HITCHHIKER CAPABILITIES

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OVERVIEW:

A new carrier system has been developed for economical and quick response flight of small attached payloads on the Space Shuttle. Hitchhiker can accommodate up to 750 lb. of customer payloads in canisters or mounted to an exposed side-mount plate or up to 1200 lb. mounted on a cross-bay structure. The carrier connects to the orbiter's electrical systems and provides up to six customers with standard electrical services including power, real time telemetry, and commands. A "transparent" data and command system concept is employed to allow the customer to easily use his own ground support equipment and personnel to control his payload during integration and flight operations. The first Hitchhiker was successfully flown in January 1986 on STS 61C.

Hitchhiker is an extension of the Space Transportation System (STS) capabilities, is operated by the NASA Office of Space Flight Carrier Systems Division, and is available to any STS customer. The Hitchhiker approach has been specifically designed to be user friendly, reduce the time and effort required of space flight customers, and make most efficient use of STS payload capacity.

HITCHHIKER PROGRAM

The Hitchhiker Program was initiated in early 1984 by the NASA Office of Space Flight with the objectives of providing a quick reaction and low cost capability for flying small payloads that required more services than Get Away Special (GAS) experiments but did not require the extensive, custom, services of a Spacelab. The Hitchhikers will be flown under the NASA STS secondary payload program. Two versions of Hitchhiker were selected: Hitchhiker-G, developed by Goddard Space Flight Center (GSFC), can carry up to six customer payloads weighing a total of up to 750 lbs. mounted on the side of the payload bay; Hitchhiker-M, developed by Marshall Space Flight Center (MSFC), was combined with the GSFC Project at Goddard in 1987. HH-M will have electrical interfaces and services identical to HH-G and will carry up to 1200 lb. of customer equipment mounted on a cross-bay bridge type structure.

Hitchhiker payloads may be accommodated in the Shuttle under either the STS Small Payload Accommodations (SPA) policy or under the Standard Mixed Cargo (SMC) policy. The SPA policy has restrictions regarding crew activity, power, harness arrangement, payload bay location, etc. intended to simplify Shuttle integration and analysis and so has shorter lead time requirements and increased manifesting flexibility. Payloads on Hitchhiker carriers flying under the SMC policy may use almost any STS interface, resource, or activity available to any other STS secondary payload at the expense of increased lead time and reduced manifesting flexibility. Hitchhiker payloads are manifested and processed under a name and acronym assigned by the customer.

Hitchhikers are nominally carried in "bays" 2 and 3 near the forward end of the payload bay. Hitchhiker-G is side mounted on the starboard side to avoid interference from the RMS which is normally carried on the port side. In order to meet the requirement for quick reaction Hitchhiker is designed with standard pre-defined electrical interfaces and also has special transparent data system features to reduce the time required to perform electrical integration and checkout of the customer hardware on the carrier. Mechanical interfaces are also simple and consist of a flat vertical plate with a 70 mm. grid hole pattern or a canister similar to GAS with or without a motorized door on HH-G and standard mounting rails on HH-M.

