1. INTRODUCTION

In 1984, the NASA Headquarters Office of Space Flight (OSF) established "Hitchhiker" (HH) projects at the Goddard Space Flight Center (GSFC) and Marshall Space Flight Center (MSFC) to develop and operate carrier systems for low-cost and quick-reaction accommodation of secondary payloads on the NASA Space Transportation System (STS). In 1987 all responsibility for HH activities was assigned to GSFC.

The HH carriers can carry payloads side mounted in the Shuttle payload bay (Hitchhiker-S) or mounted on a cross-bay "bridge" structure (Hitchhiker-C). Both carriers have the same electrical systems and provide the same electrical interfaces and services for customer equipment. Either carrier can accommodate equipment mounted in a standard canister or on a standard vertical mounting plate. The cross-bay version also has horizontal top mounting plates.

In 1993, development was begun for a reduced version of HH (Hitchhiker-JR) intended for Shuttle secondary payload customers familiar with the Get Away Special (GAS) carrier interfaces who do not need HH ground control capability. Hitchhiker-JR (HH-J) is planned for an initial flight in 1995 and provides canister mounting and electrical interfaces similar to GAS but with some electrical power and improved monitoring capability.

1.1 PURPOSE

This document defines available standard interfaces and services provided by the HH carrier systems, the Shuttle Small Payloads Project (SSPP), the Shuttle Program, and NASA to a HH payload customer as well as requirements to be met by the customer in areas such as interfaces, environmental capability, Electro-Magnetic Interference (EMI) control, and safety.

1.2 CUSTOMER PAYLOAD REQUIREMENTS (CPR) DOCUMENT

The customer shall prepare a CPR document (appendix E) which specifies all interface requirements and parameters. The CPR contains thermal, mechanical, electrical, attitude control, alignment, test and checkout, contamination control, mission operations, and shipping and handling requirements. It also includes customer-prepared interface drawings and schematics. The document defines which of the available carrier services and interfaces the customer needs and is requesting. Requirements over and above those noted here need specific authorization by

the HH Project Office. They shall be documented in the CPR document as deviations from standard interfaces and services.

1.3 HH PROJECT ORGANIZATION

The HH Program is managed by the Carrier System Division of the NASA Headquarters OSF and implemented by the GSFC HH Project Office which is part of the GSFC SSPP.

1.4 POINTS OF CONTACT

Key points of contact within the HH Program and Project Offices, as well as their telephone numbers follow.

HH Program Office

NASA Headquarters, Code MOB
Washington, DC 20546

Facsimile: (202) 358-2889

Program Office: (202) 358-4413

HH Project Office

Code 740.3
Goddard Space Flight Center
Greenbelt, MD 20771
(301) 286-8799

Facsimile: (301) 286-1694
E-MAIL: SSPP@SSPP.GSFC.NASA.GOV

Project Office: (301) 286-8799

Customer Support Office: (301) 286-6760

HH Reimbursable Payloads

NASA Headquarters, Code MOC

Washington, DC 20546

Program Office:	(202) 358-1849
Facsimile:	(202) 358-2803

1.5 HH PAYLOAD MANIFESTING

In 1987, NASA redefined Space Shuttle payload categories as follows. Primary payloads weigh more than 8,000 pounds each; their requirements may determine Shuttle mission parameters such as orbit altitude and inclination. Secondary payloads are accommodated in space remaining after manifesting the primary payloads; weighing less than 8,000 pounds each, their requirements can not determine major mission parameters. Secondary payloads such as HH will be manifested under a system to be described later. Tertiary payloads are accommodated in space remaining after manifesting primary and secondary payloads; these currently consist of GAS payloads already in the GAS queue.

Potential HH customers should submit a Request for Flight, Form 1628 (Figures 1.1, 1.1a, and 1.1b) through the appropriate Headquarters discipline office and arrange to be included in the office priority list. Department of Defense (DOD) HH customers should contact the United States Air Force/Space Systems Division Code CLP.

FIGURE 1.1

NASA FORM 1628

FIGURE 1.1a

NASA FORM 1628 (Cont'd)

FIGURE 1.1b

NASA FORM 1628 (Cont'd)

1.6 SPACE SHUTTLE HH ACCOMMODATIONS

HH payloads are accommodated on the Space Shuttle, which is operated by the NASA Headquarters Office of Space Flight. HH payloads are flown under the Space Shuttle Secondary Payload Program.

HH payloads can connect to one of the four Standard Mixed Cargo Harnesses (SMCH) in each Orbiter (normally used for cross-bay carriers) or to the Small Payload Accommodation (SPA) harness (normally used for side-mount carriers). The capabilities vary slightly as shown in Table 1.1.

Table 1.1

Small Payload Accommodations (SPA) and
Standard Mixed Cargo (SMC) Payload Classes

	Small Payload	Standard Mixed
Orbiter Electrical Harness	SPA	SMCH
Total Payload Power (28VDC)*	1.4kw	1.75kw
Nominal Total Energy (Kwh/day)*	6	12.5
Crew Control Panel Switch	SPA Switch Panel	Standard Panel
Payload Bay Locations	2-8, 12, 13	2-12

* Includes Carrier Requirements of 75-125 W (1.8 - 3.0 Kwh/day)

HH carriers are designed to interface with either the SPA harness or the SMCH. Each Orbiter has a single SPA harness to service a payload in bay positions two or three. A SPA Switch Panel (SPASP) in Aft Flight Deck (AFD) position A6 provides for crew control of a SPA payload. Each Orbiter also has four SMCH cable sets which can be connected to payloads anywhere in the payload bay. Each SMC payload will be connected to one-half of a Standard Switch Panel (SSP). SPA power is obtained through a tap on one of the SMCH power lines and is restrained by the requirements of any SMC payload connected to that line.

HH-C payloads are equipped with electrical connectors on either end of the bridge for connection to either a SPA or SMCH harness.

1.7 TRANSPORTATION AND INTEGRATION COSTS

HH is considered an extension of the basic Space Shuttle services. It is provided at no cost to NASA organizations (non-reimbursable organizations) for standard transportation and integration services. The standard HH integration service covers HH Project costs for a payload requiring no optional services or hardware. Additional integration costs are billed to the customer organization.

Reimbursable customers provide NASA with funds to cover transportation costs as well as standard and optional HH integration costs.

The OSF (Code MOC) has developed a preliminary policy for reimbursable HH payloads as follows:

The standard HH mounting "slot" accommodates any payload equipment which can be mounted in a canister or on a 25-inch mounting plate and attached to a HH side-mount or cross-bay carrier. The current charge factor per slot for customer payloads wishing to purchase space on a HH carrier on a shared basis is .0078. The FY1990 price for an entire shuttle payload is $142M. The charge per HH slot is therefore .0078 x $142M or $1.108M. This charge covers shuttle transportation costs and standard GSFC integration services as defined in this document for a one-slot payload. Payloads requiring more than one slot are charged an integral multiple of the above fee. Fractional slot payloads are not allowed. The above example is for FY1990. Current year pricing is based on the current Shuttle flight price which may be obtained from NASA Headquarters, Code MOC.

Customers requiring a dedicated HH carrier may be accommodated under the standard Shuttle Mixed Cargo Pricing Policy. GSFC integration charges for dedicated payloads are individually negotiated.

Customers desiring to use HH services as part of the customer's primary payload or on the customer's dedicated flight will pay GSFC integration charges to be individually negotiated. Contact NASA

Headquarters, Code MOB for current pricing policy.

In cases where GSFC and the customer identify optional GSFC activities required by the customer, these will be priced on a case-by-case basis and are funded by the customer organization.

Payloads sponsored by NASA discipline offices do not pay transportation costs. During the development of the Payload Integration Plan (PIP) with the Johnson Space Center (JSC) and the Kennedy Space Center (KSC), optional transportation services associated with a particular customer may be identified and estimated.

The current estimated weights (in lbs.) of various HH carrier equipment which could be used on a given mission are as follows:

Adapter Beam Assembly (ABA)		**163.0**
HH-S 50"x60" Plate (SPOC)		**370.0**
HH-S 25"x39" Plate		**50.0**
Avionics Unit (Beam Mount)		**182.0**
- Avionics	127.0	
- Plate	50.0	
- Bolts, etc.	5.0	
Sealed 5 ft^3 Canister		**153.8**
HMDA Canister		**234.5**
HMDA w/ Window Canister		**258.3**

HH-C Carrier			**2165.0**
- HHBA		1434.6	
- STP-1 MPE		323.4	
- STP-1 Cables		144.9	
- STP-1 Bolts		21.1	
- Avionics Assy		241.0	
(Avionics	127.0)		
(Plate & Misc.	114.0)		

	SEALED	HMDA
Canister w/ Blankets	67.0	67.0
Bridge Brkts & Bolts	15.0	15.0
Ground Strap	0.2	0.2
Lower End Plate (LEP)	29.4	29.4
Lower IEC	7.0	7.0
Battery Vent	1.3	1.3
End Plate Bolts	4.0	4.0
Upper End Plate	24.0	---
Upper IEC	6.0	---
HMDA	---	75.5
HMDA Blankets & Sht. Mtl.	---	15.5
HMDA EMP	---	11.0
HMDA Cable from LEP	---	2.0
HMDA Relay Box	---	6.7
Total	**153.9**	**234.6**
HMDA Window		18.9

Window Retainer	4.9
Total (HMDA w/ Window)	258.4

1.7.1 Integration Cost

The integration costs consist of the cost of a package of normal services defined in Section 3 of this document covering GSFC activities in support of all HH payloads. In addition to the normal services, optional GSFC integration services may be required. Anticipated GSFC optional services will be identified and estimated. Finally, JSC and KSC may impose optional service costs for special activities required by a particular payload. Any such anticipated charges will also be identified and estimated during GSFC evaluation of the customer's requirements.

If you need more information regarding integration costs, contact the HH Project Office.

2. THE HITCHHIKER CARRIER SYSTEM

The HH carrier system implements various modular hardware in mounting customer equipment in the payload bay. HH-S customer equipment is mounted in canisters, on small mounting plates, or directly to the Orbiter adapter beams. HH-C customer hardware is mounted to the HH bridge using standard canister hardware, small experiment mounting plates, or custom-mounting equipment. The standard avionics unit forms a part of both the HH-S and HH-C configurations. This unit provides the electrical interface between the Orbiter and up to six customer units. The weights of the various carrier units and their maximum customer weight capacities are shown in Table 2.1. Actual allowable customer weight depends on detailed analysis of actual mounting configuration and center of gravity. Table 2.1. also shows the weights of the GAS-type beam (attachment hardware for HH-S) and Keel Trunnion attachment hardware (used with HH-C). The attachment hardware weight is not counted in determining re-imbursement to NASA for transportation cost.

Customer interfaces for the side-mount and cross-bay versions of HH have been designed to be as similar as possible allowing many customer payloads to be accommodated on either carrier. This results in maximum manifesting flexibility.

An additional HH version, Hitchhiker-JR (HH-J) is available for small instruments which require only canister mounting and do not require real-time ground command or data services. HH-J has customer electrical interfaces similar to GAS and can be accommodated on Shuttle missions where Orbiter electrical services required by the standard HH carrier are not available. HH-J customers are not required to support the control center operations required by the other HH versions and can avoid the cost and effort associated with the necessary equipment and personnel.

Table 2.1

HH Carrier Equipment Capacities

Carrier Equipment	Carrier Weight (lbs)	Maximum Customer Weight (lbs)	Mounting Surface
Sealed Canister (insulated top plate)	160	200	19.75" Dia.
Sealed Canister (uninsulated top plate)		140	20019.75" Dia.
Motorized Door Canister	235	170	19.75" Dia.

HH-S Small EMP	55	300	25" x 39"
HH-S Direct Mount	-	700	20" x 40"
HH-C Side Mounting Plate (Experiment) (No Brackets)		61	250* 25.6" x 39.5"
HH-C Small Top Mounting Pallet (Exp.)		90	600*33.38" x 27.45"
HH-C Large Top Mounting Pallet (Exp.) (No Brackets)		207	600*55.65" x 33.38"
Avionics Unit (includes mounting plate & mounting hardware)	236	--	--
HH-C (includes avionics unit, mounting plate and standard MPE)	2165	1200	Custom-mounted

Attachment Hardware	Weight
HH-S GAS Beam, Bays 2-8, 12, 13	170 lbs.
HH-C Bridge Attachment Fittings for Bay 2	365 lbs.
HH-C Bridge Attachment Fittings for Bay 3	418 lbs.

*Specific center of gravity envelope limits weight capability.

2.1 MECHANICAL SUPPORT SYSTEMS

HH-S and customer hardware will be side-mounted to the Orbiter payload bay longeron and frame attachment points using GAS-type adapter beams. HH-S carrier components are illustrated in Figure 2.1. HH-C payloads are carried on an across-the-bay structures as described in section 2.1.4.

Existing HH-S equipment is designed to be mounted on the starboard side of the cargo bay in bay locations 2 or 3. These locations are indicated in Figure 2.2 which shows the forward-most available positions in the bay for the GAS adapter beam mounting as well as the X-axis station numbers associated with these positions.

Figure 2.3 depicts an example of a typical structural configuration for HH-S payloads. Figure 2.4 shows a sideview of a typical HH-S payload mounting.

All plates that are to be side-mounted to the Orbiter are parallel to the X-Z plane. The X axis is along the long axis of the Orbiter; positive towards the tail. The Y axis is across the payload bay positive towards the starboard (right) wing. The Z axis completes the coordinate system and is positive moving "up" from the bottom of the Orbiter payload bay. See Figure 2.5.

The dynamic envelope of the cargo bay defines the maximum permitted extent of thermal and dynamic distortions of payload equipment. A maximum static design radius of 88 inches has been established for customer hardware (Figure 2.6). The maximum dynamic envelope radius is 90" (Figure 2.6). The maximum extent of payload equipment out from the sides of the mounting plates (along the Orbiter ± X directions) is mission-dependent. It will normally, however, be restricted to the width of the mounting plate to prevent interference with Orbiter integration Ground Support Equipment (GSE).

The following subsections describe the various mechanical accommodations available with the HH-S system.

FIGURE 2.1 HH-S CARRIER COMPONENTS

FIGURE 2.2

HITCHHIKER-S AVAILABLE SIDEWALL MOUNTING LOCATIONS

FIGURE 2.3 HH-S TYPICAL STRUCTURAL CONFIGURATION

FIGURE 2.4 HH-S PAYLOAD MOUNTING CONCEPT

FIGURE 2.5 ORBITER COORDINATE SYSTEM

FIGURE 2.6

MAXIMUM PAYLOAD STATIC AND DYNAMIC ENVELOPES

SMALL MOUNTING PLATE LAYOUT

2.1.1 HH Canister

The HH canister is an adaptation of the canister developed by the GAS Program. It is mechanically very similar to a GAS canister and offers the customer the simplest mechanical accommodation in the HH-S system. It is available as a completely closed canister (Figure 2.7) or with an opening lid known as the Hitchhiker Motorized Door Assembly (HMDA) (Figure 2.8). Figure 2.9 shows the canister mechanical and electrical components. Figure 2.10 illustrates the field-of-view restrictions for payloads using the HMDA. Canister extensions to facilitate additional payload volume are available as an optional service and will be considered on a case-by-case basis.

Use of the standard container facilitates safety. The container provides for internal pressure which can be varied from near vacuum to about 1 atmosphere absolute. It also provides thermal protection for the experimental apparatus. The sides of the container may be thermally insulated or may be uninsulated with a white paint surface. The top may be insulated or not, depending upon the customer requirements. The bottom of the container is always insulated.

The experiment mounting plate, which is also the upper end plate of the canister, provides a standardized mounting surface for customer hardware. Any experiment venting will be through the experiment mounting plate. The lower end plate contains ports through which a payload may vent. The HMDA uses a different experiment mounting plate and similar, but different, payload venting.

The weight the canister can support depends upon whether it is mounted for a HH-S or HH-C configuration. For the HH-S configuration, the canister is qualified to support 200 lbs. of payload weight. The HH-C configuration is qualified to carry a total of 400 lbs. for the canister carrier weight and payload weight. If the canister carrier weight to support a payload increases, then the payload weight that can be flown is reduced. For example, a standard insulated canister with an uninsulated top plate weighs about 140 lbs., this would limit the payload to 260 lbs. If the payload required the HMDA, then the payload weight allowed would be reduced by the weight of the HMDA.

2.1.1.1 Container Construction. The standard container is made of aluminum. There is white paint or multilayer insulation on the exterior. The top may or may not be insulated depending on the particular Shuttle mission and needs of the experimenter. The circular top and bottom end plates are 5/8" thick aluminum.

The bottom 3" of the container is reserved for HH-S interface equipment such as interface harnesses and venting systems. This volume is in addition to the 5-cubic foot space available to the experimenter.

The container is a pressurized container capable of:

a. maintaining about 1 atmosphere absolute pressure at all times, (dry nitrogen or dry air),

b. evacuation during launch and repressurization during re-entry (vented).

c. evacuation prior to launch.

d. evacuation on orbit with vacuum being maintained through re-entry.

FIGURE 2.7 HITCHHIKER SEALED CANISTER

FIGURE 2.8 HITCHHIKER MOTORIZED DOOR CANISTER

FIGURE 2.9 HITCHHIKER CANISTER
MECHANICAL AND ELECTRICAL COMPONENTS

FIGURE 2.10

HITCHHIKER-S CANISTER MOUNTING TO ORBITER

2.1.1.2 Sealed Canister Experiment Mounting Plate

The sealed canister upper end plate (see Figure 2.11) serves four purposes:

a. it seals the upper end of the standard container,
b. it provides a mounting surface for the experimental equipment,
c. it can act as a thermal absorption or radiation surface, and
d. it provides accommodations for experiment box venting when required.

