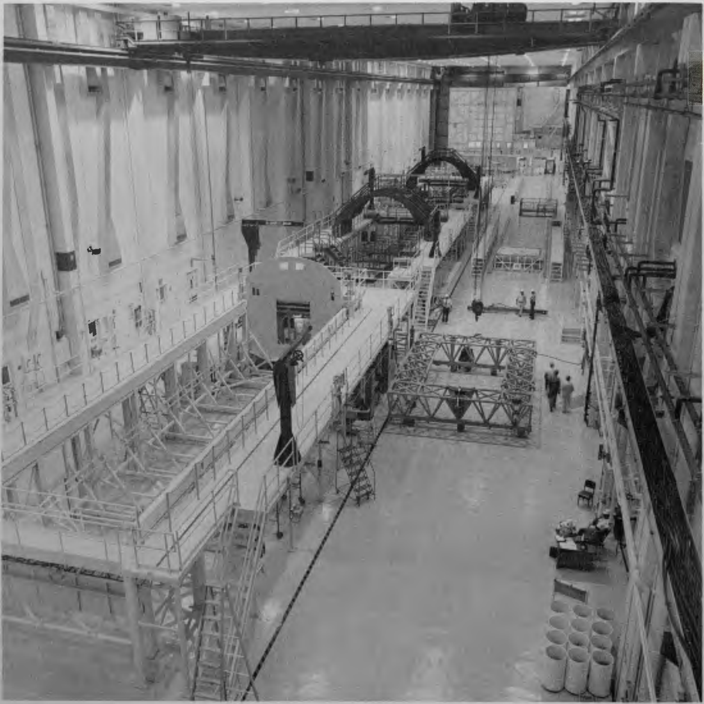

Figure 7. Operations & Checkout Building Highbay Interior

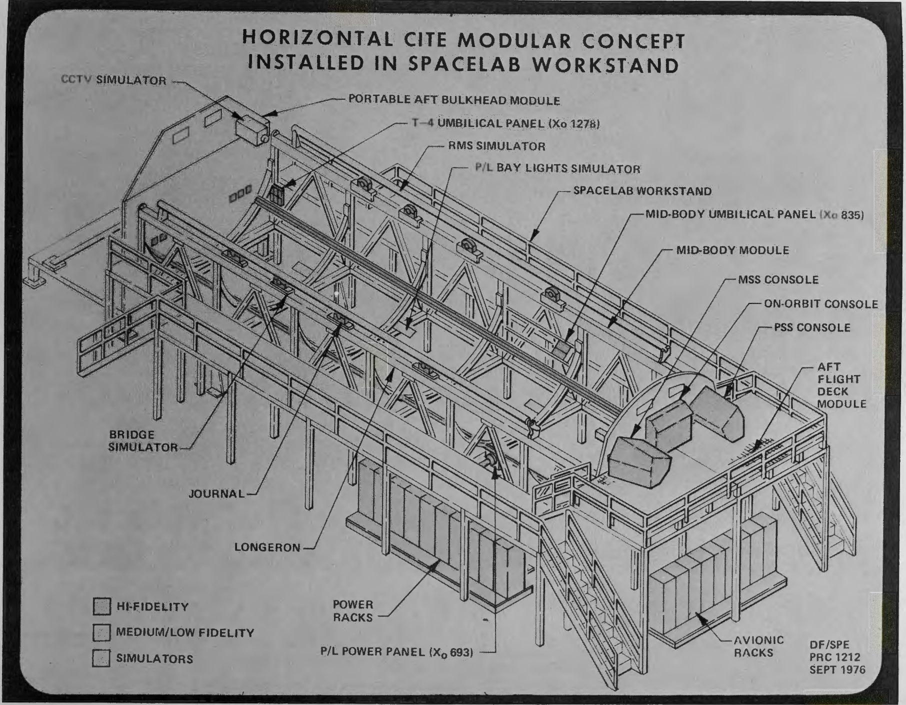
HORIZONTAL CITE MODULAR CONCEPT
INSTALLED IN SPACELAB WORKSTAND
CCTV SIMULATOR
PORTABLE AFT BULKHEAD MODULE
T–4 UMBILICAL PANEL (Xo 1278)
RMS SIMULATOR
P/L BAY LIGHTS SIMULATOR
SPACELAB WORKSTAND
MID-BODY UMBILICAL PANEL (Xo 835)
MID-BODY MODULE
MSS CONSOLE
ON-ORBIT CONSOLE
PSS CONSOLE
AFT FLIGHT DECK MODULE
BRIDGE SIMULATOR
JOURNAL
LONGERON
POWER RACKS
P/L POWER PANEL (X_o 693)
AVIONIC RACKS
HI-FIDELITY
MEDIUM/LOW FIDELITY
SIMULATORS
DF/SPE
PRC 1212
SEPT 1976

Figure 8.