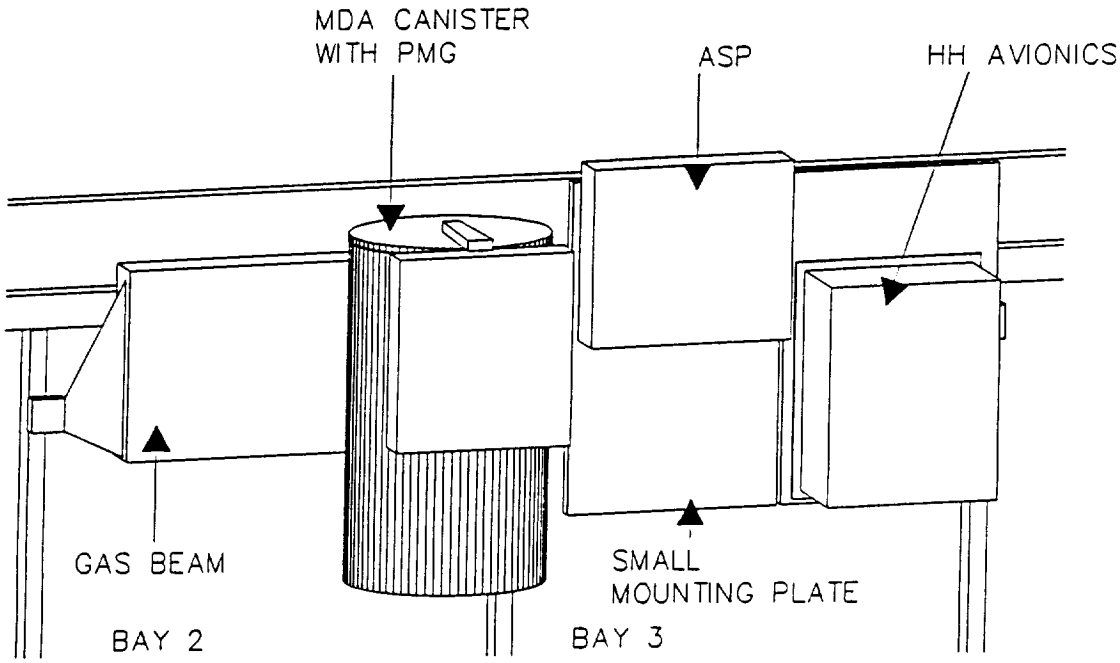
Hitchhikers are considered secondary payloads and may not interfere with primary payload requirements on the same mission. Unique crew activity and attitude (pointing) requirements of a limited nature (Eg. several hours) can usually be accommodated on a SPA payload. Allowable activities on SMC payloads are negotiable.

SHUTTLE PAYLOAD OF OPPORTUNITY CARRIER (SPOC)

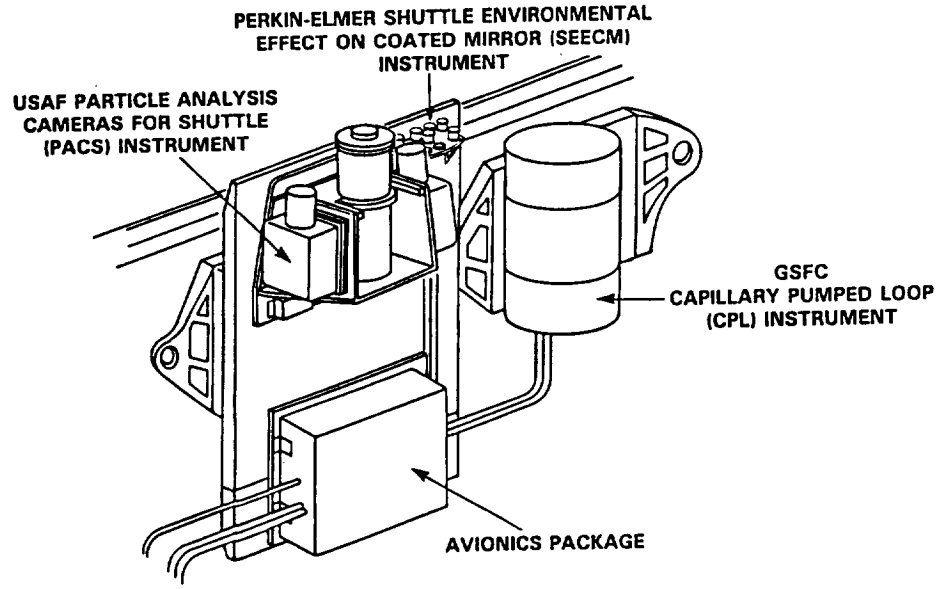
The Hitchhiker-G was implemented using the Shuttle Payload of Opportunity Carrier (SPOC). The SPOC system is designed to be modular and expandable in accordance with payload requirements to allow maximum efficiency in utilizing orbiter resources and thereby increase the potential for early manifesting on the Shuttle. A typical Hitchhiker-G configuration is shown in Figure 1.

FIGURE 1

HITCHHIKER–G2 (ASP/PMG) CONFIGURATION



HITCHHIKER-G MISSION ONE



The SPOC system consists of the following elements:

The avionics unit provides standard electrical interfaces for up to six customer payloads. It contains a microprocessor control unit, relay switching equipment, medium-rate multiplexer, and other hardware necessary to interface with the customer hardware and orbiter. A switch panel in the cabin allows the crew to activate and de-activate the payload and provides an independent command path to control inhibits to any hazardous functions. Under SMC policy a crew keyboard/display unit may also be used.