The inner surface of the plate has a hole pattern adaptable for mounting a variety of hardware. Forty-five stainless steel, internally threaded inserts exist for experiment mounting purposes. The experimenter may use any of them in any combination required. The inserts do not go through the plate. They will accept #10 - 32 UNF machine screws to a depth of 0.31 inches. The project is responsible for approving the structural dimensions of the experiment interface and the number and location of mounting screws.

The line from the center of the plate through the two purge ports will always be positioned toward the starboard (right) side of the Orbiter, perpendicular to the Orbiter centerline.

The canister will be purged with dry nitrogen, or dry air, as specified by the customer. Two purge ports are shown on the experiment mounting plate (see Figure 2.11). At least one of these must be unobstructed to allow purged gas to flow through the canister.

The customer must provide a grounding strap from the payload to the experiment mounting plate. Any mounting hole on the experiment mounting plate may be used for grounding.

If safety considerations require that a battery box or other component be vented, it can be plumbed to a special pressure-relief valve turret (illustrated in Figure 2.12). Since the turret can be rotated 360°, the experimenter can pick the most convenient orientation within the plumbing circle shown in Figure 2.11. If no turret is required for the payload, this area will be completely clear and will not affect payload mounting.

The customer must provide attachment points on the bottom of the payload structure for lifting in the inverted orientation by means of a crane and sling. The sling must be provided by the customer. Customers may not alter the mounting plate unless changes have been negotiated with the HH Project Office. As an optional service to be individually negotiated, the top mounting plate may be modified to provide apertures or customer electrical connectors. Customer equipment may be mounted to the top (external) surface of the mounting plate.

FIGURE 2.11 HITCHHIKER SEALED CANISTER
STANDARD EXPERIMENT MOUNTING PLATE
(UPPER END PLATE)

FIGURE 2.12 HITCHHIKER SEALED CANISTER
BATTERY VENT TURRET INTERFACE

2.1.1.3 Opening Lid Canister. A canister may be fitted with a HMDA if the customer payload requires a field of view or exposure to the space environment. The door is opened and closed by ground command as required. The HMDA is capable of maintaining a 15 psi differential (psid) pressure or evacuated environment similar to the standard canister. It is possible to eject packages from a HMDA canister; however, the interface and safety requirements are considerably beyond the scope of this document and must be defined and approved on a case-by-case basis.

HMDA canisters are normally equipped with redundant pressure-relief valves which act to reduce the pressure to less than 1 psid during ascent. Once in orbit, a ground command may be used to open a vent valve and reduce the pressure to less than 0.1 psid prior to opening the door. HMDA canisters normally return with internal vacuum.

The mounting provisions for the opening lid canister are shown in Figure 2.13. Because the contents of the canister are exposed when the door is open, the materials, safety, and Electro-Magnetic Interference (EMI) considerations are essentially the same as for plate-mounted hardware.

For safety considerations, a pressure-relief valve turret designed for use on the HMDA Mounting Plate is available to vent battery boxes or other components (see Figure 2.15). Four venting locations have been provided to accommodate battery box orientation requirements. An experiment may use any one of these four locations. If no turret is required for the payload, this area will be completely clear and will not affect payload mounting.

Multiple interlocks are provided to prevent the door from opening prior to or during ascent. However, in the event of an in-flight door failure, the contents of the canister must be designed to allow safe descent and landing with the door open. The customer is responsible for designing and providing any thermal treatment of exposed surfaces.

2.1.1.4 Canister Orientation. A canister will always be mounted with the experiment mounting plate facing out of the payload bay. There are, however, two different container ground handling orientations. First, during insertion of a payload into the container and the subsequent checkout and transportation, the container's major axis will be vertical. Second, after the container is installed in the Orbiter bay, the container's orientation will become Orbiter dependent, i.e., the major axis of the container will be perpendicular to that of the Shuttle.

Care should be taken in experiment design to assure that systems that are sensitive to ground orientations, such as wet cell batteries, are properly oriented in the experiment. The customer should inform the HH staff of any special payload orientation requirements which must be met prior to installation in the Orbiter.

2.1.1.5 Lateral Load Support. Because the experiment structure will be cantilevered from the experiment mounting plate, radial loads at the free end of the experiment structure must be supported by at least three equally spaced bumpers between the experiment structure and the canister. Figure 2.16 illustrates one possible bumper design configuration.

The customer is responsible for providing bumpers as part of the experiment hardware. Bumper design should be in accordance with the following guidelines:

a. A minimum surface area of 4 in^2 (2" x 2") should be used for each bumper pad.

b. The bumper face should have a 10-inch radius so that it will fit snugly when adjusted against the 20-inch diameter container.

c. Where the bumper contacts the container wall, it should be faced with a resilient material at least 1/8 inch thick to protect the container. If the container is to be evacuated, select a non-outgassing material such as viton. If the bumper face is not round, every corner should have a minimum radius of 0.40 inches.

d. It is very important to provide a positive locking device for the bumpers. Do not depend on friction or a set screw alone to hold them in place.

e. After installing the payload in the container, bumper adjustment should be easily accessible from the open lower end of the container.

2.1.1.6 <u>Center of Gravity (CG) Considerations</u>. To minimize the amount of analysis required for a particular mission, the composite CG of a canister and payload must be constrained within certain limits. The CG envelope is shown in Figure 2.14.

FIGURE 2.13 OPENING LID CANISTER EMP

CANISTER CG ENVELOPE

ADAPTER BEAM OR BRIDGE MOUNTING

FIGURE 2.14

FIGURE 2.15 HMDA BATTERY VENT ASSY

2.16 BUMPER DESIGN EXAMPLE

2.1.1.7 Customer Emblems. HH customers may attach a logo or emblem to the exterior of their equipment. Emblems may also be attached to the exterior of canisters containing customer equipment. The canister emblems should be on a .010 inch Lexan sheet 11 inches square. Emblem artwork must be submitted to GSFC for NASA approval. Materials used for emblems must meet all Space Shuttle payload bay materials requirements.

2.1.2 PLATE MOUNTING

Experiment packages which are not best suited for the canister approach may be mounted on a plate (see Figure 2.17). A small HH-S plate is capable of supporting experiment packages of up to 300 pounds, mounted on an area 25" x 39". Customer equipment is attached to the core plate using a grid hole pattern on 2.756" (70-mm) centers with 3/8" - 24 UNF stainless steel bolts. The bolts are supplied by the HH Project. A similar matrix of #10 - 32 mounting bolt locations will be used by the HH staff to route interface cables as well as intercomponent harnessing and plumbing. The experiment structural dimensions and attachment points at the mounting plate interface must be reviewed for acceptance by the HH Project.

2.1.2.1 Experiment Package Integrity. The package must be designed, fabricated, inspected, analyzed, and tested to demonstrate the ability to constrain, or to contain, the elements of the experiment package during launch, flight, and landing. All customer equipment shall be designed to withstand limit acceleration load factor limits as stated in Section

3.1.1.3.2. Also refer to Random Vibration Verification Levels given in Section 3.1.1.5.3 (Table 3.6) .

2.1.2.2 Experiment Package Volume. Specific volume restrictions other than those provided in Section 2.1 are not generally placed on customer equipment since the equipment mass and CG location are the controlling factors. In general, the experiment CG should be located as close to the mounting interface as practical. The complexity of the weight/CG relationship, the possibility of multiple customers per plate, manifesting considerations, and other factors require that the HH-S staff perform accommodation assessments on a case-by-case basis. Guidance will be provided to determine specific equipment design and accommodation details as part of the normal mechanical interface documentation exchange.

FIGURE 2.17 HH-S EXPERIMENT MOUNTING PLATE

2.1.2.3 Mounting Bolt Loading Limitations. The mounting bolts must be included in the payload stress and fracture analysis (see Section 3.0). Bolt strength and material data will be supplied by the HH Project.

2.1.3 Direct Mounting of Experiment Package

The maximum weight-carrying configuration in the current HH-S system is accomplished by mounting the customer's flight unit directly to the Adapter Beam Assembly (ABA). This mode will accommodate up to 700 pounds but requires detailed case-by-case analysis and approval. The mounting hardware between the experiment package and the ABA will be supplied by the HH Project. The available experiment mounting locations are noted in Figure 2.18.

2.1.3.1 Experiment Package Integrity. See 2.1.2.1 for design considerations.

2.1.3.2 Experiment Package Volume and Mounting Limitations. The experiment volume in the direct mount configuration can be somewhat higher than in the plate mount setup; however, it is similarly restricted as described in subsections 2.1.2.2 and 2.1.2.3. The HH staff provides assistance in adapting customer hardware to the ABA interface and defining CG and volume restrictions. Direct-mount payloads are normally designed to be mounted on the adapter beam after the beam is installed in the Orbiter. The mounting scheme must be simple and involve captive fasteners. In the event that a payload is designed to mount on the beam prior to Orbiter installation, adequate access to the longeron bolts must exist. Special lifting equipment for hoisting the payload/beam combination must also be provided.

2.1.4 HH-C Structure

The HH-C cross-bay carrier is implemented using a truss structure (Figure 2.19) called the Hitchhiker Bridge Assembly (HHBA). The HHBA is similar to other Mission Peculiar Experiment Support Structure (MPESS) structures used on Spartan, GAS, Materials Science Laboratory (MSL), and other NASA payload programs and consists of an upper support structure and a lower support structure. The lower structure is normally attached to the upper structure at the launch site. During integration and transportation to the launch site, the upper structure is mounted on a special dolly (see Figure 2.20) which allows easier access and handling.

FIGURE 2.18 EXPERIMENT TO ADAPTER BEAM MOUNTING INTERFACE

FIGURE 2.19 HITCHHIKER-C PAYLOAD

FIGURE 2.20 HHBA UPPER STRUCTURE ON SHIPPING DOLLY

2.1.4.1 Standard HHBA. Attachment of payload equipment to the HHBA is done by means of special Mission Peculiar Equipment (MPE), structure elements which can be attached to the HHBA in five different locations spaced 28.20 inches apart across the top and sides of the structure. The standard MPE has eight positions on the sides of the HHBA for side experiment mounting plates and canisters. However, one experiment mounting plate position is reserved for the HH avionics. Of the remaining seven positions, three can be used for side experiment mounting plates or canisters. The other four positions can only be used for canisters. The HHBA and MPE are un-insulated and can experience large temperature deviations during a mission. For this reason, special mounting brackets are used to attach the plates and canisters to the MPE. The brackets provide thermal isolation and allow for thermal expansion when plates or canisters are temperature controlled.

The top of the MPE structure has positions for two sizes of top plates. It will accommodate two large top plates, four small top plates or combination thereof. Customers considering accomodation on the HHBA should request drawing number GE1550253 from the HH Project for additional detailed information beyond what is listed in the following sections.

2.1.4.2 HH-C Canisters. Canisters identical to those specified for HH-S can be used with the HH-C. The canister is rotated 90 degrees about the Z axis in the HH-C case. All possible canister locations are shown in Figures 2.21, 2.22, and 2.23. Figure 2.21 shows the HH-C Canister Locations. Figure 2.22 shows the HH-C Canister and Mounting Plates , and Figure 2.23 shows the HH-C Canister highlighting the Y-Axis Coordinates and Field-of View Restrictions.

2.1.4.3 HH-C Side Mounting Plates. The HH-C side mounting plates (shown in Figure 2.24) are functionally identical to, although not interchangeable with, the small HH-S mounting plates. The plates are 25" x 39" and can support up to 250 pounds. The "Y" and "Z" axis coordinates of these plates and the field-of-view restrictions are shown in Figure 2.25.

FIGURE 2.21 HITCHHIKER-C CANISTER LOCATIONS

FIGURE 2.22 HITCHHIKER-C CANISTER AND MOUNTING PLATES

2.23 HITCHHIKER-C CANISTER

Y-AXIS COORDINATES AND FIELD-OF-VIEW RESTRICTIONS

FIGURE 2.24 HITCHHIKER-C MOUNTING PLATE LOCATIONS

FIGURE 2.25

HITCHIKKER-C MOUNTING PLATE LOCATIONS

Y-AXIS COORDINATES AND FIELD-OF-VIEW RESTRICTIONS

2.1.4.4 HH-C Top Mounting Pallets. The HH-C top mounting pallets are also shown in Figure 2.24. Their field-of-view restrictions are shown in Figure 2.25. The small pallet is roughly 33" by 27". The large pallet is roughly 33" by 56". Both pallets can handle up to 600 pounds, provided the center of gravity of the experiment hardware is within the design envelopes as shown in Figure 2.26.

2.1.4.5 HH-C Direct Mounting. Large/heavy customer equipment which is not suitable for accommodation on the standard plates or canisters may be attached directly to existing HH MPE or may be attached to the structure by means of new customer-unique MPE, provided by GSFC as an optional service. Hardware mounting locations are shown in Figure 2.27. In either case, the customer's structural design must safely accommodate larger differential temperature changes between his/her equipment and the carrier. Proposals for direct mounting should be sent to the HH project for evaluation.

2.1.5 HH Side Mounting Plates. The HH side mounting plate is a generic plate combining the capabilities of the HH-S and HH-C side plates.

FIGURE 2.26 CG ENVELOPE AND POSITIONS

FIGURE 2.27 HITCHHIKER-C EXPERIMENT MOUNTING INTERFACE

SIDE MOUNT

2.2 THERMAL CONSIDERATIONS

Although the Orbiter has a fluid loop heat exchanger for payloads, manifesting and engineering difficulties with its use are extensive. The HH carrier and customer equipment, therefore, rely on heater/thermostat type thermal control systems which depend on radiation for removal of heat. Generally, thermal design of the customer thermal control system is a customer responsibility as described below. Safety of payloads must not be affected by loss of heater power. Payloads must be safe to land 40 minutes after payload bay door closure, occurring anytime during the mission.

2.2.1 Thermal System Design (Canister)

There are presently four options available to HH canister customers:

1. Fully insulated canister
2. Insulated canister without upper-insulating end cap.
3. Uninsulated canister with bottom insulating end cap.
4. Opening lid canister (uses insulated canister).

The first three options pertain to a sealed HH canister, while the fourth refers to the opening lid canister. The three canister insulation options for the sealed canister are intended to offer a wide range of heat rejection capabilities depending on customer requirements. Customers using the uninsulated canister option must perform the thermal analysis and provide the thermal control systems (heaters, thermostats, internal surface coatings, insulation, etc.) required for their instruments.

The first option, a fully insulated canister, would be the best choice for customers with relatively low power requirements. This option minimizes heater power needed to maintain operational temperature levels at cold Orbiter orientations. It does not, however, allow for large power dissipations on a continuous basis. The steady-state average canister temperature for various Shuttle attitudes and customer payload power levels is given in Figure 2.28. The corresponding Orbiter attitudes are defined in Figure 2.29. The canister temperatures from Figure 2.28 can be used as boundary conditions to calculate customer instrument temperature levels using techniques described in "GAS Thermal Design While U Wait" which is the appendix to <u>Get Away Special Thermal Design Summary</u>, GSFC-732-83-8.

FIGURE 2.28 AVERAGE CANISTER TEMPERATURE FOR
FULLY INSULATED AND UNINSULATED CANISTERS

FIGURE 2.29 TYPICAL ORBITAL THERMAL ATTITUDES

The majority of the Shuttle missions flown to date have had the Earth-viewing attitude as the base one with excursions to other attitudes as required. Generally speaking, customer thermal designs should be tailored to this case, yet be flexible enough to withstand the other attitudes as well. The time-dependent or transient behavior of the canister should be considered as well, since its effects are usually favorable. For example, a fully insulated 160 pound canister with a 200 pound customer payload takes over 48 hours to cool from 20 degrees C to 0 degrees C in the Earth-viewing attitude. Heater requirements calculated on a steady-state basis would, therefore be much higher than that determined using a transient analysis.

Option 2 offers an increased heat rejection capability over option 1, as shown in Figure 2.30. The canister top plate exterior surface is coated with silver teflon (a = .15, E = .75) and acts as a radiator while the rest of the canister is insulated. Increased heater power, however, is required in order to maintain minimum temperature levels in cold Orbiter orientations. Transient response time is lower as well, with the canister cooling from 20 degrees C to 0 degrees C in 24 hours with the same conditions as the previous example. Finally, temperature gradients between the top and sides of the canister are more pronounced with this option. The curves shown in Figure 2.30 are average canister temperatures and do not show this effect.

Option 3 is available to customers requiring a large heat rejection capability. In this case, the side walls of the canister are painted white (a = .32, E = .86) and are allowed to radiate directly to the Shuttle bay and space. The average container temperature for various conditions is given in Figure 2.28. Power levels higher than those shown can be accommodated for short time periods depending on customer thermal design. However, large temperature gradients can be realized along with high power levels. Therefore, special attention should be given to the thermal design if Option 3 is selected. Also, large heater power levels are required to maintain minimum temperature levels even in the Earth viewing case. Transient response times are reduced as well, with the canister temperature cooling to 0 degrees C in less than 10 hours in the previous example.

FIGURE 2.30 INSULATED CANISTER
WITHOUT INSULATED ENDCAP (OPTION 2)

Option 4 refers to the opening-lid canister. When the lid is closed, the canister thermal behavior is approximately the same as that of the fully insulated canister (Option 1). When open, thermal behavior is heavily dependent on the customer payload thermal design, especially the exposed upper portion of the instrument. It is suggested that customers using this option pay particular attention to their thermal design, due to the increased complexity resulting from the opening lid. Thermal information for customers with opening-lids can be found in "Thermal Design Guide for Get Away Special/Motorized Door Assembly Users."

GSFC provides all exterior thermal insulation and coatings for canisters except for the top surface of an HMDA customer payload.

The temperatures listed for each orientation are approximate, and may vary somewhat (approx. +/- 10°C) depending on the Shuttle orbital attitude and beta angle (angle between the Shuttle orbit plane and the sun). All orientations shown were flown on STS-3, with the exception of the bay-Earth orientation, which was flown on STS-2.