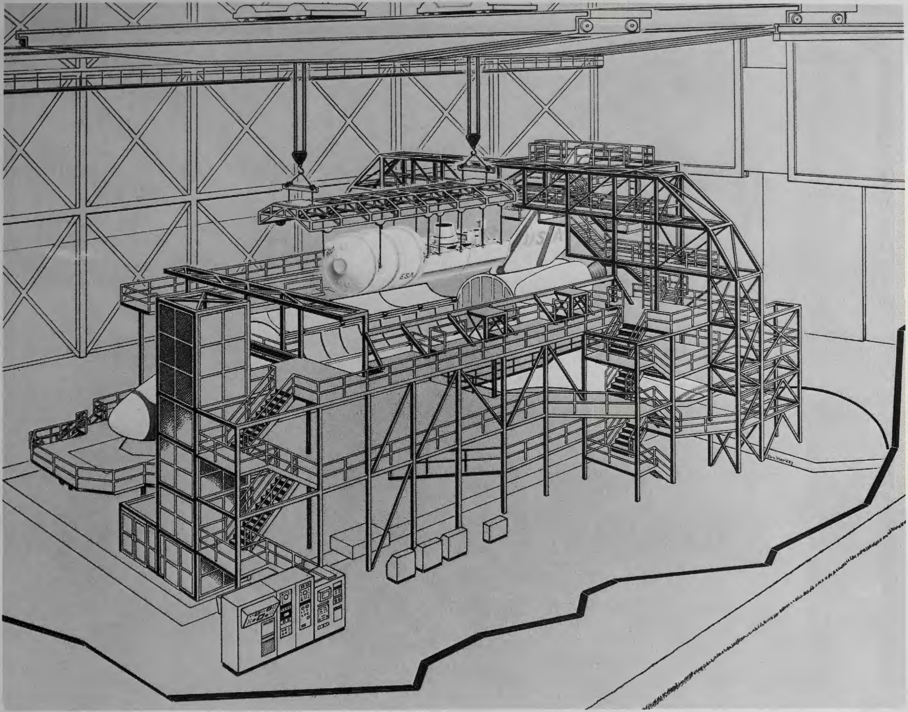

Figure 9. Artist Concept of Spacelab Insertion into Orbiter at OPF.

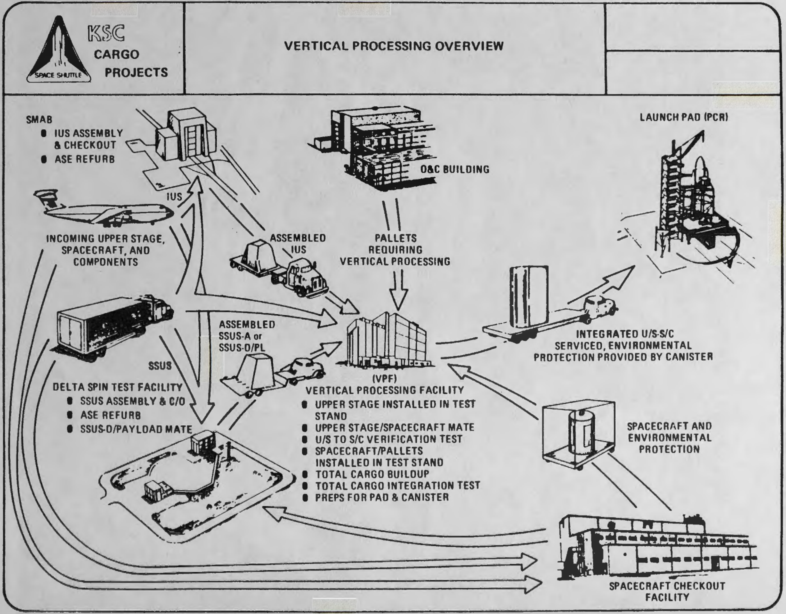

Figure 10

CP 0108

Figure 11. Solid Motor Assembly Building.