The SPOC plate provides a 50 by 60 inch mounting surface for the avionics and customer hardware. The plate accepts 3/8 inch bolts on 70 mm. centers and is equipped with heaters, thermostats and thermistors for maintaining and measuring thermal control of the plate and mounted hardware as well as thermal blankets and surfaces for the back and unused portions of the front of the plate. Plate mounted customer hardware may need additional customer provided blankets, heaters, or other thermal control provisions. A smaller and lighter 25 by 39 inch plate may also be used to mount customer hardware or to mount the avionics unit. All Hitchhiker-G equipment attaches to the orbiter longeron and frame structure via three large bolts and the "GAS beam" attachment fitting. In unusual cases customer hardware may be attached directly to the attachment beam.

The SPOC motorized door canister has mechanical interfaces nearly identical to a GAS canister and can accommodate a customer payload of up to 170 lbs., 19.75 inches in diameter and 28 inches deep. A sealed canister (no door) can also be chosen and can accommodate 200 lbs. of payload in an atmosphere of nitrogen or air. The canisters may be insulated or uninsulated depending on the customer's heat rejection requirements. An uninsulated canister can reject several hundred watts of heat (steady state) under typical conditions and is normally used where the customer requires high power dissipation. Even higher dissipation is possible over short periods (hours) separated by cool-down intervals. The customer's payload must contain heaters and thermostats to maintain the desired temperature.

The standard electrical interface or "port" consists of a signal cable and a separate power cable which provide the following:

- o Two 28 V (+/- 4 V) 10 Amp. power lines which can be turned on (together) by ground command. Customer power and energy are monitored by the carrier system. The maximum simultaneous total customer power for a Hitchhiker is 1300 W and the nominal maximum total customer energy is about 4 Kwh/ day with additional energy negotiable (SPA policy). Under SMC policy customer power and energy are 1600 W and about 10 Kwh/day.

- o Four 28V bi-level or pulse commands (10 ma max) which can be used with relay drivers and relays to control additional power switching within a payload. (For canister payloads one command is reserved for control of the door.)

- o An asynchronous 1200 baud uplink command channel.

- o An asynchronous 1200 baud low-rate downlink data channel. This data is available over Ku-band service or S-band service and can also be recorded on the orbiter's tape recorder.

o A medium-rate downlink channel 1-1400 KB/s for use with the real-time-only Ku-band TDRS service. The total simultaneous customer data rate for the Hitchhiker cannot exceed 1400 KB/s.

o IRIG-B serial time code and a one pulse per minute square wave signal which can be complemented by a time command via the above asynchronous uplink channel.

o Three channels for temperature sensors to allow measurement of payload temperatures even when the payload power is off (for canister payloads these channels are reserved for door position, canister pressure, and temperature).

o An analog channel, 0-5V, 8 bit quantizing, 10 hertz sample rate. An index pulse is also supplied which can be used to advance a user supplied analog multiplexer to allow measuring a large number of parameters.

In order to provide low cost, quick reaction, and increased autonomy for the customer, SPOC has been implemented with a transparent data system concept (fig. 3). The Customer provided Ground Support Equipment (CGSE), associated software, and personnel can be used to generate commands to the customer's payload and display data from the payload during payload to carrier integration and verification testing and also during flight operations. The asynchronous data and command interfaces, and medium-rate data interface are transparent in that the interface between the customer's flight hardware and the carrier is identical in electrical characteristics and protocols to the corresponding interface between the SPOC GSE and the CGSE thus the GSE the customer used during development of his instrument may be used without modification during carrier integration and flight. The remaining interfaces (bi-level commands, analog channel, etc.) can also be connected but require conversion to asynchronous format at the CGSE. If desired the CGSE can also be provided with orbiter attitude and position data. These interfaces operate in real-time with transmission delays of 5-15 seconds during flight. Simpler experiments with minimal command and data display requirements can be accommodated without customer delivered GSE. All of the data is available on computer compatible (9 track) magnetic tape within one month after the flight.