Experimental data were obtained from the GAS Flight Verification Payload (FVP) on the flight of STS-3. Table 2.2 lists the steady-state temperature predictions and results for both hot and cold cases for the inside portion of the FVP. The experimental results are averages of thermistors or nodes at the indicated locations. The flight results listed are the hottest and coldest levels actually attained. They are not, however, the worst possible hot or cold case temperatures since steady-state conditions were not attained.

TABLE 2.2

CONTAINER AND PAYLOAD FLIGHT STEADY STATE THERMAL RESULTS

(Temperatures In ^{o}C)

FROM GAS VERIFICATION PAYLOAD

LOCATION	HOT CASE PREDICTED	HOT CASE ACTUAL	COLD CASE PREDICTED	COLD CASE ACTUAL
Top Plate	48.0	32.0	-20.6	-2.5
Container Sides	49.2	32.0	-19.1	-3.0
Bottom Plate	49.9	34.0	-19.5	-3.0
Battery	52.3	31.0	-5.7	+1.0
Tape Recorder	52.9	35.0	0.0	+4.0
Power	13.0W	13.0W	34.0W	13.0W

Note: Actual flight thermal levels did not reach steady-state conditions.

The levels are the maximum and minimum temperatures that were reached.

Table 2.3 shows external environmental thermal levels for steady-state conditions of the GAS container. It includes both predicted and actual flight thermal levels. Steady-state temperatures were not attained for the tail-to-sun, extreme cold case, which, therefore, is omitted from the table. The two predicted values for the adapter beam hot case correspond to two absorptivity values. The higher absorptivity value gives a better hot case correlation.

Additional thermal design information can be found in the Get-Away-Special Thermal Design Summary (X-732-83-8).

TABLE 2.3

GAS CONTAINER EXTERNAL THERMAL LEVELS AT STEADY STATE

	PREDICTIONS ºC	FLIGHT ºC
Adapter Beam (Hot-Bay to Sun)	+37 to +46	+45 to +50
Adapter Beam (Cold-Nose to Sun)	-78	-40
Bottom Cover (Hot-Bay to Sun)	+63	+63 to +65

Bottom Cover (Cold Nose to Sun)	-76	-45 to -50
Top Cover (Bracket) (Hot-Bay to Sun)	+31	+25 to +35
Top Cover (Bracket) (Cold-Nose to Sun)	-73	-47 to -52

2.2.2 Thermistors

Three thermistors are available for all plate experiments. Opening can experiments have no thermistors except for one mounted on the base plate. Closed can experiments have one thermistor available and one mounted on the base plate. Additional thermistors may be available through negotiation with the HH project.

These thermistors, Yellow Springs Instrument Company (YSI) 44006 type or equivalent (see the manufacturer's specification sheet on the following page), are supplied by the HH Project for connection to appropriate pins on J2, as outlined in Tables 2.4 and 2.5. This interface configuration allows monitoring of up to three temperatures when customer payload power is on or off. The thermistor interface between customer and carrier is shown in Figure 2.31.

MANUFACTURER'S SPECIFICATION SHEET
FOR YSI PRECISION THERMISTORS

FIGURE 2.31 THERMISTOR INTERFACE
TO CARRIER

2.2.3 Customer Thermal Responsibilities for Plate Mounting

In general, the customer is responsible for the thermal design of a plate-mounted experiment system. This design will encompass the plate and its attachments to the GAS beam and Orbiter or to the HH bridge. Normally, in order to avoid problems with thermal/mechanical stress, a customer will want to provide good thermal conduction between his/her equipment and the HH mounting plate. On HH-S, the mounting plate has poor thermal conduction to the GAS beam. On HH-C, mounting plates are thermally isolated from the cross-bay structure by means of special hardware which allows for thermal expansion. The HH-S GAS beam is attached to the Orbiter with hardware which also provides thermal isolation and allows for expansion.

GSFC will supply thermal model data on the HH plates and their attachments to customers. GSFC will also supply insulation for the backs of plates and custom-designed white painted kapton sheet to cover the unoccupied front surface of plates. GSFC will supply a standard heater system on the back of the HH-S and HH-C small plate consisting of 104-watt heater and one thermistor. For the top of the bridge single and double bay pallets, GSFC will supply 52 and 104 watts of heater power, respectively. (Thermostats on these plates open at 12 +/- 3 deg C and close at 6 +/- 3 deg C.) The customer may use this system by providing a cable to connect the thermal system to power from his customer port. The customer will provide GSFC with thermal model data on all platemounted hardware and will also provide copies of his/her thermal design and analysis for GSFC review. Additional information may be found in the SPOC Thermal Design Handbook.

2.3 ELECTRICAL/POWER SUPPORT SYSTEMS

2.3.1 Electrical/Power System Design

The electrical interfaces for plate mount and canister customers differ slightly. Figure 2.32 and Table 2.4 give plate mounting details. Figure 2.33, 2.34, and Table 2.5 provide details on the canister mount. Figure 2.34 shows the Motorized Door Canister with the control and monitoring interface. Each of the two 12 gauge 28V power lines is protected by a 20A fuse (vacuum derated to 10A). Customers must provide consistent wiring and fusing within their payloads. Prior to using a smaller gauge wire for power service, an appropriate smaller fuse must be used to provide protection from fire hazard. Table 2.6 shows acceptable wire and fuse sizes.

FIGURE 2.32

HH STANDARD INTERFACE CABLES

(PLATE MOUNTED CUSTOMER)

TABLE 2.4

SPOC PLATE ELECTRICAL INTERFACE CONNECTORS

ID	PIN (NOTE 3)	TYPE (NOTE 2)	FUNCTION
POWER CONNECTOR J1: (NOTE 4)			
+28A	A	C	+28V POWER CIRCUIT A
RETA	B	C	POWER RETURN (NOTE 1)
+28B	C	C	+28V POWER CIRCUIT B
RETB	D	C	POWER RETURN (NOTE 1)
+28HTR	E	B	+28V HEATER POWER
RETH	F	B	HEATER POWER RETURN (NOTE 1)
FRMGND	G	B	FRAME GROUND
SIGNAL CONNECTOR J2: (NOTE 4)			
PCMAD	1	A	PCM ANALOG DATA
PCMINDX	41	A	PCM INDEX PULSE
SIGGND	2	A	SIGNAL GROUND
PCMCLK	42	A	PCM BIT RATE CLOCK
PCMENA	32	A	SERIAL DIGITAL ENABLE A
PCMENB	33	A	SERIAL DIGITAL ENABLE B
PCMDATA	3	A	SERIAL DIGITAL DATA A
PCMDATB	8	A	SERIAL DIGITAL DATA B
THER1	14	A	THERMISTOR 1
THER2	15	A	THERMISTOR 2
THER3	16	A	THERMISTOR 3

SHIELD	6	A	SHIELD FOR COMMAND AND DATA SIGNALS
RD+	21	A	RECEIVE DATA ASYNC + FROM SPOC
RD-	22	A	RECEIVE DATA ASYNC - FROM SPOC
SD+	23	A	SEND DATA ASYNC + TO SPOC
SD-	24	A	SEND DATA ASYNC - TO SPOC
BLCMD1	17	A	BI-LEVEL/PULSE COMMAND 1

TABLE 2.4 (Cont'd)

SPOC PLATE ELECTRICAL INTERFACE CONNECTORS

ID	PIN (NOTE 3)	TYPE (NOTE 2)	FUNCTION
BLCMD2	18	A	BI-LEVEL/PULSE COMMAND 2
BLCMD3	19	A	BI-LEVEL/PULSE COMMAND 3
BLCMD4	20	A	BI-LEVEL/PULSE COMMAND 4
SCMDCLK	10	A	SERIAL COMMAND CLOCK
SCMDENV	11	A	SERIAL COMMAND ENVELOPE
SCMDDAT	12	A	SERIAL COMMAND DATA
METMIN	40	A	MET/MET ONE MINUTE PULSE
IRIGMET+	30	A	IRIG-B MET (MET) +
IRIGMET-	31	A	IRIG-B MET (MET) -
FRMGND	49	A	FRAME GROUND
KUMRCLK+	34	A	CUSTOMER GENERATED MR CLOCK +
KUMRCLK-	35	A	MR CLOCK -
KUMRDAT+ +	43	A	CUSTOMER GENERATED MR DATA
KUMRDAT-	44	A	MR DATA -
KUMRSHLD	25	A	SHIELD FOR KU SIGNALS
UNDTSP1+	61	D	UNDEDICATED TSP 1 +
UNDTSP1-	66	D	UNDEDICATED TSP 1 -
UNDTSPS1	54	A	SHIELD FOR UNDEDICATED TSP 1
UNDTSP2+	62	D	UNDEDICATED TSP 2 +
UNDTSP2-	63	D	UNDEDICATED TSP 2 -
UNDTSPS2	55	A	SHIELD FOR UNDEDICATED TSP 2
UNDTSP3+	56	D	UNDEDICATED TSP 3 +
UNDTSP3-	57	D	UNDEDICATED TSP 3 -

UNDTSPS3	48	A	SHIELD FOR UNDTSP3
UND4	58	A	UNDEDICATED 4
UND5	59	A	UNDEDICATED 5
UND6	60	A	UNDEDICATED 6
UND7	64	A	UNDEDICATED 7
UND8	65	A	UNDEDICATED 8
UNDS	53	A	SHIELD FOR UNDEDICATED 4-8
MDAOC	52	A	RESERVED
MDASTP	51	A	RESERVED

TABLE 2.4 (continued)

NOTE 1: POWER RETURN PINS B, D AND F MAY BE CONNECTED TOGETHER WITHIN PAYLOAD.

NOTE 2: WIRE TYPE DESIGNATIONS:

A	22 GA
B	16 GA
C	12 GA
D	26 GA

NOTE 3: CUSTOMER WILL MAKE NO CONNECTIONS TO UNUSED PINS

NOTE 4: THE DESIGNATIONS "J1" AND "J2" IN THIS TABLE INDICATE THE PIN OUT FOR A CHASSIS MOUNT CONNECTOR MOUNTED TO A PARTICULAR SCIENTIFIC EXPERIMENT. THE HH-PROVIDED CONNECTING CABLE WILL BE TERMINATED IN CONNECTORS WITH A DESIGNATION OF "P1" AND "P2" BUT WILL HAVE THE IDENTICAL PIN-OUT AS SHOWN IN THIS TABLE.

FIGURE 2-33

HH-S STANDARD INTERFACE CABLES

(CANISTER CUSTOMER)

FIGURE 2.34 HITCHHIKER MOTORIZED DOOR CANISTER

CONTROL AND MONITORING INTERFACE

TABLE 2.5

CANISTER ELECTRICAL INTERFACE CONNECTORS

ID	PIN(NOTE 3)	TYPE(NOTE 2)	FUNCTION
POWER CONNECTOR P1:			
+28A	A	C	+28V POWER CIRCUIT A
RETA	B	C	POWER RETURN (NOTE 1)
+28B	C	C	+28V POWER CIRCUIT B (NOTE 5)
RETB	D	C	POWER RETURN (NOTE 1)
+28HTR	E	B	+ 28V HEATER POWER
RETH	F	B	HEATER POWER RETURN (NOTE 1)
FRMGND	G	B	FRAME GROUND
SIGNAL CONNECTOR P2:(NOTE 4)			
PCMAD	1	A	PCM ANALOG DATA
PCMINDX	41	A	PCM INDEX PULSE
SIGGND	2	A	SIGNAL GROUND
PCMCLK	42	A	PCM BIT RATE CLOCK
PCMENA	32	A	SERIAL DIGITAL ENABLE A
PCMENB	33	A	SERIAL DIGITAL ENABLE B
PCMDATA	3	A	SERIAL DIGITAL DATA A
PCMDATB	8	A	SIERAL DIGITAL DATA B
THER1	14	A	THERMISTOR 1 (NOT WIRED TO PLD) (NOTE 6)
THER2	15	A	CANISTER PRESSURE (NOT WIRED TO PLD)
THER3	16	A	MDA DOOR POSITION 0-5 V (NOTE 7)

SHIELD	6	A	SHIELD FOR COMMAND AND DATA SIGNALS
RD+	21	A	RECEIVE DATA ASYNC + FROM SPOC
RD-	22	A	RECEIVE DATA ASYNC - FROM SPOC
SD+	23	A	SEND DATA ASYNC + TO SPOC
SD-	24	A	SEND DATA ASYNC - TO SPOC
BLCMD1	17	A	BILEVEL/PULSE COMMAND 1
BLCMD2	18	A	BILEVEL/PULSE COMMAND 2
BLCMD3	19	A	BILEVEL/PULSE COMMAND 3
BLCMD4	20	A	BILEVEL CMD 4/OPEN CLOSE MDALID (NOTE 8)

TABLE 2.5 (continued)

CANISTER ELECTRICAL INTERFACE CONNECTORS

ID	PIN(NOTE 3)	TYPE(NOTE 2)	FUNCTION
SCMDCLK	10	A	SERIAL COMMAND CLOCK
SCMDENV	11	A	SERIAL COMMAND ENVELOPE
SCMDDAT	12	A	SERIAL COMMAND DATA
GMTMIN	40	A	GMT/MET ONE-MINUTE PULSE
IRIGGMT+	30	A	IRIG-B GMT (MET) +
IRIGGMT-	31	A	IRIG-B GMT (MET)-
FRMGND	49	A	FRAME GROUND
KUMRCLK+	34	A	CUSTOMER-GENERATED MR CLOCK +
KUMRCLK-	35	A	MR CLOCK -
KUMRDAT+	43	A	CUSTOMER-GENERATED MR DATA +
KUMRDAT-	44	A	MR DATA -
KUMRSHLD	25	A	SHIELD FOR KU SIGNALS
UNDTSP1+	61	D	UNDEDICATED TSP 1 +

UNDTSP1-	66	D	UNDEDICATED TSP 1 -
UNDTSPS1	54	A	SHIELD FOR UNDEDICATED TSP 1
UNDTSP2+	62	D	UNDEDICATED TSP 2 +
UNDTSP2-	63	D	UNDEDICATED TSP -
UNDTSPS2	55	A	SHIELD FOR UNDEDICATED TSP 2
UNDTSP3+	56	A	UNDEDICATED TSP 3+
UNDTSP3-	57	A	UNDEDICATED TSP 3-
UNDTSPS3	48	A	SHIELD FOR UNDEDICATED TSP 3
UND4	58	A	UNDEDICATED 4
UND5	59	A	UNDEDICATED 5
UND6	60	A	UNDEDICATED 6
UND7	64	A	UNDEDICATED 7
UND8	65	A	UNDEDICATED 8
UNDS	53	A	SHIELD FOR UNDEDICATED 4-8
MDAOC	52	A	MDA DOOR OPEN/CLOSE SIG TO MDA
SW-6 NO NORMALLY OPEN	26	E	MDA DOOR OPEN SWITCH S6, (NOTE 9)
SW-6 C	27	E	MDA DOOR OPEN SWITCH S6, CENTER CONTACT
SW-6 NC NORMALLY	28	E	MDA DOOR OPEN SWITCH S6, CLOSED

TABLE 2.5 (continued)

CANISTER ELECTRICAL INTERFACE CONNECTORS

ID	PIN(NOTE 3)	TYPE(NOTE 2)	FUNCTION
SW-5 NO	36	E	MDA DOOR OPEN SWITCH S5, NORMALLY OPEN
SW-5 C	37	E	MDA DOOR OPEN SWITCH S5, CENTER CONTACT
SW-5 NC	38	E	MDA DOOR OPEN SWITCH S5, NORMALLY CLOSED

SAFE/ARM CONNECTOR P3: (NOTE 10)

PYRO 1 PWR	A	B	- - -
PYRO 1 RET	B	B	- - -
PYRO 1 PWR (DEV)	G	B	- - -
PYRO 1 RET (DEV)		R	B - - -
PYRO 2 PWR	N	B	- - -
PYRO 2 RET	C	B	- - -
PYRO 2 PWR (DEV)	J	B	- - -
PYRO 2 RET (DEV)	H	B	- - -
PYRO 3 PWR	P	B	- - -
PYRO 3 RET	D	B	- - -
PYRO 3 PWR (DEV)	L	B	- - -
PYRO 3 RET (DEV)	K	B	- - -
PYRO 4 PWR	F	B	- - -
PYRO 4 RET	E	B	- - -
PYRO 4 PWR (DEV)	M	B	- - -
PYRO 4 RTN (DEV)	S	B	- - -

TABLE 2.5 (continued)

NOTE 1: POWER RETURN PINS B, D, AND F MAY BE CONNECTED TOGETHER WITHIN PAYLOAD

NOTE 2: WIRE TYPE DESIGNATION:

A	22 GA
B	16 GA
C	12 GA
D	26 GA
E	24 GA
F	20 GA

NOTE 3: CUSTOMER WILL MAKE NO CONNECTIONS TO UNUSED PINS

NOTE 4: THE DESIGNATIONS "P1" AND "P2" IN THIS TABLE INDICATE THE PIN-OUT FOR A CABLE-MOUNTED CONNECTOR. A CANISTER EXPERIMENT WOULD NEED THIS TERMINATION TO INTERFACE TO THE CANISTER BASEPLATE CONNECTOR (DESIGNATED AS "J1" AND "J2"). THE PINOUTS ARE IDENTICAL FOR EITHER "J" OR "P" DESIGNATED CONNECTORS. CONNECTOR PAIR J3/P3 IS A SAFE AND ARM CONNECTOR WHOSE USE IS NOT A STANDARD SERVICE. THE PIN-OUT IS NOT INCLUDED.