Figure 12. Vertical Processing Facility.

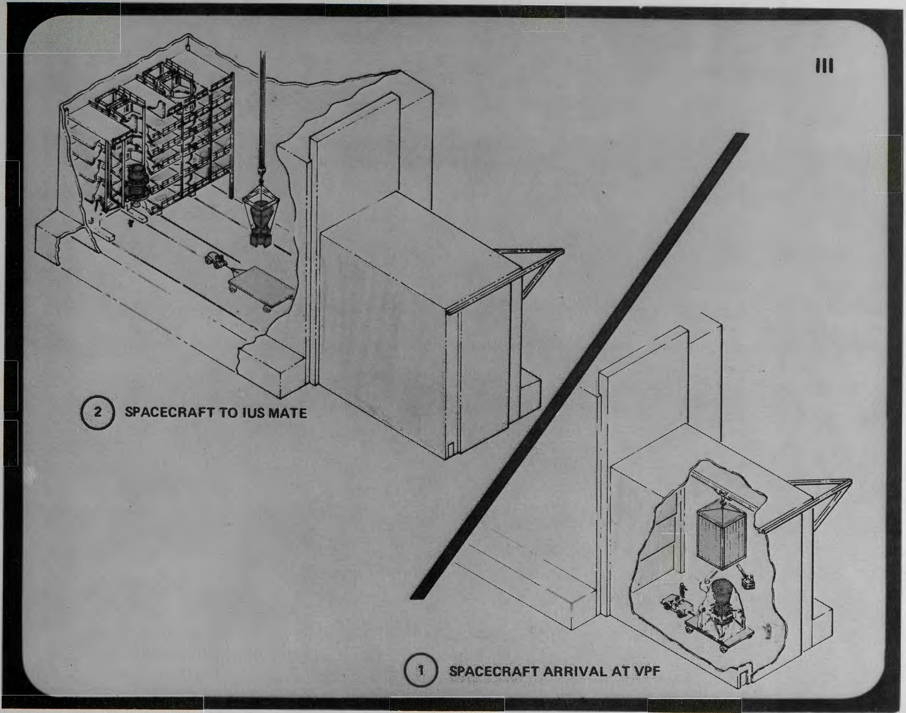

Figure 13. Artist Concept of VPF Activity.

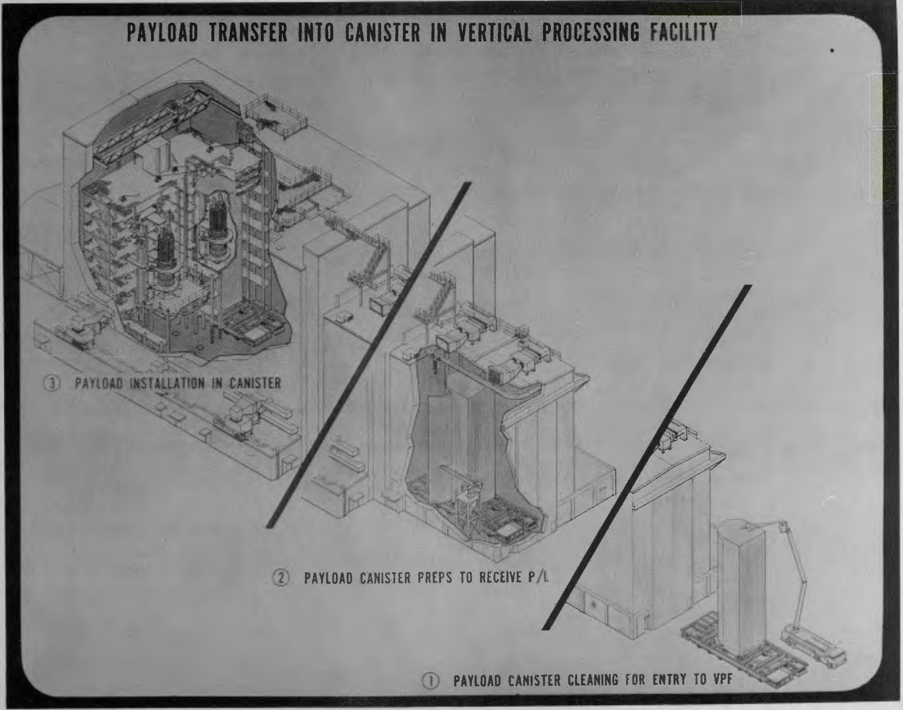
PAYLOAD TRANSFER INTO CANISTER IN VERTICAL PROCESSING FACILITY
③ PAYLOAD INSTALLATION IN CANISTER
② PAYLOAD CANISTER PREPS TO RECEIVE P/L
① PAYLOAD CANISTER CLEANING FOR ENTRY TO VPF