The Hitchhiker-M carrier has mounting rails for customer hardware in three places on each side (27.9 x 28.2 inches) and three positions (36.0 x 28.2 inches) on the top.

HITCHHIKER MANIFESTING SCENARIO

Prospective Hitchhiker customers first discuss their requirements with the Goddard Project Office to determine feasibility and compatibility with Hitchhiker capabilities. They then submit a Customer Payload Requirements (CPR) document to GSFC and a Request for Flight (NASA form 1628) through the appropriate NASA Headquarters discipline office. Under the NASA STS secondary payload policy adopted in 1987 each discipline office has been assigned a percentage of the available secondary payload weight available on the Shuttle (Virtually all payloads under 8000 lb. are considered

secondary payloads). Each office prepares a list of its secondary payloads in priority order. In the case of Hitchhiker payloads the "chargeable weight" of the payload will include the weight of the necessary carrier equipment. The STS manifesting office creates the manifest using an algorithm and the discipline priority lists. There are two separate reimbursable categories under which foreign and domestic customers can purchase space on Hitchhiker. Costs for this service are not firm but are expected to be the same as the standard mixed cargo pricing (currently about $2100/lb.) for customer and carrier equipment plus an integration charge. At present about 112,000 lb. of space has been identified for manifested secondary payloads through 1993. Approximately an additional 75,000 lb. of capacity is being held as contingency reserve. This contingency (if not required by the primary payloads) is released to use by secondary payloads and Get-Away-Special at specified intervals before the flight. Because short lead times are involved in using the contingency space it will be applied mainly to Get-Away-Specials and secondary payloads meeting the SPA policy.

As of May, 1988, the secondary payload discipline offices, and their allocation of secondary payload space (percent) are as follows:

Discipline	Percent
Science and Applications (E)	38
Commercialization (C)	31
Space Station (S)	10
Space Technology (R)	9
STS Technology (M)	5
Administrator (A)	3
Foreign Reimbursable (X)	3
Domestic Reimbursable (C)	1
DoD (under review)	0
Total	100

Since secondary payloads are manifested in space remaining after accommodation of the primary payloads, manifesting opportunities are extremely sensitive to payload weight. The weight of each payload (including carrier) is subtracted from the discipline office allocation as the payload is manifested. Approximate weights of various Hitchhiker carrier items (lbs.) are as follows:

Gas Beam attach fitting	170
50 x 60 inch plate	370
25 x 39 inch plate	55
Avionics unit	155
Motorized door canister	235
Sealed canister	160
Hitchhiker-M carrier (including avionics)	1800
HH-M attach fittings	400