NOTE 5: 28V B POWER CIRCUIT SHARED WITH MDA MOTORS - MAY CONTAIN EXCESS EMI DURING DOOR MOTOR OPERATION

NOTE 6: THERMISTOR 1 IS LOCATED ON CANISTER BOTTOM PLATE

NOTE 7: PIN 16 (MDA DOOR POSITION) MAY ONLY BE CONNECTED TO HIGH-RESISTANCE (100 K OHMS) LOAD WITHIN PAYLOAD IF MDA IS FLOWN

NOTE 8: PIN 20 BLCMD 4 TO BE CONNECTED TO PIN 52 (MDA OPEN/CLOSE CONTROL) UNLESS PAYLOAD HAS OTHER PROVISION FOR GENERATING 28V 10MA SIGNAL TO OPEN DOOR (IF MDA IS FLOWN)

NOTE 9: WHEN DOOR IS FULLY OPENED, NORMALLY OPEN CONTACT IS SHORTED TO CENTER CONTACT. WHEN DOOR IS CLOSED, NORMALLY CLOSED CONTACT IS SHORTED TO CENTER CONTACT.

NOTE 10: SAFE/ARM CONNECTOR IS CURRENTLY CONFIGURED AS A FEED THROUGH, FROM OUTSIDE CANISTER TO EXPERIMENT.

TABLE 2.6

CIRCUIT PROTECTION REQUIREMENTS

MIN. WIRE GAUGE	MAX. FUSE	MAX.	TYP. FUSE

(IN A BUNDLE OF 20 WIRES)	SIZE (A)	LOAD (A)	VOLTAGE DROP
26	3	1.5	.163
24	5	2.5	.102
22	6	3.0	.102
20	7	3.5	.101
18	10	5.0	.098
16	14	7.0	.076
14	15	7.5	.116
12	20	10	.16

Six electrical interfaces are provided via six standard sets of cables and connectors. Two additional sets are reserved for system use. These provide up to 500W of 28VDC power to each interface and 50W of "Survival Heater Power." In addition to providing this type of interface during on-orbit operations, the HH has provisions for a transparent bi-directional data path between the customer's payload and the Customer Ground Support Equipment (CGSE). This type of interface allows the customer to maintain autonomous control over his/her payload.

The characteristics of the power will be the same as Orbiter power (see excerpts from Vol. XVI, ICD 2-19001, Appendix H of this document) except for higher source resistance due to the added carrier wiring. It is important to note that, while power is switched to each experiment through the HH avionics, no EMI filtering is provided. Customers will see the EMI environment specified in Appendix H and are expected to meet all EMI requirements by providing filtering with each experiment. Each power interface will consist of 28 VDC +/- 4 VDC power supplied via dual 12 gauge 10A circuits. Each of the dual circuits can be switched in through independent contacts of a Double-Pole Single Throw (DPST) relay (Figure 2.35). Each power interface will have independent current measurement capability. This data is available to the customer either in real-time or post-fight when specified as a requirement. Figure 2.36 provides a schematic drawing of the HH-S customer power interface. Customer signal ground must be isolated from chassis (case) ground for dc at a minimum resistance of 10K ohms, although there is no limitation on capacitative connection between signal ground and case. The 28V return must be isolated from both signal ground and case by a minumum resistance of 10K ohms. **This requirement cannot be waived.**

Tables 2.7 and 2.8 provide the detailed characteristics of the electrical system interfaces. A switch panel is used for carrier and experiment power activation and de-activation and may be used to provide a safety inhibit to a customer's hazardous function if required.

2.3.2 DC Power Ripple and Transient Limits (For Payload Main Circuit Only)

See Appendix H of this document.

TABLE 2.7

CUSTOMER ELECTRICAL INTERFACES AND SERVICE SUMMARY

---

1. 28 VDC (+/- 4 VDC) POWER (DUAL 10A CIRCUITS)
2. ASYNCHRONOUS INTERFACE (BI-DIRECTIONAL, 1200 BAUD)
3. SERIAL COMMAND (CLOCK/DATA/ENVELOPE) CAN ALSO FUNCTION AS
   INDIVIDUAL BI-LEVEL 0, +5V COMMANDS (3 EACH).
4. BI-LEVEL OR PULSE 0, +28V COMMAND (4 EACH)
5. IRIG-B MET AND MET ONE-MINUTE PULSE

6. MEDIUM-RATE KU-BAND DATA (16 Kb - 1.4 Mb/s TOTAL, CLOCK/DATA INTERFACE)

ITEMS 2, 3, 4, and 6 CAN BE INTERFACED TO CUSTOMER GSE

ITEMS 2 AND 6 ARE "TRANSPARENT" INTERFACES

TABLE 2.8

HITCHHIKER ELECTRICAL ACCOMMODATIONS

	TOTAL HH AND CUSTOMER PAYLOADS MAX	SINGLE CUSTOMER PAYLOAD PORT MAX
POWER (28 +/- 4DC)	1300W	500W
ENERGY (KWH)	60	10**
LOW-RATE DOWNLINK	6000 b/s	960 b/s*
MEDIUM-RATE DOWNLINK	1.4 Mb/s	1.4 Mb/s***
SERIAL COMMAND CHANNELS	6	1
BI-LEVEL COMMANDS	24	4

* NOMINAL INFORMATION RATE OF ONE STANDARD ASYNCHRONOUS CHANNEL. ANY COMBINATION OF FIVE 1.2k BAUD CHANNELS MAY BE DOWNLINKED SIMULTANEOUSLY.

** NOMINAL 1/6 ALLOCATION

* * * BY MISSION REQUIREMENTS

FIGURE 2.35 CUSTOMER POWER INTERFACE

FIGURE 2.36 HITCHHIKER AVIONICS UNIT-POWER DISTRIBUTION

2.4 COMMAND AND COMMUNICATION SUPPORT SYSTEM

2.4.1 Transparent Data System

Figures 2.37 through 2.42 illustrate the transparent data system available to the customer through HH. The figures present the command, low-rate and medium rate data flows. The data communications interface generally remains unchanged from the customer's point of view independent of whether the payload is at the customer's facility, at the integration facility, or during flight operations. All commands issued by the CGSE have the general format shown in Figure 2.39. Some ground data processing functions may have optional service charges for reimbursable customers. Contact the Project Office for details.

HITCHHIKER TRANSPARENT DATA SYSTEM

FIGURE 2.37

FIGURE 2.38 HITCHHIKER SIGNAL PORT
TO CUSTOMER INTERFACE

FIGURE 2.39 CUSTOMER ASYNCHRONOUS

MESSAGE FORMAT - GENERAL

FIGURE 2.40 CUSTOMER/CARRIER GROUND
SUPPORT EQUIPMENT (CCGSE)

FIGURE 2.41

HH COMMAND FLOW

FIGURE 2.42

HH MEDIUM RATE (MR) DATA FLOW

FIGURE 2.43

HH LOW RATE DATA FLOW

FIGURE 2.44 LOW RATE DATA PROCESSING SYSTEM
AND MEDIUM RATE DATA PROCESSING SYSTEM

2.4.2 Bi-Level Command System

Signals that traverse the bi-level command interface may be set to 0V (false) or +28V (+19.5 to +32V) (true), or may be pulsed from false to true and back to false. There are four bi-level signals per interface. Figure 2.45 illustrates the customer bi-level command interface while Figures 2.46 and 2.47 show the command formats. Only one of the four signals may be affected by any one command.

CUSTOMER BI-LEVEL COMMAND INTERFACE

FIGURE 2.45

FIGURE 2.46

CCGSE ASYNCHRONOUS FORMAT FOR 28 V BI-LEVEL COMMANDS

FIGURE 2.47

CUSTOMER MESSAGE FORMAT FOR 28 V PULSE COMMANDS

2.4.3 Serial Command System

The serial command interface consists of one signal set containing clock, data, and envelope, per customer interface. Signals that traverse this interface have voltage levels that are 0V and 5V for false and true conditions, respectively. The complete command, including sync, byte count, CID/type, and checksum, will be transferred to the user. The signal characteristics are shown in Table 2.9. The maximum number of data bytes is 4 (see Figures 2.48 and 2.49). Figure 2.48 shows the customer asynchronous CGSE format for serial commands. Figure 2.49 shows the customer serial command interface. The serial command signal is provided to support existing customer hardware and is not recommended for new flight equipment.

TABLE 2.9

DISCRETE OUTPUT LOW (DOL)/CARRIER-TO-PAYLOAD

ELECTRICAL INTERFACE CHARACTERISTICS

(SPOC SERIAL COMMAND INTERFACE)

PARAMETER	DIMENSION	CHARACTERISTICS OF CARRIER/PAYLOAD INTERFACE	NOTES
Type		Single-Ended	
False	min volt	-0.5	(1) (4)
("0")	max volt	+0.5	(1) (4)

True	min volt	+4.0	(1) (4)
("1")	max volt	+6.0	(1) (4)
Ripple & Noise		Milli-max volt	400
Rise/Fall Time		min Microsec	1 (2)
(10 to 90%)	max Microsec	20	(1)
Bit Rate	bps	125 +/-25	

TABLE 2.9 (Cont'd)

PARAMETER	DIMENSION	CHARACTERISTICS OF CARRIER/PAYLOAD INTERFACE	NOTES
Transfer	Direct Coupled	Grounded at Carrier	
Source Impedence		min ohm	30
(Carrier)	max ohm	100	

Load Impedence		min ohm	600
(Payload)	max ohm	4K	(3)
Capacitance	max Pico-Farad	3500	Payload not to exceed 1500
Pwr Off Impedence			min ohm10K (+6
VDC)	Payload shall exceed 600 w/pwr off		
Current Drive	Milliamp	10 (Logic "1")	
Current Sink	Milliamp	-10 (Logic "0")	+/- 0.5 volts
Overvoltage Protection	Max volt	±32	

TABLE 2.9 (Cont'd)

PARAMETER	DIMENSION	CHARACTERISTICS OF CARRIER/PAYLOAD INTERFACE	NOTES

Fault Voltage Emission	Max volt	±15
Fault Current Limitation	Max Milliamp	±20
Power-Ground Isolation	Megohms	10

Table 2.9 NOTES

(1) Reference Signal Ground
(2) 400 ohm ±5% in parallel with 5 nanofarad ±0% load
(3) An open input shall not result in an ambiguous logic state
(4) 0.2 millisecond state uncertainty maximum following power up

CUSTOMER ASYNCHRONOUS FORMAT FOR SERIAL COMMANDS

FIGURE 2.48

FIGURE 2.49

CUSTOMER SERIAL COMMAND INTERFACE

2.4.4 Asynchronous Uplink

The asynchronous uplink is used to transmit customer asynchronous command messages and Mission Elapsed Time (MET) messages to the payload.

The customer message format for asynchronous commands is shown in Figure 2.50. The format of the asynchronous MET message is shown in Figure 2.51. The format of the synchronize to met commend is shown on Figure 2.52. One receive data (RD) signal is available through each HH port.

The interface operates at 1200 baud asynchronous data rate. The signal format is shown in Figure 2.53 where each signal contains one start bit, eight data bits (no parity), and one stop bit. The uplink messages may originate from the CCGSE or from CGSE. The transport delay between CGSE and the customer's payload is nominally 2 to 20 seconds. The transport delays are due to latencies introduced by the number of CGSEs issuing commands, the networks, JSC Mission Control Center (MCC) and uplink delays. The delay does not account for retrying a command because of command uplink failure.

Customer CGSE's are connected to the CCGSE via the Command Concentrator Interface (CCI) referenced in Figure 2.41. This device places some limitations on user command thru-put, especially for long "back to back" experiment command strings.

In reference to the HH Command Flow, the following three elements apply:

1. The presence of a 1200-baud CGSE/CCI line does not mean that the user can continuously pump commands at this rate. The maximum command string length is 119 bytes. User minimum Delay Time (DT) between command strings sent by its CGSE to the CCGSE CCI is:

   DT = (Number of active command lines) * (400 milliseconds).

   This had been derived from extensive testing of the current CCI properties. The CCI has a single buffer for encoding user commands for its interface to the CCGSE computer. This buffer is called CCI Block Buffer. The CCI also has six Input Buffers to store user input commands for the CCI/CGSE Command Interfaces.

   It takes the CCI 400 milliseconds to encode one of the six user Input Command Buffers into the CCI Block Buffer and transfer it to the CCGSE computer. It will take twice as long, on average, to process two user Input Buffers. If user does not enforce a delay of DT milliseconds between long command strings, a CCI overflow can occur placing the CCI into an unpredictable state.

2. Once a CCI Command Block is transmitted to the CCGSE computer, the CCGSE Command Subsystem places the block into a unique user command queue. This queue will not be the subject of command transmission for the time Tmin = 6 seconds and until a previously transmitted command block is acknowledged by SPOC avionics in telemetry.

   The user is advised to hold its long command strings in its own CGSE for DT time rather than using the CCGSE to stage its long command strings.

   Command string staging is of significant overhead for the CCGSE. Suggested average separation between long strings of Universal Asynchronous Receiver Transmitter (UART) commands with two active command lines is 800 milliseconds.

3. Note that the CCGSE "round-robin" prioritization of users can improve the CCGSE processing of long and short command strings generated by two concurrent users.

CUSTOMER MESSAGE FORMAT FOR ASYNCHRONOUS COMMANDS

Figure 2.50

Figure 2.51

CUSTOMER MESSAGE FORMAT FOR MET

Figure 2.52

SYNCHRONIZED MET COMMAND

Figure 2.53

CUSTOMER ASYNCHRONOUS RD INTERFACE

2.4.4.1 Orbiter Computed Data. A future capability is planned for transferring the output of payload-related Orbiter processes to the payloads. The Orbiter-computed data and Orbiter/payload-related processes available to support payloads are defined in the following paragraphs.

2.4.4.2 Orbiter State Vector/Attitude Data. Capability to transfer Orbiter state data to payloads is planned. The data to be transferred consists of the Orbiter state/vector attitude relative to Greenwich true of date Cartesian or Aries mean of 1950, Cartesian coordinate system, and Orbiter attitude rates about the Orbiter body axes.

2.4.4.3 Time Tag Accuracy. Under error-free on-orbit conditions, the MET shall be within plus or minus five milliseconds of the time at which the state vector or attitude is calculated.

2.4.4.4 Transport Lag. The Orbiter state vector/attitude message shall be output from the General Purpose Computer (GPC) no later than five seconds past the MET time tag of the data. However, errors occurring in the Orbiter Data Processing System (DPS) and Guidance, Navigation, and Control (GN&C) sensors may cause occasional degradation of this interface.

2.4.5 Asynchronous Downlink

One asynchronous Send Data (SD) signal per interface that operates at 1200-baud asynchronous and has a similar message pattern (one bit start, 8 data bits, and one stop bit) as the uplink interface is available through the HH interface. (See Figure 2.54).

The downlink can support continuous 1200-baud transmission which will be routed to the customer's GSE via the CCGSE to CGSE interfaces. Downlink messages do not have a format requirement. Nominally, the transport delay between customer payload and customer GSE is 5 to 15 seconds. The standard HH carrier arrangement can simultaneously downlink any five asynchronous downlink channels selected by command.

FIGURE 2.54

CUSTOMER ASYNCHRONOUS SD INTERFACE

2.4.6 Medium-Rate Ku-Band Downlink

The carrier contains a Medium-rate Multiplexer (MRM) capable of multiplexing up to six simultaneous customer-provided serial-bit non-return to zero (NRZ) data signals into a single serial 2MB/s bit-stream for transmission via channel 2 of the Orbiter Ku-band Tracking and Data Relay Satellite System (TDRSS) signal processing system. The combined input rate to the MRM from all HH experiments cannot exceed 1.4 MB/s. This effectively limits customer downlink rates if the MRM is accepting data from more than one source. As previously shown in Figure 2.42, channel 2 is not available for exclusive use of HH data but is shared with dumping of the Orbiter's tape recorder and the payload interrogator. In addition, use of the medium-rate system requires the TDRSS as well as deployment and pointing of a steerable antenna on the Orbiter which cannot be used in certain attitudes or orbit positions. In general, Ku-band medium-rate service should be available approximately 50 percent of the time during a typical flight.

Each customer-supplied input data stream must be continuous and stable within 1 percent of its assigned data rate during the customer's data-take periods. If the customer's desired information is discontinuous or event-oriented, then the data stream supplied by the customer may be discontinuous with the clock stopping between periods of valid data. Alternately, the customer's equipment may transmit continuous clock but discontinue transmitting valid frame synchronization patterns. Each valid data period must be proceeded by no less than 4 data frames of leader telemetry (to provide for synchronizing GSFC and customer ground equipment) prior to the first frame of required data (assuming the customer's GSE can synchronize within one frame of data). Since the MRM contains data buffers for each customer, each data period must be followed by at least 66 bytes of clock to flush the buffer. The main purpose of discontinuous data is to avoid generating magnetic tapes of data which are not desired since a considerable amount of tape is involved at the higher data rates. Customer data during valid data periods must consist of a continuous series of data frames each containing a fixed integral multiple of 8 bits but no more than 8,192 bits. Each data frame must contain a fixed synchronization pattern of at least 24 bits to be specified by the customer. The pattern FAF320 (hexadecimal, most significant bit and byte first) is recommended. The remaining format of the data frames can be determined by the customer as desired; however, the following considerations should be taken into account. Each data frame should contain a frame number that does not repeat for at least 256 frames as well as time information adequate for the customer's needs; it should also contain provision for error detection if necessary to meet the customer's goals.

During testing and flight operations, the Medium-Rate Data Processing System (MRDPS), referenced in Figure 2.42, will decommutate the multiplexed signal and regenerate the customer's clock and data for use by the CGSE. This data interface is shown in Figure 2.55. The clock will generally be at a slightly higher bit rate than the onboard customer supplied clock. The ground clock and data will stop momentarily periodically to equalize the average data rate.