Figure 14

Figure 15. Payload Canister.

Figure 16. Payload Canister Transporter.

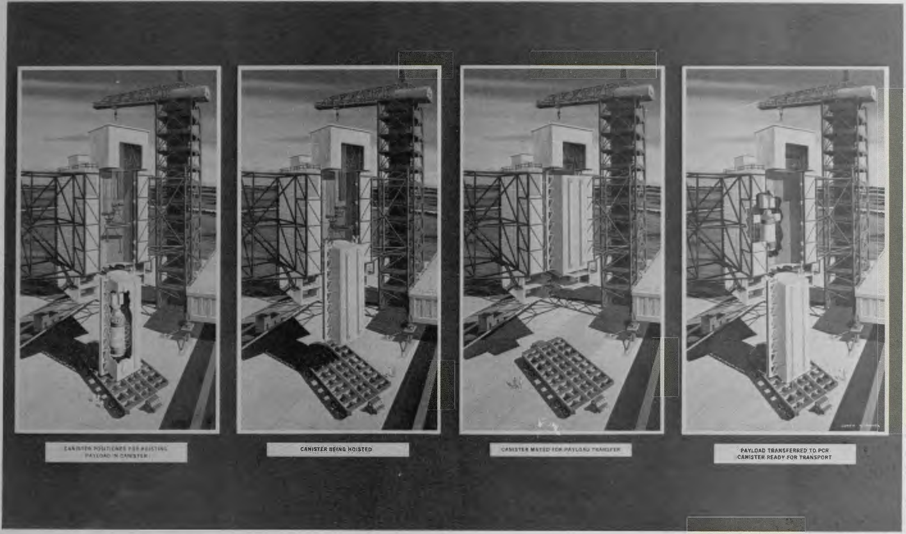

Figure 17. Artist Concept of Payload Transfer from Canister to Rotating Service Structure at Launch Pad.

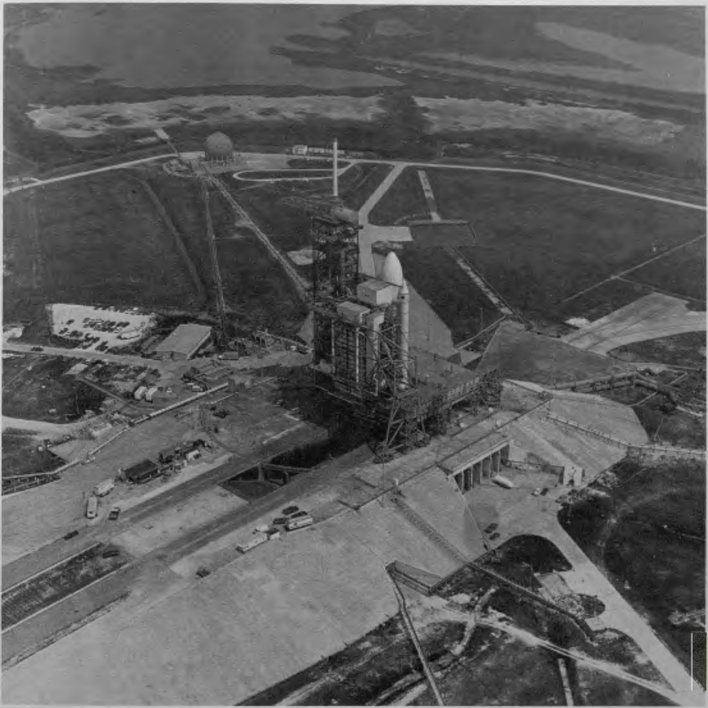

Figure 18. Rotating Service Structure in Access Position.