At least 24 months (SMC payload) or 13 months (SPA payload) before flight the

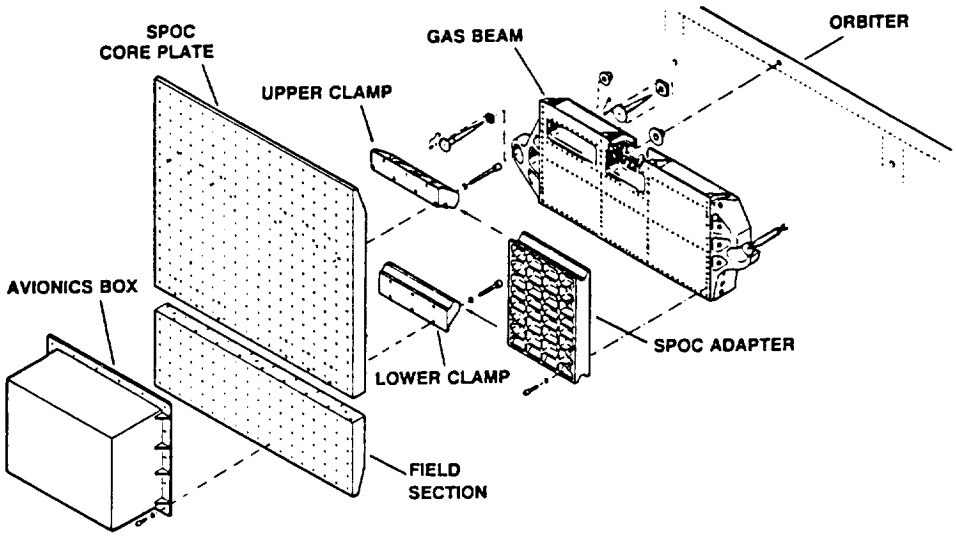


Fig. 2 SPOC PLATE

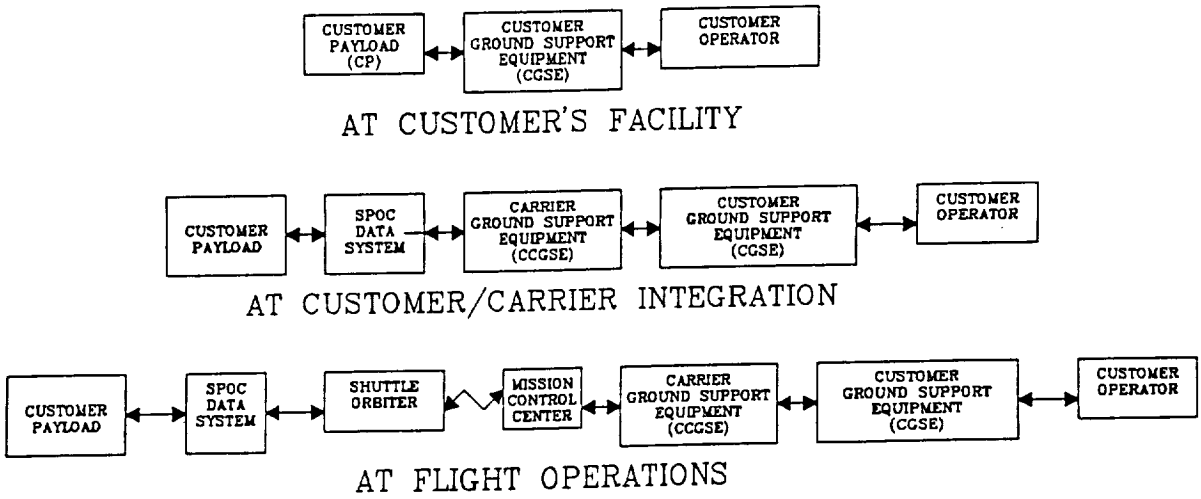


Fig. 3 SPOC TRANSPARENT DATA SYSTEM COMMUNICATIONS

customer delivers complete documentation on his payload to GSFC. The safety data package requirements are similar to GAS in the case of canister payloads but are somewhat more complex if the customer's equipment will be plate mounted. About 6 months before flight the customer's hardware is delivered to GSFC and with the help of the customer and his CGSE the payload is integrated to the carrier, and system functional tests and EMI tests are performed. Prior to delivery the customer is responsible for performing any necessary tests required for safety certification (such as static load tests) as well as any tests required by the customer to confirm proper operation (such as vacuum or vibration tests). Following tests at GSFC the integrated payload is shipped to Kennedy Space Center and integrated into the orbiter where only interface verification tests are performed. Launch occurs typically about 8 weeks after orbiter integration. During flight the Hitchhiker is operated from a control center at GSFC with participation of the customers and their CGSE. Displays of orbit position, attitude, ancillary data, and any downlink TV are provided along with access to crew voice transmissions. Following landing the Hitchhiker is removed and de-integrated and the customer hardware is returned to the customer at KSC or GSFC.

HITCHHIKER MISSIONS

The Hitchhiker-G1 payload (fig. 4) flew on STS 61C in January 1986. The customer payloads were: The USAF Particle Analysis Cameras for Shuttle (PACS) which was designed to make photographs of particle contamination in the vicinity of the orbiter; The NASA/GSFC Capillary Pump Loop (CPL) experiment which determined the zero-gravity performance of a proposed Space Station thermal system; and the NASA/Perkin Elmer Shuttle Environmental Effects on Coated Mirrors (SEECM) experiment which studied the effects of residual atmosphere on telescope mirror contamination. The PACS consisted of a stereo camera and flash assembly mounted on the upper portion of the plate. The CPL instrument was carried in a sealed canister and was connected to multiple power ports to allow over 1000 W of power to be used. The carrier operated nominally with over 800 commands being sent and over 120 hours of data obtained. Currently, six Hitchhiker-G and four Hitchhiker-M missions are manifested.