The data bit error rate is expected to be generally no worse than 10^{-5}; however, there will be periods of dropout and deteriorated data especially near the ends of TDRSS coverage periods. The data delay will be several hundred bytes plus approximately 2 seconds. The CGSE must be designed to obtain and maintain synchronization and otherwise operate in a satisfactory manner under these conditions.

The electrical interfaces and timing for the medium-rate system are shown in Figures 2.56, 2.57, and 2.58. Data signals are connected to CGSE by means of a transparent interface. Data return on the ground can be either by NRZ-L serial data and clock interface identical to Figures 2.56, 2.57 and 2.58 or post mission by Computer Compatible Tape (CCT). The CCT format is shown in Appendix C and will be frame synchronized data sets if the customer uses a fixed-frame length. GSFC engineers can assist customers in the design of prospective medium rate (MR) telemetry formats. Again, the customer's medium-rate ground data interface is shown on Figure 2.55.

Figure 2.55

CUSTOMER MEDIUM RATE GROUND DATA INTERFACE

FIGURE 2.56 MEDIUM RATE CUSTOMER INTERFACE

FIGURE 2.57

MEDIUM RATE CUSTOMER DATA

FIGURE 2.58

MEDIUM RATE CUSTOMER CLOCK

2.4.7 Pulse Code Modulation (PCM) Telemetry

A five-wire interface (continuous clock, data 1, data 2, envelope 1, envelope 2) is available for Pulse Code Modulation (PCM) telemetry interfaces. This five-wire interface is only available by special negotiations with the HH Project, and if the bandwidth is available. The CCGSE can extract PCM data and send it to the CGSE. See Section 2.4.9 for a discussion of the interface. The wave forms and electrical interfaces are shown in Figures 2.59 and 2.60. A continuous clock controls transmission of data on both of the two data lines. The envelope signals indicate the times at which data is being accepted on the respective data lines. Data is accepted in multiples of 8 bits and the envelope pulses will be an integral multiple of 8 bits in length. The clock rate (and bit rate) will be nominally 8 KB/S for HH. The sample timing for channels 1 and 2 is controlled by a mission-unique read-only memory and will be negotiated on a mission-unique basis with each user of the PCM data interface. The PCM five-wire interface is provided to maintain compatibility with existing equipment and is not recommended for new flight equipment.

FIGURE 2.59 PCM DIGITAL INTERFACE WAVEFORMS

FIGURE 2.60

CUSTOMER PCM DATA INTERFACES

2.4.7.1 Analog Data. One analog data line is provided in each standard interface. This line is sampled at a rate of approximately 15 Hz. Voltages in the range of -0.06 to 5.04 volts are converted to 8-bit values (00 and FF, respectively). Voltages slightly below -0.06 or above 5.04 volts will be transmitted as 00 or FF (i.e., no foldover occurs). An index pulse on a separate wire occurs once per sample and can be used to advance a customer-supplied analog multiplexer to allow multiple parameters to be sampled over the single analog line. Several (typically three) of the multiplexer's inputs should be connected to known fixed voltages (e.g., +5.10, zero, +2.50) to allow the customer's ground equipment to determine synchronization with the returned sample sequence. Analog interfaces are shown in Figure 2.61.

FIGURE 2.61

CUSTOMER ANALOG DATA INTERFACES

2.4.7.2 Temperature Data. As provided in each interface, three additional analog data lines (Figure 2.31) are sampled at approximately .5 Hz (-0.06 - +5.04v, 8 bits) and are provided with a regulated power source and resistor network. These are intended for connection to YSI 44006 (see Section 2.2.2) thermistors to be supplied by GSFC and installed inside the customer's flight equipment by the customer. These networks and thermistors allow temperatures in the range of -20 to +60 degrees C to be measured without requiring the customer equipment to be operating. If all the thermistor lines are not required for temperatures, they may be used by the customer to measure other parameters such as: canister temperature, bottom plate temperature, canister pressure, and door position (if door is present).

2.4.8 Inter-Range Instrumentation Group, Type B (IRIG-B) MET Signal

Orbiter MET in IRIG-B format will be distributed to each interface. This signal is maintained to within 10 milliseconds (ms) and consists of a 100 Pulse Per Second (PPS) Pulse-Width-Type PCM signal giving days, hours, minutes, and seconds, once each second. In addition, there will be a MET minute signal; Transistor-Transistor Logic (TTL) levels, nominal square wave 1 ppm; edges traceable to MET within 10 ms. The customer timing interface is shown in Figure 2.62. Greenwich Mean Time (GMT) may be used in place of MET on some HH missions.

In general, post mission data tapes supplied by the HH Project will have time indications which can be interpreted to within 10 seconds. Real-time data transmitted to customer's GSE can usually be tagged by the customer's software to within 10 seconds. Therefore no time signals may be necessary at the customer's payload if time knowledge to within 10 seconds is adequate. If it is necessary to have time knowledge within the customer's payload, the MET minute signal can be used to reset a customer one-minute clock to 10 milliseconds accuracy. If the customer is using the asynchronous command channel, day-hour-minute-second time may be sent to the customer's payload periodically to update an on-board clock to within 3 seconds. This may be used in conjunction with the above minute pulse to obtain maximum accuracy. The IRIG time signal may also be decoded to obtain day-hour-minute-second time to within 10 milliseconds but is recommended only for existing designs because of the larger number of electronic parts required for decoding.

FIGURE 2.62

CUSTOMER INTERFACES FOR TIME

FIGURE 2.63 MET OUTPUT FORMAT

The signal characteristics of this interface are described in paragraph 8.2.10 of JSC 07700 Vol. XIV Attachment 1 (ICD 2-19001) SHUTTLE ORBITER/CARGO STANDARD INTERFACES, Rev. K dated January 15, 1991. This paragraph follows.

> [8.2.10.1.1] GMT (in HH Application, MET). The absolute time data, at any given time during a seven-day mission, shall not deviate by more than +/- 10 milliseconds from the ground station MET Reference Time Standard and shall be synchronized with the ground MET at certain times during a mission, subject to mission procedural constraints to prevent unacceptable time base perturbations. The accuracy of these time updates shall be +/- 5 milliseconds. The Master Timing Unit (MTU) frequency offset and drift rates shall constrain the time error growth rate to a maximum of +/- 10 milliseconds per 24 hours.

The MET output format shall be modified IRIG-B as shown in Figure 2.63. The electrical interface characteristics were previously shown in Figure 2.60.

2.4.9 CGSE Interface

Overall communication between the customer's payload and their ground support equipment are shown in Figure 2.64. The CCGSE provides the customer with (1) the command interface between the CGSE and the customer payload, (2) low-rate customer payload data as telemetered by the HH avionics, and (3) Orbiter ancillary data. The CCGSE provides two asynchronous data lines for these purposes.

The CCGSE will accept command requests from the CGSE over a 1200 baud RS-232-C link or a 1200 baud RS422 link. These commands will be screened by the CCGSE for criticality, formatted for the HH avionics, packaged for the appropriate transmission mode (network or Space Shuttle simulator), and transmitted. The CCGSE will verify that the commands were accepted by the HH avionics. It will not, however, monitor the telemetry to determine if the payload responded to the commands. Commands that are rejected by the networks or HH avionics will be retransmitted upon the direction of the CCGSE operators. The CCGSE will perform limited health and safety checks for the customer payload such as monitoring customer payload power currents and temperatures.

FIGURE 2.64

HITCHHIKER/CUSTOMER COMMUNICATIONS

The CCGSE will extract payload asynchronous downlink data and send it in near real-time to the CGSE. The CCGSE can provide this data in two modes:

(1) Customer 1200-baud, asynchronous data identical to downlink data received from customer's payload except that any time gaps between characters may not be preserved. The electrical interface can be RS422 (Figure 2.54) or alternately RS-232 C.

2) Reformatted customer data in blocks with additional intermixed blocks of ancillary information transmitted in 19.2 K-baud synchronous format over an RS-232 C connection.

The CCGSE can send a subset of the Orbiter's ancillary data to the CGSE. These data are transmitted over a 19.2 K-baud asynchronous RS-232-C line. If the rate and/or format of the Shuttle Orbiter auxiliary data changes, the message format and line rates used for the CCGSE will change appropriately. A summary of the RS-232-C lines and rate requirements and uses are presented in Table 2.10.

The following paragraphs define in detail the data transferred between the CCGSE and CGSE and the electrical interfaces supported by the CCGSE.

For formatted data, an RS-232 port is provided for the transmission of Space Shuttle-related data, HH system ancillary data, customer energy data, command acknowledgements, CCGSE blocked payload data from one or more HH asynchronous ports and payload PCM data. The aggregate data rate of all the multiplexed data (including overhead) will not exceed 75 percent of the data line baud rate.

TABLE 2.10

CCGSE - CGSE COMMUNICATIONS

LINE

L I N E

#	CHARACTERISTICS	FUNCTION	COMMENTS
1	FULL DUPLEX, 1200 BAUD, NO ECHO, 1 START, 1 STOP, NO PARITY, RS422 OR RS232	CCGSE RECEIVE SIDE: CGSE COMMAND MESSAGES CCGSE SEND SIDE: RAW PAYLOAD DATA FROM SPOC ASYNCHRONOUS SEND DATA PORT.	1 LINE PER CID
2	HALF DUPLEX, 19.2K BAUD, NO ECHO, 1 START, 1 STOP, NO PARITY, 8 BIT DATA RS232	MULTIPLEXED DATA MESSAGES OF ANY OF THE FOLLOWING TYPES: 2 - CUSTOMER ASYNC DATA 3 - CUSTOMER ANALOG DATA 4 - HH ANCILLARY DATA 5 - CUSTOMER COMMAND COMPLETION 6 - CUSTOMER COMMAND LINK STATUS 10 - SHUTTLE ANCILLARY DATA	1 LINE PER CID IF UTILIZATION RATE EXCEEDS 75% OF BAUD RATE, A SECOND LINE WILL BE REQUIRED

(ORBIT/ATTITUDE)

14 - CUSTOMER PCM-B DATA

15 - CUSTOMER PCM-A DATA

Whenever the data rates are predicted to exceed the 75 percent threshold, another RS-232 line will be provided. In this case, the assignment of data type transferred over each line will be negotiated by the Project. The user may reconstruct each data stream by grouping data of similar types.

HH system ancillary messages consist of data telemetered by the HH avionics. They include the payload temperatures, relay states, current load, user analog data, and energy usage. The frequency and content of this message is dependent upon the mission-peculiar HH telemetry format. Currently, the message is transmitted approximately once every 4 seconds assuming a nominal 8 kb/sec telemetry rate.

A 1200-baud asynchronous port is provided for direct transfer of customer payload asynchronous downlink data. Customer data are transmitted to the CGSE without any data reformatting. One 1200-baud asynchronous port will be provided for each HH asynchronous port used.

All data, with the exception of customer payload asynchronous data, transferred to the CGSE from the CCGSE will be formatted into messages as shown previously in Figure 2.57. Each user will be assigned a Customer Identification (CID) by the HH Project. The customer will be issued multiple CIDs if the payload uses more than one HH port.

PCM and customer payload asynchronous data transferred between the CCGSE and CGSE will be packetized and received asynchronously. No attempt is made to simulate the timing relationship between data bytes as sampled on-board by the HH avionics or between the various independent data streams. No retransmission of data is provided.

The Space Shuttle orbit and attitude messages will contain data extracted from the Shuttle Ancillary Data blocks sent to the CCGSE by the Shuttle MCC. No conversion of the data will be performed.

Asynchronous downlink payload telemetry data are available in one of two modes: (1) transmitted over a dedicated 1200-baud, asynchronous port without any framing by the CCGSE, or (2) multiplexed with Shuttle orbit and attitude data and HH ancillary data. In the second mode, the CCGSE will place payload data originating from unique HH asynchronous ports into individual messages. In either case, no attempt is made to synchronize the data within the messages.

The CGSE may issue payload commands using the command line provided by the CCGSE. Commands are formatted as if they were being issued directly to the payload. The CCGSE will hold and release the commands after 119 command data bytes have been received (the maximum command string length) or when a time gap between commands is detected. After transmission by the CCGSE, the CCGSE issues an optional command acknowledgment message indicating the number of commands successfully transmitted to the HH avionics. Upon receipt of this message, the CGSE may issue another set of commands.

If the CGSE does not opt for the command completion message, the CGSE should verify the receipt of the commands by the payload prior to transmitting more commands. Failure to do so may result in the loss of commands because the command link is slower than the aggregate command rate of all the users. In fact, transmission delays of 10-20 seconds may be common in operations because of additional delay in the networks and MCC.

2.4.9.1 CCGSE-CGSE Physical Interface Requirements. The asynchronous interfaces provided for the transmission of HH ancillary data, formatted payload data, Shuttle orbit and attitude data are RS-232-compatible. The interfaces for customer payload asynchronous telemetry and command generation are RS-232 or RS-422-compatible. Some of the characteristics of the lines and usage were defined in Table 2.10. Refer to Tables 2.11 and 2.12 for connector types and pin assignments.

The customer must negotiate with the HH Project to determine the exact configuration requirements for a particular mission.

TABLE 2.11

PIN DESIGNATION
FOR
RS-422 ASYNCHRONOUS SERIAL COMMAND
MESSAGES
AND UNFORMATTED DATA
(EGSE or CGSE to SPOC CCGSE)

Pin Number	Function	Comments
1	Frame Ground	Connector Type -
2	(+) Transmit Data	25-Pin Male
3	Signal Ground	Suggested Part
4	(-) Transmit Data	Sources
5	Signal Ground	(Male Connectors)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/M 0325PV
8	(-) Receive Data	2. TRW 'Cinch'
9	Signal Ground	P/M DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

TABLE 2.12

PIN DESIGNATION
FOR
RS-232 ASYNCHRONOUS SERIAL FORMATTED PCM DATA
AND
SPOC ANCILLARY AND SHUTTLE ORBIT/ANCILLARY DATA
OR
CGSE TO SPOC CCGSE SERIAL COMMAND MESSAGE AND UNFORMATTED DATA

Pin Numbers	Functions (CCGSE)
1	Frame Ground (FG)
2	Transmit Data (TD)
3	Received Data (RD)
4 - 6	N/C
7	Signal Ground (SG)
8 - 25	N/C

2.4.9.2 CCGSE-CGSE Telemetry Interface. The CCGSE can provide HH telemetry and payload telemetry to the CGSE. The following subsections describe the format of the data transferred. No data interpretation or conversions are performed by the CCGSE. All data of a given type are transferred in a time-sequential order.

1. Unformatted Customer Payload Asynchronous Downlink Data

The customer may receive the payload asynchronous data in real time in a "transparent" manner. The data are bursted to the CGSE over a 1200-baud line as they are received by the CCGSE. These data are transmitted over the asynchronous CGSE command line. No attempt is made to synchronize this stream with any other data stream. No attempt is made to maintain the data sampling timing relationship within a stream.

2. Formatted Customer Asynchronous Downlink Payload Data (Type 2)

The customer may receive asynchronous payload data in real time multiplexed with other HH telemetry over one CCGSE-CGSE RS-232 line. The CCGSE throughputs the data without attempting to synchronize to the payload data.

The CCGSE formatted messages contain a maximum of 120 bytes of payload data and contain the HH time code of the telemetry frame containing the last data byte transmitted within the message. This data message format is shown in Table 2.13. The CCGSE schedules transmission of these blocks upon the filling of the data fields within the message or after one second if the message is not empty. If these messages are multiplexed with other message blocks, the timing between messages is erratic. Note that it is possible to receive a block with "no data bytes" if a sync error is encountered.

TABLE 2.13

CCGSE FORMATTED ASYNCHRONOUS DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	$0 \leq N \leq 120$
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 6$
3	5-8	Message type	2
4-5	1-8/1-8	Binary day of MET from SPOC PCM frame containing last payload data byte (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8	Milliseconds of day from SPOC PCM frame containing last payload data byte. Treated as a 32-bit integer (M)	$0 \leq M \leq 86399999$
10	1	SPOC minor frame sync loss indicator 1 = sync loss during data collection	0/1
10	2	MCU frame sync loss indicator 1 = sync loss during data collection	0/1
10	3	MCU encountered data overrun if set to 1	0/1

10	4	MCU encountered parity error if set to 1	0/1
10	5-8	Spare	0'S
10+N	1-8	Payload data	0-255
11+N	1-8	Exclusive OR of bytes 2 through (N+10)	0-255

3. Customer Analog Data (Type 3)

The customer may receive data from its analog channel assigned by the HH mission. The CCGSE format the data into message blocks as shown in Table 2.14. The data are tagged with the HH time code (MET) of the minor frame containing the last byte of user data transmitted within the message. No attempt is made to synchronize the data within the sequence of analog samples. This message is scheduled for transmission to the CGSE every HH major frame. It is multiplexed with other ancillary and command acknowledgment messages, hence the timing between the messages is erratic. However, the time for messages of the same time is in ascending order.

4.HH Ancillary Data Message (Type 4)

The CCGSE will provide HH avionics ancillary data messages which contain information such as temperature data, bus voltage, relay states, etc. The format of the HH ancillary data messages is defined in Table 2.15. The time field is the HH time code of the minor frame from which the last data byte was sampled.

TABLE 2.14

CCGSE FORMATTED PAYLOAD ANALOG DATA STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5(Base 16)
2	1-8	Number of data bytes in message	32
3	1-4	Customer Identification (CID)	$1 \leq \text{CID} \leq 6$
3	5-8	Message type	3
4-5	1-8/1-8	Binary day of year from SPOC PCM frame containing last byte of multiplexer data transferred (DD)	$0 \leq \text{DD} \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day from SPOC PCM frame containing last byte of analog data transferred (M)	$0 \leq \text{M} \leq 86399999$
10	1	SPOC minor frame sync loss during data collection if set	0/1
10	2-8	Spare	0
11-42	1-8	Analog data	0-255
43	1-8	Exclusive OR of bytes	0-255

TABLE 2.15

CCGSE ANCILLARY DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	10
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 6$
3	5-8	Message type	4
4-5	1-8/1-8	Binary day of year	$0 \leq DD \leq 366$
6-9	1-8/1-8/1-8/1-8	Milliseconds of day	$0 \leq M \leq 86399999$
10	1	HH minor frame sync loss indicator (1=Loss)	0/1
10	2	MCU sync loss indicator (1=Loss)	0/1
10	3	SPOC analog channel sync loss (1=Loss)	0/1
10	4-8	Spare	0
11	1-8	Current drawn by user in counts (as telemetered)	0-255
12	1-8	Relay status as telemetered	0-255
13	1-8	Heater bus status	0-255
14	1-8	Thermistor #1 reading in counts	0-255
15	1-8	Thermistor #2 reading in counts	0-255
16	1-8	Thermistor #3 reading in counts	0-255
17	1-8	Energy usage as computed by MCU in counts (Sample 1)	0-255
18	1-8	Bus voltage as sampled by MCU in counts (sample 1)	0-255
19	1-8	Energy usage as computed by MCU in counts (sample 2)	0-255
20	1-8	Bus voltage as sampled by MCU in counts (sample 2)	0-255
21	1-8	Exclusive OR of bytes 2-20	0-255

5.Shuttle Orbit and Attitude Data Messages (Type 10)

The customer may receive the Shuttle orbit and attitude parameters as they are received by the CCGSE from the Calibrated Ancillary System (CAS). No attempt is made to convert the data values. The time field is contained in the Shuttle ancillary data block received from the CAS. Table 2.16 depicts the default format and content of the message. The frequency of the message is approximately once a second. The customer may negotiate with the Project for the inclusion of other data found in the Shuttle ancillary data block.

Algorithms for converting the quaternions in these messages to RA/DEC of the Z axis or orbiter R,P,Y angles are given in Appendix G.

TABLE 2.16

SHUTTLE ORBIT AND ATTITUDE DATA MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5(Base 16)
2	1-8	Number of data bytes in message, excluding header and checksum	92
3	1-4	Customer Identification (CID)	1 ≤ CID ≤ 6
3	5-8	Message type	10
4-5	1-8/1-8	Binary day of year computed from Primary Source MET	0 ≤ DD ≤ 366
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day computed from Primary Source MET	0 ≤ M ≤ 86399999
10	Spare		
11-18	All	X-Component of current Shuttle position vector in IBM floating point. M50 coordinate system.	
19-26	All	Y component of current Shuttle position vector IBM floating point. M50 coordinate system.	
27-34	All	Z component of current Shuttle position vector in IBM floating point M50 coordinate system.	

35-38	All	X component of velocity vector in IBM floating point. M50 coordinate system.	
39-42	All	Y-component of velocity vector in IBM floating point. M50 coordinate system.	
43-46	All	Z component of velocity vector in IBM floating point. M50 coordinate system.	
47-54	All	Time Tag associated with current state in IBM floating point.	

TABLE 2.16 (Cont.)

Byte	Bits	Function	Value
55-58	All	M50 to measured body quaternion element 1 in IBM floating point	
59-62	All	M50 to measured body quaternion element 2 in IBM floating point	
63-66	All	M50 to measured body quaternion element 3 in IBM floating point	
67-70	All	M50 to measured body quaternion element 4 in IBM floating point	
71-74	All	M50 WRT LVLH quaternion element 1 in IBM floating point	
75-78	All	M50 WRT LVLH quaternion element 2 in IBM floating point	

79-82	All	M50 WRT LVLH quaternion element 3 in IBM floating point
83-86	All	M50 WRT LVLH Quaternion Element 4 in IBM floating point
87-102	All	Vernier Jet Data
103	1-8	Exclusive OR of bytes 2-102

TABLE 2.16 (Cont)

VERNIER JET DATA

Bytes 87-102

Up to 16 Samples of Orbiter Vernier Thruster Data in Time Sequence

Bit 1 = 0 Valid Sample
Bit 1 = 1 Fill (No valid sample)

Bit 2 Spare

Bits 3-8 Vernier Jet Data
1 = Jet Firing
0 = Jet Not Firing

BIT	JET	POSITION	PLUME DIRECTION
3	F5L	FWD-Left	Down/Left
4	F5R	FWD- Right	Down/Right
5	L5D	AFT-Left	Down
6	L5L	AFT-Left	Left
7	R5R	AFT-Right	Right
8	R5D	AFT-Right	Down

6.Payload PCM Data Messages (Type 14/15)

The customer may receive its contribution to the PCM telemetry (see sub-section 2.4.7) stream. The CGSE will format the data into message blocks shown in Table 2.17. The time field is the HH time code associated with the minor frame from which the last data byte was extracted. This data may be multiplexed over the asynchronous line used for Shuttle auxiliary data or transmitted over a dedicated line. The exact details must be negotiated with the HH Project.

TABLE 2.17

CCGSE FORMATTED PAYLOAD PCM DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of PCM data bytes in message, starting byte 11 to end not incl. check sum	1 ≤ N ≤ 255
3	1-4	Customer Identification (CID)	1 ≤ CID ≤ 6
3	5-8	Message Type	15 (PCM A) or 14 (PCM B)
4-5	1-8/1-8	Binary Day of Year	0 ≤ DD ≤ 366
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day	0 ≤ M ≤ 86399999
10	1	HH-S Sync loss indicator (1 = loss)	0/1

102-8		SPARE	
111-8		PCM Data	
*		*	
*		*	
*		*	
10+N	1-8	PCM Data	
N+11	1-8	exclusive OR of bytes 2 through N + 10	0-255

2.4.9.3 CCGSE-CGSE Command Messages. Messages are exchanged between the CCGSE and CGSE for payload commanding and command acknowledgment.

1. CGSE Command Messages

The CGSE CCI will buffer the commands for transmission to the HH avionics in a burst. The commands are not released by the CCGSE CCI until either (1) 100 milliseconds have elapsed between command messages or (2) the maximum of 119 bytes have been transferred. This maximum is the longest command message that can be transmitted to the avionics.

2. CCGSE Command Acknowledgement (ACKS) Messages (Types 5/6)

These messages are multiplexed with the HH system ancillary data messages, Shuttle orbit and attitude data messages, etc. All messages are optional.

The CCGSE will originate messages if errors are detected in the command data link. The messages indicate the error and the number of commands rejected by the CCGSE because of the error. The format of the messages is shown in Tables 2.18 and 2.19. These messages are transmitted from the CCGSE to the CGSE on the 19.2k baud link. The time in these two messages is the CCGSE computer GMT time when the message was generated.

TABLE 2.18

CCGSE COMMAND COMPLETION STATUS

MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in the message, excluding header and checksum	2
3	1-4	Customer Identification (CID)	1 ≤ CID ≤ 6
3	5-8	Message type	5
4-5	1-8/1-8	Binary day of year	1 ≤ DD ≤ 366 (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day	0 ≤ M ≤ 86399999
10	1-8	Spare	0
11	1-8	Number of commands transmitted	
12	1-8	Number of commands accepted by SPOC	
13	1-8	Exclusive OR of bytes 2-12	0-255

Note 1: This time is the CCGSE computer GMT time.

TABLE 2.19

CCGSE DATA LINK STATUS

MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in message, from bytes 11 to end not including check sum	2
3	1-4	Customer Identification (CID)	1 ≤ CID ≤ 6
3	5-8	Message Type	6
4-5	1-8/1-8	Binary day of year	1 ≤ DD ≤ 366 (Note 1)
6-9	1-8/1-8/ 1-8/1-8	of day (M)	Millisecond time0 ≤ M ≤ 8639999
10	1-8	Spare	0
11	1-8	Number of command bytes accepted or rejected	1 ≤ M ≤ 120
12	1-8	Status indicator (no bits set = received CMD without errors)	
	Bit #1	- CGSE shipped too many	

		bytes in command message	
	Bit #2	- Parity error in transmission between CGSE-CCGSE	
	Bit #3	- Data overrun	
	Bit #4	- Framing Error	
	Bit #5	- Invalid CID	
	Bit #6	- Checksum Error	
	1-8	Exclusive OR of bytes 2 through 12	0-255

Note 1: This time is the CCGSE computer GMT time.

TABLE 2.20

CCGSE AIA DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message from byte 11 to end not including checksum	73 or 14 (Note 2)
3	1-4	Customer Identification (CID)	0
3	5-8	Message Type	0
4-5	1-8/1-8	Binary day of the year	

(GMT) 0<=DD<=366 6-9 1 -8 / 1 -8 / 1 -8 / 1

8 Milliseconds of day (GMT) 0<=M<=86399999

1	1-8	Spare	0
11-83	1-8/all	73 bytes of Alternative AIA or MCU subcom Data (Note 1)	0-255
84	1-8	Exclusive OR of bytes 2-83	0-255

Notes: 1. The 73 byte data field contains:

9 byte header + 64 byte AIA frame or
9 byte header + 16 byte status + 48 byte MCU subcom

The header and status fields contain information internal to the CCGSE for the CCGSE use only.

2. When the data field contains 14 bytes, it is a status message
internal to the CCGSE.

2.4.10 Crew Control (CC)

The CC system provides a second method (independent of the ground command system) for controlling the flow of power to the customer payloads and, thus, ensures that power could be removed from the payload even in the event of any single failure. Since two independent commands (crew and ground) are required to apply power to a customer payload, two inhibits are present to prevent a hazardous payload function from occurring during ascent or descent. Additional crew control functions can be used to inhibit a hazardous payload function during on-orbit operations.

CC of the carrier power system (see Figure 2.33) is implemented using the first two switches S1 and S2 (DS1 and DS2 indicate the state of S1 and S2) of the SPASP or normally the first two switches of the SSP (see Figure 2.65). The carrier can be assigned to either half of the SSP and if assigned to the other half, S13 and S14 (DS13 and DS14 indicate the state of S13 and S14) would be used. The remaining switches can be assigned to a customer function with a negotiated electrical interface. Switch panel control is normally provided only to inhibit a hazardous function or provide a crew controlled function which must be synchronized with some other crew activity such as Orbiter attitude control. The use of the SPASP or SSP is determined by NASA based on the STS manifesting rules. The available switch and indicator characteristics are shown in Figure 2.66. The SSP cargo switching and fusing interface schematic is shown in Figure 2.67 (sheet 1 & 2).

2.4.11 Undedicated Connections in Standard Interface

Some Twisted Shielded Pair (TSP) and single wires in each interface are undedicated and may be connected by mission unique jumper plugs to the following:

1. CC (Switch Panel)
2. Undedicated wires in a second standard interface port assigned to the same customer.
3. Other function as negotiated.

Use of the special connections may result in conflicts between customer payloads on the same flight and may therefore reduce manifesting possibilities and flight opportunities for each customer.

FIGURE 2.65
SPASP AND SSP SWITCH PANELS

FIGURE 2.66

SPASP OR SSP SWITCH AND INDICATOR CHARACTERISTICS

FIGURE 2.67 (sheet 1)

SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC

FIGURE 2.67 (sheet 2)

SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC

2.4.12 Orbiter CCTV Interface

A special interface can be provided on SMC payloads to allow the display of a customer payload generated TV signal in the crew cabin. This signal can also be recorded on-board or transmitted to the ground. The signals are standard National Television Standard Committee (NTSC) (EIA RS170/RS330) color or black and white television signals transmitted on a differential interface. Details of the CCTV interfaces and services can be provided by the project office.

2.5 Hitchhiker-JR (HH-J)

2.5.1 Hitchhiker-JR Overview

The HH-J carrier provides mechanical and electrical interfaces similar to the existing GAS carrier which has been used in the past to carry Shuttle secondary payloads. Following availability of the new carrier, the GAS carrier will not be used for secondary payloads.

The new avionics system (Figures 2.68 - 2.70) provides for better monitoring of carrier functions and can provide improved monitoring and power services for customer equipment if desired.

The HH-J carrier system consists of a canister (with or without a motorized door) equipped with a HH Remote Interface Unit (HRIU). The HRIU communicates via the GAS intercom line with a Payload and General Support Computer (PGSC) in the crew cabin. The PGSC is a lap top class personal computer and contains payload unique software provided by SSPP.

The HH-J avionics is operated from Orbiter power unlike the GAS avionics which is battery operated. Orbiter power may also be used for heaters and can be used to operate customer equipment if certain restrictions are met. Customer equipment may also be operated from customer supplied batteries if desired.

During flight operations, the crew controls HH-J and GAS payloads using a menu type control and display interface on the PGSC. Unlike the avionics used with GAS, the HRIU reports carrier status information for display to the crew. The status information includes canister temperature and pressure, customer battery voltage and current, door status, and commanded relay status. This information will help SSPP, the customer, and flight crew make decisions during the flight. On some missions it will be possible to record the status data in the laptop periodically for post flight use. Each HRIU has a unique data bus address allowing the crew to individually communicate with a number of HH-J canisters.

If the customer desires and provides the necessary wiring, it is possible to provide the crew with some displays of customer hardware status.

Customer mechanical interfaces are the same as for the standard HH canister (section 2.1.1.). HH-J canisters may be flown on the side-mount or bridge configuration.

2.5.2 Hitchhiker-J Electrical Interfaces

2.5.2.1 HH-J Electrical Power

HH-J customer equipment may be operated from Orbiter power or from internal customer batteries with power switched by carrier relays in a manner similar to GAS as shown in Figure 2.69. If internal power is used, the carrier provides two size 12 power wires individually protected by 20 amp fuses in the carrier and switched by a crew controlled relay. Customer peak power should be limited to a maximum of 10 amps in either line because of vacuum derating of the fuses.

The enable relays ("E") in all the canisters are simultaneously activated by the crew near the beginning of the mission and deactivated near the end of the mission. The "E" relays are controlled by a single switch on the Bus Interface Assembly (BIA) in the cabin and are independent of the computer for safety reasons. The "E" relays provide power to the HRIUs in the canisters. Once the HRIUs are activated, the crew can individually activate the "K3" relay (to provide power to the customer equipment) and the "K4" relay (controlling canister heater and door power) in any specific canister.

The HRIU is provided with a current monitor which measures the total current in the A, B, and C power lines. The HRIU also measures the voltage on the down stream side of the K3 and K4 relays.

The customer may elect to use Orbiter +28 VDC power. In this case, maximum power draw of the equipment is limited to 100 watts and the energy use over the duration of the mission is limited to a maximum of 4 Kwh. The customer equipment must meet the requirements of section 2.3.1 with regard to power voltage, conducted electromagnetic noise emitted by the customer equipment, ground isolation, and susceptibility of customer equipment to Orbiter generated electromagnetic noise. Orbiter power is normally available starting several hours after payload bay doors are opened and extended to several hours prior to payload bay door closing.

2.5.2.2 HH-J Control Relays

The HRIU has two control relays "K1" and "K2" which may be used to control customer equipment. The relays are limited to 1 Amp and 32 volts and are break-before-make single pole double throw type. The nominal launch configuration of all relays is "reset".

2.5.2.3 HH-J Thermistors

The user may elect to place SSPP supplied temperature sensors in his equipment wired to the customer interface connector. The characteristics of the sensors are given in section 2.2.2. The use of the sensors will improve crew monitoring of significant temperatures in customer equipment.

2.5.2.4 HH-J Analog Telemetry Data

The user may elect to connect internal status measurements to carrier analog telemetry inputs which allow crew monitoring of a voltage between zero and +5 volts. A single measurement may be connected to the PCMAD signal line as defined in section 2.4.7.1. Also, an index pulse, PCMINDX, may be used to step a customer's internal multiplexer as described in section 2.4.7.1. For HH-J, only infrequent sampling of the data is possible. Contact the Project Office for more information.

2.5.2.5 HH-J Bi-level or Pulse Commands

The user may elect to connect to bi-level/pulse command lines as defined in section 2.4.2. Because of other demands on their time, the crew can only support limited commanding of HH-J payloads.

2.5.2.6 HH-J Customer Connectors

The HH-J canister bottom plate contains connectors for connecting customer equipment designated J13, J2, and J11 as shown in Table 2.21. J13 provides the Orbiter power interfaces, J2 provides signal interfaces, J11 connects to a connector on the canister bottom plate and can be used for ground test connection to customer equipment after it has been installed in a canister or for connecting two adjacent canisters during flight using an optional interconnect cable. An additional connector, J12 is used in place of J13 if the customer equipment contains its own battery. The Project Office will furnish connectors to the customer for use in fabricating the customer to carrier cables.

2.5.2.7 HH-J Grounding

The customer equipment return for Orbiter 28VDC power is Orbiter power return. If the customer provides his own battery power, the battery voltage may not exceed 32 VDC and the battery negative terminal should be connected to frame (structure) ground in the customer equipment. Orbiter power return connection in customer equipment using Orbiter power must be isolated from frame ground by a minimum of 10 K Ohms resistance. Orbiter power return is connected to frame ground in the Orbiter.

The reference for analog signals, thermistor returns, and PCMINDX signal is carrier signal ground. The signal ground must be isolated from frame ground and Orbiter 28 V return by a minimum of 10 K ohms unless a project waiver is obtained. Signal ground is connected to frame ground in the carrier.

2.5.2.8 HH-J Electromagnetic Interference Control

HH-J customer equipment must meet the requirements of Appendix H.

2.5.2.9 HH-J Thermal Control

Customer equipment may contain heater(s) and thermostat(s) connected to the 28V Orbiter heater power lines (+28HTR, RETH) controlled by commandable relay K4 and not exceeding a maximum of 50 watts (for all heaters on simultaneously at 32 volts). Thermostats should not be set to a temperature higher than 5 degrees C unless approved by the Project Office.