FUTURE ENHANCEMENTS UNDER STUDY

The following are enhancements which may be added to the SPOC system in the future depending on demand and feasibility:

- o An ejection mechanism to allow deployment of small probes or spacecraft from the canister. This would be similar to the existing GAS system except that power and electrical services could be obtained prior to launch via an umbilical connector. Spin-up capability is also being studied. Payloads up to 150 lbs. could be accommodated.

- o Capability for attaching Hitchhiker-G type accommodations (canisters, plates) to the Hitchhiker-M carrier.

- o A method for late installation of payloads into motorized door canisters on the launch pad to reduce the time-to-launch from 8 weeks to 2-3 days.

o A cooling system to extend the existing heat rejection capability.

o A larger canister.

o A longer canister.

o A probe bus for ejectable experiments is being considered. This bus would be ejected from a canister, contain batteries, data system, transmitter, and receiver and would carry a customer's instruments for a brief mission in the vicinity of the orbiter while communicating to an antenna and SPOC port on the attached carrier.

FURTHER INFORMATION

For further information about the Hitchhiker Program contact:

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or C. Prouty (301) 286-9090

Hitchhiker Program Office
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Washington, D.C. 20546

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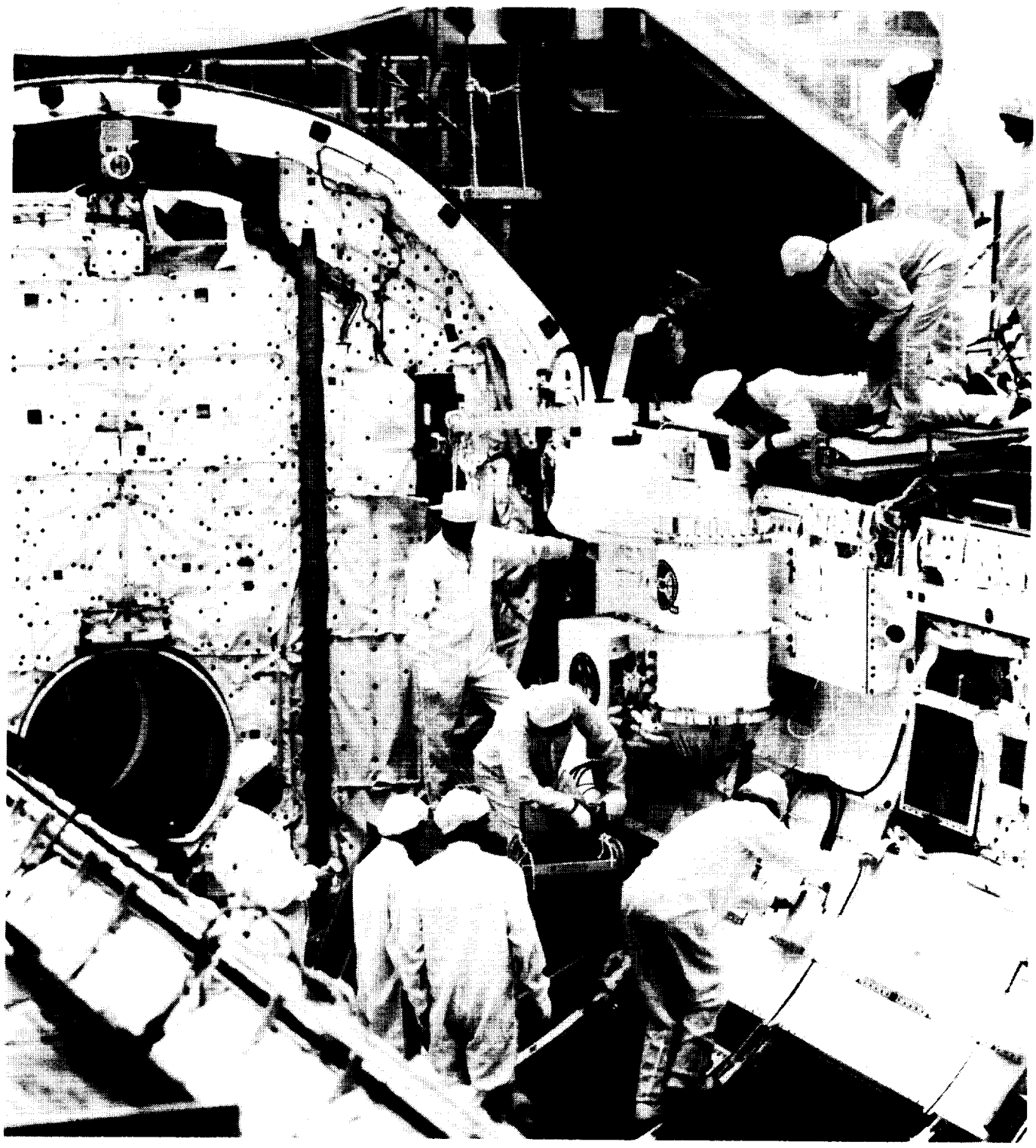
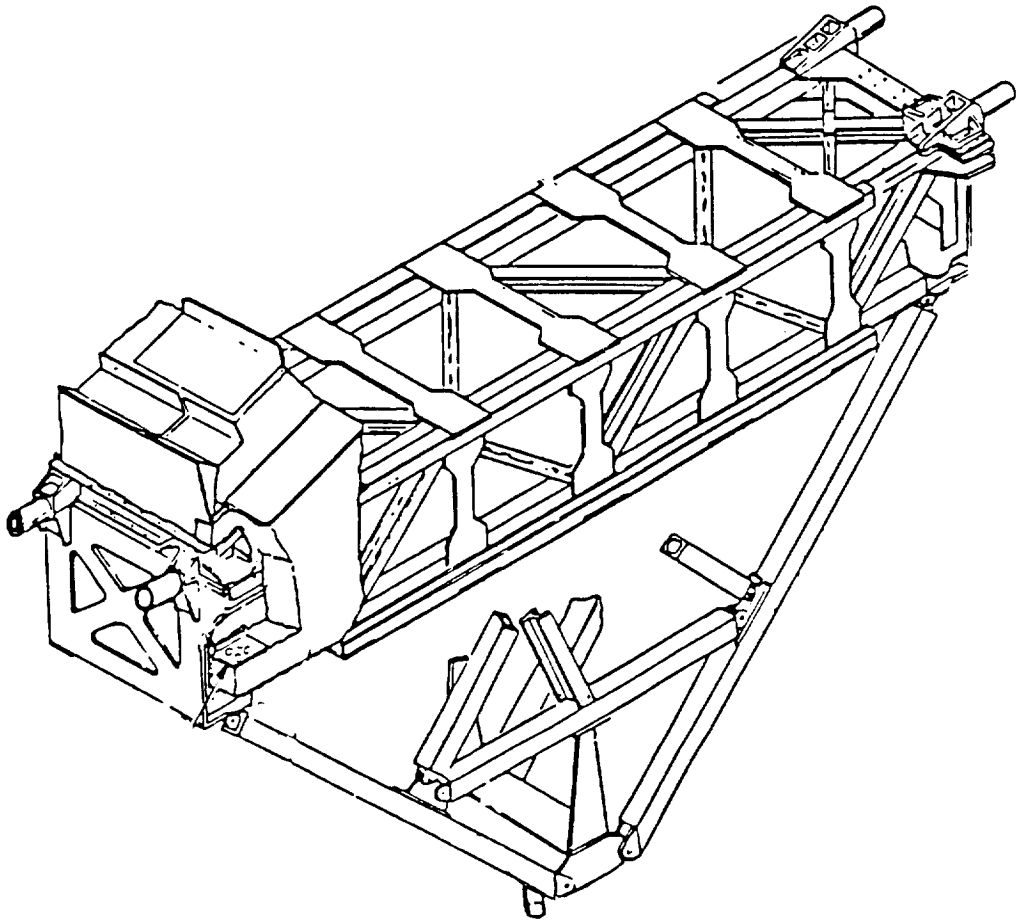


FIG. 4 HITCHHIKER-G1 PAYLOAD INSTALLED IN ORBITER COLUMBIA



HITCHHIKER-M CARRIER