2.5.2.10 HH-J Malfunction Inputs

Two of the thermistor inputs, THER1 and THER2, may instead be used as malfunction inputs. Malfunction inputs on HH-J are similar but not identical to the functions in the GAS carrier. A user may provide a "true" malfunction input to cause the carrier to reset the power relay in the carrier and remove power from the instrument. A malfunction true condition is indicated by an input voltage between zero and 2.0 volts relative to circuit ground, or by a resistance of less than 100 ohms between the malfunction input and circuit ground. A malfunction false condition is indicated by an input voltage between 3.5 volts and 5.0 volts or an input resistance higher than 100K ohms.

If a malfunction true condition is sensed at either of the malfunction inputs for 2 seconds or more, the HH-J carrier software will reset the power relay. The relay will remain reset unless set by the flight crew. The values of the malfunction input voltages are available for display to the crew in the Orbiter cabin.

The equivilant circuit for the malfunction input in the carrier is the same as for the thermistor input shown in figure 2.70.

TABLE 2.21

HITCHHIKER-JR ELECTRICAL INTERFACE CONNECTIONS

POWER CONNECTOR P13 (ORBITER POWER)

CUSTOMER CONNECTOR TYPE: NB6GE24--19 PNT-3

ID	PIN	TYPE	FUNCTION
+28	A	C	+28 POWER CIRCUIT A
RETA	B	C	POWER RETURN (NOTE 1)
+28B	C	C	+28 POWER CIRCUIT B
RETB	D	C	POWER RETURN (NOTE 1)
+28HTR	E	B	+28 HEATER POWER
RETH	F	B	HEATER POWER RETURN (NOTE 1)
FRMGND	G	B	FRAME GROUND

SIGNAL CONNECTOR P2

CUSTOMER CONNECTOR TYPE: TVSO6RF-19-35S(453)

PCMAD	1	A	ANALOG DATA, O - +5V
PCMINDX	41	A	INDEX PULSE
SIGGND	2	A	SIGNAL GROUND
SHIELD	6	A	SHIELD (TO BE TIED TO FRAME GROUND IN PLD)
BLCMD1	17	A	BILEVEL/PULSE COMMAND 1
BLCMD2	18	A	BILEVEL/PULSE COMMAND 2
BLCMD3	19	A	BILEVEL/PULSE COMMAND 3
BLCMD4	20	A	BILEVEL/PULSE COMMAND 4
THER1	14	A	THERMISTOR 1 OR MALF INPUT #1
THER2	15	A	THERMISTOR 2 OR MALF INPUT #2
THER3	16	A	THERMISTOR 3

K2RES	58	A	K2 RELAY RESET CONTACT
K2SET	57	A	K2 RELAY SET CONTACT
K2ARM	59	A	K2 RELAY ARM
K1RES	49	A	K1 RELAY RESET CONTACT
K1SET	48	A	K1 RELAY SET CONTACT
K1ARM	50	A	K1 RELAY ARM

SAFE/ARM OR INTERCONNECT CONNECTOR P11

CUSTOMER CONNECTOR TYPE: TVSO6RF-21-16S(453)

ID	PIN	TYPE	FUNCTION
	A	B	
	B	B	
	G	B	
	R	B	
	N	B	
	C	B	
	J	F	
	H	F	
	P	F	
	D	F	
	L	F	
	K	A	TWISTED SHIELDED PAIR TSP1+
	F	A	TSP1-
	E	A	TSP SHIELD

MA TSP2+

S A TSP2-

POWER CONNECTOR P12 (BATTERY POWER)

CUSTOMER CONNECTOR TYPE: JTO6RE-16-6S

BATA+	A	C	CUSTOMER BATTERY + CIRCUIT A
BATB+	B	C	CUSTOMER BATTERY + CIRCUIT B
PPWRA	C	C	CUSTOMER LOAD CIRCUIT A
PPWRB	D	C	CUSTOMER LOAD CIRCUIT B
+28HTR	E	B	ORBITER 28V HEATER POWER
RETH	F	B	HEATER POWER RETURN

NOTE 1: POWER RETURN PINS B, D MAY BE CONNECTED TOGETHER WITHIN PAYLOAD.

NOTE 2: WIRE TYPE DESIGNATION:

TYPE	SIZE
A	22 GA
B	16 GA
C	12 GA
F	20 GA

SEE FUSING REQUIREMENTS IN TABLE 2.6.

NOTE 3: CUSTOMER WILL MAKE NO CONNECTIONS TO UNUSED PINS

2.6 Hitchiker Ejection System

The Hitchhiker Ejection System (HES) (figures 2.71 - 2.75) provides for launching a small spacecraft from the Shuttle payload bay. The ejected payload is equipped with a user supplied 9.375 inch marmon plate interface which is clamped to the carrier with a clamp mechanism. Payload and ejection system are mounted in a canister with a motorized door which can contain an air or inert atmosphere prior to launch. Once in orbit with the Orbiter in the requested attitude, the clamp is released by the crew and the payload is ejected. The system does not provide for rotation (spin) of the payload prior to ejection. Orbital lifetime of ejected objects in typical Shuttle orbits is usually less than one year.

There is no electrical power or signal connection to the spacecraft.

The user must provide means for lifting the spacecraft during installation on to the clamp assemble. Following installation of the payload and launcher into the canister, only the top of the payload will be accessable through the open door for servicing.

Vibration and shock environment is the same as for other canister payloads.

Spacecraft must be designed to avoid contact with the canister under launch loads or during ejection.

The ejection system and door mechanism are considered zero fault tolerant against a failure which would cause inability to eject or inability to close the door. Therefore, the spacecraft design must satisfy Shuttle safety requirements for a landing in the Shuttle with the door open.

Spacecraft which have appendages which deploy or other hazardous function which occurs after ejection must provide adequate safety inhibits to prevent premature activation.

Ejection attitude must be such that there is no possibility of collision with the Shuttle during the portion of the mission following ejection. JSC will perform a recontact analysis to insure that no recontact occurs.

Table 2.22 shows the characteristics of the HES.

TABLE 2.22

HITCHHIKER EJECTION SYSTEM CHARACTERISTICS

Maximum spacecraft weight	150 lb (68 Kg)

Maximum spacecraft height re separation plane	20.5 in (52 cm)
Maximum spacecraft diameter	19 in (48 cm)
Canister inside diameter	20 in (50 cm)
Maximum CG location re canister centerline	0.5 in (1.27 cm)
Maximum CG location re separation plane	10.25 in (26 cm)
Ejection velocity (at 150 lb.)	2-4 fps (.6 - 1.2 mps)
Maximum rotational impulse at ejection	TBD
Minimum payload resonant frequency	TBD Hz

3. CUSTOMER/NASA RESPONSIBILITIES

3.1 CUSTOMER RESPONSIBILITIES

Customer responsibilities in the development of a HH mission begin early in the flight system development phase and continue throughout the post-mission phase. The following subsections describe the customer responsibilities throughout the planning/development phase, pre-mission phase, mission operations phase, and post-mission phase. (See milestone schedule on page 3.25.)

3.1.1 CUSTOMER PLANNING/DEVELOPMENT RESPONSIBILITIES

During the planning/development phase, the customer is responsible for the activities described in the following subsections.

3.1.1.1 Programmatic Responsibilities. The customer must:

a. Conduct all pre-planning activities with the HH Project Office at the GSFC, Greenbelt, MD.

b. Prepare the HH CPR Document (Appendix E) for GSFC review and approval.

c. Designate what services they require.

3.1.1.2 Mechanical Responsibilities. Prior to implementation, the customer must submit a structural integrity verification plan for approval by the HH Project Office. This plan addresses the specific manner in which the various design, analysis, and test requirements of this section will be satisfied, and defines which of the documents and reports listed in Table 3.1 will be delivered to the HH Project Office for review. The customer may request an exception to a specific requirement provided that sufficient technical rationale accompanies the request. The request should be presented as part of the plan; it will be evaluated concurrently.

Once the structural integrity verification plan has been implemented, the customer is responsible for providing a structural integrity verification report, which presents the results of all analysis and test activities described in the verification plan. The structural integrity verification report (due at L-13 months) is referenced in the Hazard Report section of the customer safety data submittal. This cross-referencing is used to document the completion of a particular hazard control verification activity.

TABLE 3.1

STRUCTURAL INTEGRITY VERIFICATION PLAN DELIVERABLES

Miscellaneous:	Complete Parts and Materials List
	Complete Payload Assembly and Interface Control Drawings
Analyses:	Detailed Stress Analysis
	- including finite element model
	Fracture Control Analysis
	- including certification of Nondestructive Evaluation (NDE) inspections
	Thermal Analysis
	Pressure Profile Analysis
Test Reports:	Random Vibration Test
	Structural/Strength Qualification Test
	Modal Test
	- modal survey, sine test, etc.
	Acoustic Test
	Mass Properties Measurements
	Thermal Test

Other Payload-Specific Tests
to meet requirements

The customer may be exempted from a specific requirement by the HH Project Office. Only the applicable analyses and tests from the above list should be included as deliverables in the structural integrity verification plan and report.

3.1.1.2.1 Standards. The customer is responsible for using design analysis, fabrication, inspection, assembly and testing practices consistent with commonly accepted aerospace industry standards and specific NASA requirements.

3.1.1.2.2 Drawings. The customer is responsible for providing the drawings and other information required for GSFC to produce the Mechanical Interface Control Drawings (MICD). These drawings will be controlled by GSFC; any proposed changes after initial release will require the approval of both parties. The type of mechanical interface control drawing information required is listed in Table 3.2.

The MICD is a vital document since it states the mutual customer-NASA understanding in all mechanical interface areas such as:

a. Hole location tolerances
b. Hole diameter tolerances

c. Interface plane flatness
d. Interface plane finish
e. Interface thickness

In addition, two sets of final detail fabrication and assembly drawings shall be provided to the GSFC for review and reference. If the customer submits a 3-D autocad model, GSFC will incorporate it into the integrated payload autocad model used for illustrations and studies of access and field of view requirements.

3.1.1.2.3 Exposed Corners, Edges, and Protrusions. Customer hardware shall be designed to minimize the likelihood of personal injury from contact with sharp corners, edges, protrusions, or recesses. In general, this means rounding exposed edges and corners to a minimum radius of 0.03 inches. Edges and corners that present a safety hazard or may be potentially damaging to other equipment during usage shall be suitably protected or rounded to a minimum radius of 1/2 inch. Protrusions, which for operational reasons cannot be made safe, shall be covered with a protective device.

3.1.1.2.4 Mass Properties. The weight, center of gravity, moments and products of inertia (about the component cg) of each component shall be provided in the CPR document. The basis for these numbers shall also be provided (i.e., estimated, calculated from fabrication drawings, or actually measured). The customer shall clearly state what contingency, if any, exists. The final experiment weight must be actually measured for incorporation into the overall HH payload finite element model. Mass properties shall be reported using the following units: inches, pounds, and slug-ft^2.

TABLE 3.2

MECHANICAL INTERFACE CONTROL DRAWING REQUIRED INFORMATION

a. Component Dimensions

b. Envelopes
  * Static
  * Thermal
  * Dynamic

c. Coordinate System
  * Origin
  * Orientation

d. Mass Properties
  * Weight, C.G.
  * Basis (% Est, Cal, Act)
  * Inertias

e. Attachment Details
  * Number, Location
  * Reaction Directions

f. Instrument Field of View
  * Origin
  * Size
  * Shape

g. Radiator Field of View
  * Origin
  * Size
  * Shape

h. Electrical Connectors

k. Radioactive Sources
  * Strength
  * Location
  * Type

l. Ground Handling Points
  * Location
  * Details
  * MRDPS
  * Orientation

m. Optical Alignment Details

n. Access Areas
  * Identification
  * Location
  * Size

o. Doors and Appendages
  * Location
  * Size
  * Mass
  * Duty Cycle

p. Remove/Install Pre/Post Item Locations
  * Size
  * Function

q. Ordnance/Actuator Details
  * Location

- Location
- Type
- Identification

i. Electrical Grounding Detail

j. Fluid Service
- Type
- Frequency
- Location
- Details

- Type
- Function

r. Notes
- Safety Precautions
- Special Provisions
- Test Configurations
- Shipping/Storage
- Cleanliness
- Materials

3.1.1.3 Design Requirements

3.1.1.3.1 Equipment Integrity and Factors of Safety. All customer equipment shall be designed to withstand the launch, operational, reentry, and landing environments of the Shuttle without failures, leaking hazardous fluids, or releasing equipment and loose debris or particles that could damage the Space Shuttle or cause injury to the crew. The customer equipment shall be subjected to structural testing at 1.25 times the limit loads and show positive margins of safety by analysis at 1.4 times the limit load for all ultimate failure modes such as material fracture or buckling. Alternatively the customer may qualify the equipment by analysis alone by showing positive margins of safety at 2.0 times the limit loads for material yield and 2.6 times the limit loads for ultimate failure modes. This technique is pending JSC approval on a case-by-case basis. Complex structural interfaces or elements may be required to undergo structural testing. Customers choosing to perform structural verification by analysis should review their qualification plans with GSFC early in their program for approval. Pressure vessels, lines, fittings, and sealed containers shall be designed in accordance with NSTS 1700.7B.

3.1.1.3.2 Limit Acceleration Load Factors. In Table 3.3 are generalized design limit load factors for HH payload/instrument structures. These loads envelope the worst case steady state, low frequency transient, and higher frequency vibroacoustic launch and landing load environment. Refined design loads may be supplied when the payload/carrier configuration has been established. Final flight limit loads will be derived from the Shuttle Coupled Flight Loads Analysis performed for the Space Shuttle mission the customer is manifested on. Smaller, nonstructural components and assemblies should be designed using load factors that account for the transmissibility between the payloads primary structure and the component or assembly. When the transmissibility cannot be measured or estimated adequately the loads given in Table 3.3 shall be used. Use of loads other than those in Table 3.3 for safety critical components/assemblies requires HH program approval.

The load factors are in g's and rad/sec/sec. All loads should be considered as positive and negative, simultaneous, and in all possible combinations. All accelerations should be applied through the payload's center of mass using the Shuttle coordinate system. Any thermally induced loading shall be combined with the above loads. On orbit thermal loading must also be considered.

GSE must be designed using a factor of safety of 5.0 for ultimate failure.

3.1.1.3.3 <u>Vibration Frequency Constraints.</u> All customer-supplied equipment shall have a lowest natural frequency of 35 Hz or greater when mounted to GSFC hardware. It is desirable to have the lowest natural frequency above 50 Hz. The frequency should be assessed at the HH-to-customer

interface. It is recommended that customer primary structure be designed to meet the higher 50 Hz minimum frequency. Verification requirements increase significantly for payloads with a lower first fundamental structural frequency, see section 3.1.1.4.2. The customer is responsible for emonstrating satisfaction of this requirement.

TABLE 3.3

HITCHHIKER PAYLOAD/INSTRUMENT STRUCTURE DESIGN LIMIT LOAD FACTORS

Load Factor, G			Angular Acceleration rad/sec^2		
NX	NY	NZ	Rx	Ry	Rz
±11.0	±11.0	±11.0	±85	±85	±85

HITCHHIKER TERTIARY ASSEMBLY/COMPONENT DESIGN LOAD FACTORS

Weight lb	Load Factor, G
<20	40

20-50	31
50-100	22

The above load factor shall be applied in most critical direction with 30% of the load factor applied in the remaining two directions.

3.1.1.3.4 Acoustic Noise and Random Vibration. All customer equipment shall be designed to withstand the vibroacoustic environment of the Shuttle without failure. If the customer chooses to perform an acoustic test, the levels given in Table 3.4 should be used. Payloads on the HHBA will normally be subjected to an acoustic test during integration. General Shuttle component random vibration test specifications are listed in Table 3.6 of the test requirements section 3.1.1.5.3.

3.1.1.3.5 Materials. Allowable mechanical properties of structural materials shall be obtained from MIL-HDBK-5D. Only the materials with high resistance to stress corrosion cracking listed in Table I of the latest version of MSFC-SPEC-522 shall be used. See Appendix B of this document. A list of materials shall be submitted to GSFC as soon as possible.

3.1.1.3.5.1 Non-Metallic Materials. Use of non-metallic material shall be restricted to those materials which have a maximum collectable volatile condensable material content of .1% or less and a total mass loss of 1.0% or less. NASA-GSFC will provide the customer a list of approved materials for use in the thermal/vacuum environment upon request.

3.1.1.3.6 Thermal Blanket Attachment Requirements. There are no formal requirements for structural attachment of thermal blankets. Specific attachment methods are determined on a case-by-case basis depending on payload design, possible contamination constraints, availability of attachment hardware, etc. Typically a combination of various methods is used to attach the blankets to the payload. One mechanical fastener is required as an attach point for thermal blanket grounding. Grounding of thermal blankets shall be in accordance with ICD-2-19001.

3.1.1.3.7 Design Envelope. In the design stage of the experiment, the customer must design the flight hardware to stay within the access envelope of the HH carrier hardware. For canisters, this envelope is shown in Figure 2.10. Experiments that are designed to mount to a HH pallet should not extend over the sides of the pallet. Experiments that do extend over the side of the pallet may interfere with ground support equipment used to lift or handle the pallets. Experiments that extend over the side may also interfere in the payload envelope of an adjacent experiment mounted nearby.

If during the design phase the design team realizes that an experiment overhang is unavoidable, the HH mission manager and the lead mechanical engineer for the payload should be contacted immediately to discuss possible workarounds.

3.1.1.4 Analysis Requirements

3.1.1.4.1 Structural Analysis Requirements. The customer is required to perform stress analysis in sufficient detail to show that the design FS described in paragraph 3.1.1.3.1 are met or exceeded and that positive MS of zero or greater can be shown for both yield and ultimate stress conditions, i.e.,

$$\text{MS} = \frac{\text{Allowable Stress}}{(\text{F.S.})\,(\text{Actual Stress})} - 1 \geq 0$$

Stress analysis shall use methods and assumptions consistent with standard aerospace practices. Buckling, crippling, and shear failures shall be considered ultimate failures. Allowable material stresses shall be taken from MIL-HDBK-5. When alignment of components is critical to performance, it is suggested that the material micro-yield allowable be used in lieu of the 0.2% offset yield allowable.

TABLE 3.4
RECOMMENDED ACOUSTIC LEVELS *
HITCHHIKER PAYLOADS (01/90)

Test Duration 60 sec

* Assumes HH payload not in an annulus region

3.1.1.4.2 Structural Modeling Requirements. The customer is required to submit a test-verified finite element math model to GSFC for each customer-supplied payload or component which has demonstrated, or is expected to have, a lowest natural vibration frequency of less than 50 Hz when mounted to a rigid interface between the carrier and the component. All finite element models delivered to GSFC must demonstrate mathematical validity by showing that the model contains six rigid body frequencies of value .001 Hz or less. The math model should contain as few degrees of freedom as necessary for accurate simulation of frequencies and mode shapes under 50 Hz but in all cases must be limited to no more than 300 degrees of freedom. Specific details with regard to the form and content of a finite element math model that is to be submitted to GSFC will be agreed upon between the payload and GSFC on a case by case basis. A finite element math model is not required for components with lowest natural frequencies above 50 Hz, unless deemed necessary by GSFC.

Payloads having a lowest natural frequency greater than 50hz must, however, provide an analysis, either classical or finite element, that confirms the result of the testing described in 3.1.1.5.2. Test verification of math models can be achieved by performing a modal survey test on the payload.

3.1.1.4.3 Fracture Control. A fracture control program is required for all customer equipment mounted on plates or in canisters with opening lids. Since canisters without opening lids provide essential containment of all customer equipment, the requirements of fracture control are generally satisfied if the payload does not include any pressure vessel or other hazardous equipment. The customer is responsible for providing a Fracture Control Implementation Plan which describes in detail how the requirements of the General Fracture Control Plan for Payloads Using the STS, 731-0005-83 Rev. B, will be satisfied. The information that should be included in the implementation plan is described in section 5-2-1 of the General Fracture Control Plan. The fracture control program implemented by the customer shall provide assurance that no catastrophic hazards to the Shuttle Orbiter or crew will result from the initiation or propagation of flaws, cracks, or crack-like defects in customer structure during its mission lifetime, including fabrication, testing, and service life. In addition, all customer structural fasteners must comply with GSFC S-313-100 (11/89) Fastener Integrity Requirements. The plan must be approved by GSFC prior to implementation. It will normally be included as part of the structural integrity verification plan described earlier.

3.1.1.4.4 Pressure Profile. Table 3.5 and Figures 3.1, 3.2, and 3.3 define the Orbiter cargo bay internal pressure history to be used by payloads for design and venting analyses. Orbiter cargo bay vent door opening occurs at altitudes between 70,000 and 94,000 feet. The repressurization rate of the cargo bay will not exceed 0.3 psi/sec during descent.

The pressure profiles given pertain to plate-mounted equipment. The pressure profiles for canister-mounted hardware may be different depending on the configuration.

3.1.1.5 Test Requirements

3.1.1.5.1 Structural Test Requirements (Qualification by test). The customer is required (for exceptions see paragraph 3.1.1.3.1) to perform strength testing of all components sufficient to demonstrate that no detrimental permanent deformation or ultimate failures occur when loads are imposed on the structure such that every primary load carrying member experiences a stress equal to a minimum of 1.25 times the limit stress. The limit stress is the highest stress produced by any one of the combinations either design limit acceleration load factors in paragraph 3.1.1.3.2 or the refined loads supplied by HH project. To satisfy this requirement, it is not necessary to impose the precise externally applied load factors in a single test. The imposed load may be artificial and may be imposed in a number of different load cases, each one of which produces the required stresses in only a portion of the structure, as long as the net result is the required stresses in all primary load-carrying members. The test load may be applied by pulling on the structure with discrete forces, by the application of a linear acceleration field (centrifuge) or by subjecting the instrument to a below-resonant frequency sine dwell or sine burst vibration test.

3.1.1.5.2 Natural Frequency Verification Test. All customer-supplied equipment shall have its lowest cantilevered natural frequency verified by test if the predicted natural frequency is below 100 Hz. Acceptable tests for verifying natural frequencies include modal survey and sine sweep vibration. Large payloads with natural frequencies less than 50 Hz may be required to undergo modal survey testing to recover both structural mode frequencies and mode shapes.

TABLE 3.5

ASCENT CARGO BAY PRESSURE AND DECAY RATE

ATTACHMENT 1 (ICD 2-19001) Change

Time	Maximum Cargo Bay Pressure	Minimum Cargo Bay Pressure	Maximum Rate of Pressure Depressurization
10	14.45	14.20	0.155
20	13.20	12.50	0.255
30	11.25	10.00	0.360
35	10.05	8.90	0.510
38	9.40	8.20	0.735
39	9.15	7.60	0.760
40	8.95	7.20	0.760
41	8.70	6.80	0.760
45	7.75	5.70	0.640
48	7.20	5.10	0.570
49	7.05	4.90	0.575
50	6.90	4.70	0.550

51	6.60	4.50	0.520
52	6.10	4.30	0.455
55	5.35	3.65	0.355
60	4.30	2.70	0.273
65	3.50	2.00	0.225
70	2.70	1.40	0.195
80	1.30	0.60	0.150
90	0.60	0.20	0.115
100	0.25	0.10	0.075

Note: a. Pressure in psia
b. Rate of depressurization in psi/second
c. Time in seconds from lift-off

3.1.1.5.3 Random Vibration. All customer flight equipment must be tested in order to qualify it for the Shuttle vibroacoustic environment. Table 3.6 below is a generalized vibration specification for Shuttle equipment. In some cases a more refined specification will be supplied once the payload/carrier configuration has been established. The HH project may waive this requirement in some instances such as reflown or contained hardware. New designs must be tested to qualification levels, reflown on previously qualified hardware may be tested to acceptance levels. A proto type unit may be used for qualification testing.

TABLE 3.6

GENERALIZED SHUTTLE COMPONENT RANDOM VIBRATION

(50 lbs. or less)

Vibration test duration is one minute in each of the three orthogonal axes.

3.1.1.5.4 Typical Test Sequence. The satisfaction of the above test requirements can often be satisfied by a single visit to a vibration test facility depending on the mass and stiffness of the payload. A typical test of this type would include:

1. A sine sweep test to verify the natural frequency,

2. A sine burst test to perform strength testing, and

3. A random vibration to qualify the payload for vibroacoustic environment.

This test sequence would typically be repeated in each axis. It must be remembered, however, that the sine burst applies a force field in a single axis whereas the design load factors occur in all three axes simultaneously.

ORBITER CARGO BAY INTERNAL PRESSURE HISTORIES

DURING ASCENT

FIGURE 3.1

MAXIMUM CARGO BAY PRESSURE DECAY RATE DURING ASCENT

FIGURE 3.2

MAXIMUM CARGO BAY ENTRY REPRESSURIZATION RATE

TIME FROM VENT DOOR OPENING   SECONDS

FIGURE 3.3

ENTRY PHASE CARGO BAY INTERNAL PRESSURE VALUES,
TO BE USED FOR PAYLOAD DESIGN

3.1.1.6 Electrical Responsibilities

a. Certify that the requirements presented in ICD-2-19001, Section 7.2 and 10.7, pertaining to EMI/EMC control have been met. Payloads will be subjected to high levels of radiation from the Orbiter transmitter and must not interfere with the Orbiter or other payloads. Experiments will also undergo conducted and radiated susceptibility tests and transient tests, per Reference #8 in Appendix I. Payloads are advised to conduct individual EMI/EMC testing.

b. Interfacing Circuits Schematic.

c. Power Distribution Schematic showing compliance with requirements of TA-92-038 for fusing and wire size.

3.1.1.7 Thermal Responsibilities. The customer must provide required thermal analysis, design data, descriptions of all surface coatings and insulation, and a **reduced** thermal math model of the payload; the reduced model should have approximately 20 nodes. The customer design is to provide heaters, thermostats, blankets, and coatings to maintain the payload temperature within the required range.

3.1.1.8 Materials and Safety Responsibilities.

a. Submit a list of all materials (see Appendix B) used in the payload design to confirm the absence of hazardous agents or materials with poor structure, outgassing, and contamination characteristics. All fasteners should be in compliance with GSFC S-313-100.

b. Certify that the requirements of NSTS 1700.7B have been satisfied. Control of any items of a hazardous nature must be demonstrated, documented, and reviewed (pressure vessels, explosive devices, radioactive sources, exposed high temperature or high voltage, electromagnetic radiation, moving parts, any other personnel or equipment hazard.

3.1.2 CUSTOMER PRE-MISSION RESPONSIBILITIES

The customer is required to meet the following responsibilities during the Pre-Mission Phase.

a. Provide all required testing procedures and documentation to demonstrate compliance with the Space Shuttle safety requirements as described in this document (Appendix A and elsewhere). Confirm proper operation of the customer thermal, mechanical, and electrical systems. Provide documentation and analysis of such tests already conducted by the customer.

b. Provide all necessary thermal coatings, blankets, inter-element cables, plus handling and shipping equipment.

c. Provide electrical ground support equipment for generating commands and providing necessary real-time data displays. This requirement is waived if the customer has minimal command/data requirements.

d. Provide all operational plans, procedures, equipment, and personnel for operating the customer payload and supporting GSFC test and operations staff during pre-flight testing and simulations.

e. Provide transportation as required of all customer equipment and personnel to the KSC or other locations for integration of the customer's payload into the Orbiter and to the GSFC for all system reviews and simulations.

f. Provide personnel support to NASA at the location designated to integrate the customer equipment to the Orbiter.

g. Provide support to NASA in systems testing to confirm proper operation of the integrated payload and the absence of interference between customer payloads.

h. Provide all Mechanical Ground Support Equipment (MGSE) required to ship flight and non-flight hardware to GSFC, KSC, or other locations for HH integration. Bagging materials must comply with KHB 1700.7B.

i. Provide personnel to support a mechanical receiving inspection and verification that all customer provided flight hardware conforms to the specifications agreed upon in the mission unique Mechanical Interface Control Drawing (MICD).

j. Provide all MGSE, personnel and procedures written in the format specified by KHB 1700.7B, required to handle flight equipment for mechanical integration to the HH system. Customer supplied MGSE, lift slings and fixtures, shall be proof loaded prior to use to a minimum of 2.0 times the rated working load. Written, dated, and signed test reports shall be provided, and if a hazard is identified, the condition shall be corrected prior to further use. These reports shall be supplied to the HH Project for approval. Following the load test, all ground handling equipment shall have a tag permanently affixed identifying the equipment, stating the rated capacity, the next scheduled load test due date, and a quality control indication assuring that the above information is correct. After this certification the MGSE shall not be disassembled or used for any other purpose.

k. Provide all necessary plans, personnel, and equipment required to support payload servicing and closeout operations at the Orbiter Processing Facility (OPF) and the pad if required.

l. Provide all requirements for space, power and air conditioning for the CGSE as well as electrical interface requirements.

3.1.3 MISSION OPERATIONS RESPONSIBILITIES

The customer is responsible for providing all operations plans, procedures, and personnel for operating the customer payload and ground support equipment as well as supporting the GSFC operations staff during all mission activities.

3.1.4 POST-MISSION RESPONSIBILITIES

The customer is responsible for providing planning, material, and personnel support to NASA at the locations designated to "safe" the payload, remove the customer equipment from the Orbiter, and, subsequently, deintegrate from the HH system.

3.2 HH AND/OR SPACE SHUTTLE ORGANIZATIONAL RESPONSIBILITIES

The joint responsibilities of the HH Project and the JSC Space Shuttle Program Office (SSPO), and those that are solely of the Shuttle, are described as follows. These responsibilities roughly parallel the mission development from planning to post-mission operations. NASA will:

a. Provide services and interfaces as agreed in the approved CPR document.

b. Provide standard HH carrier and ground equipment as defined in this document including flight interface cables and customer interface connectors (customer to carrier). (The customer will provide unique box-to-box cables.)

c. Provide integration (with customer support) of the customer equipment to the HH carrier.

d. Develop all necessary integrated documentation, plans, procedures, and software.

e. Conduct systems testing (with customer support) to confirm proper operation of all integrated payloads and the absence of interference between customers.

f. Conduct EMI testing of the complete payload to confirm compliance with the Shuttle EMI requirements.

g. Perform integration of the payload into the Orbiter; provide launch, flight, re-entry, and landing of the Orbiter; remove the payload after the mission.

h. Provide mission compatibility analysis to determine the compatibility of customer requirements with the Shuttle and HH capabilities and with the other customer payloads and non-HH mixed cargo payloads on the same mission.

i. Provide mission management to control and decide multi-payload issues such as safety-related issues and the resolution of conflicts for mission resources between payloads.

j. Provide computer-compatible tapes of the customer low-rate data and standard orbit, attitude, and ancillary data for test purposes and for flight-acquired data.

k. Provide computer compatible tapes of customer medium-rate data and standard orbit, attitude, and ancillary data for test purposes and for flight-acquired data. See Appendix C for details of data products formats.

3.3 GSFC RESPONSIBILITIES

The HH Project Office at the GSFC is solely responsible for the following activities in the development and operations of an HH mission. The office will:

a. Act as NASA's single point of contact for all customers participating in the HH Program.

b. Provide all integrated payload documentation.

c. Provide the customer with the outline for the HH CPR document and conduct review and approval of the document.

d. Provide the thermal fluxes and thermal descriptions of the areas near the customer payload. For canister customers, provide external insulation on the sides and bottom of canister if required. Provide thermal models, insulation, and heater system for plates.

e. Provide the customer with connectors that are to be used on the customer side of the electrical/signal interface.

f. Conduct tests on the integrated payload to confirm compliance with EMI requirements.

g. Provide customer facilities at GSFC as described in Appendix D. Some data services are optional extra cost services for reimbursable customers.

3.4 PAYLOAD REQUIREMENTS DOCUMENTATION

As indicated in subsection 2.3, the customer is required to prepare a CPR document and present it to GSFC for approval. The HH Project Office will provide an outline of this document to the customer for use in the preparation of the document. The document will address the following areas:

a. Mechanical Interface Definition
b. Thermal Interface Definition
c. Electrical Systems Requirements
d. Operations Requirements
e. Flight Safety Data Package
f. Ground Safety Data Package
g. Ground Handling Requirements and Procedures
h. Materials List

3.5 HH MANIFESTING SCENARIO

A list of the steps that occur during the development of the customer's payload for flight as a HH mission follows:

a. The customer studies this Customer Accommodations and Requirements Specifications (CARS) document to determine if suitable accommodations are possible on HH carriers.

b. The customer prepares the CPR document (see outline in Appendix E) specifying desired accommodations and services and submits CPR to GSFC for review.

c. The customer consults with GSFC concerning acceptability of requirements.

d. The customer's organization submits Form 1628 -- Request for Flight (see Figures 1.1 and 1.1a) through the appropriate NASA Headquarters discipline office (see Table 3.7) to the NASA Office of Space Flight, Customer Services Division. Form 1628 requests accommodation on a HH-S or HH-C carrier and specifies the weight of the customer's equipment. Customer submits deposit if reimbursable.

TABLE 3.7
NASA HEADQUARTERS SECONDARY PAYLOAD DISCIPLINE OFFICES

Discipline Office	Office Code
NASA-Sponsored Payloads:	
Space Science	S
Shuttle Advanced Technology	MD
Space Technology	RS
Commercialization	CC
Space Station Technology	MS

Discipline Office	Office Code
Reimbursable Payloads	
USA Domestic	CC[1]
Foreign	XI[1]
DOD	MC[2]

1) Reimbursable customers should contact Code MOB for pricing.
2) DOD Customers should contact USAF Space Systems Division USAF/SSD/CLP.

e. The customer discusses manifesting requirements with the discipline office official responsible for developing the discipline office secondary payload priority list and arranges to be included in the priority list at a satisfactory priority. These lists are updated periodically, so the customer needs to ensure that adverse changes in priority do not occur subsequent to the initial list.

f. The customer visits GSFC for a payload accommodation conference and detailed discussions of requirements and interfaces. GSFC approves requirements document.

g. The customer prepares and submits phase 0/1 safety data package.

h. JSC and GSFC, with customer support, perform phase 0/1 safety review.

i. GSFC and NASA Headquarters determine which customer payloads should be combined on a single HH carrier. HH-S customer equipment may be carried on a HH-M carrier if acceptable to customer and of benefit to NASA. GSFC prepares a summary payload description. GSFC and JSC begin preparation of the integrated payload documentation.

j. NASA Headquarters, JSC, GSFC, and the discipline offices assign the payload to a Space Shuttle flight based on the Summary Payload Description requirement.

k. Customer submits Phase 2 Safety Package. GSFC submits integrated payload Phase 2 Safety Packages including all customer data and applicable carrier data. JSC, KSC, GSFC, and the Customer perform payload Phase 2 flight and ground handling safety reviews.

l. Customer delivers flight hardware, Phase 3 safety data. GSFC performs customer equipment-to-carrier integration and testing. GSFC submits data for Phase 3 safety reviews. Phase 3 reviews conducted.

m. Payload is delivered to launch site, post-ship checks and servicing performed. Customer signs safety certificate.

n. Payload integrated into Orbiter, integration test performed, Shuttle is launched, flown, landed, deintegrated. Customer equipment returned to customer.

o. Customer data products sent to customer.

3.6 <u>OPERATIONS OVERVIEW</u>

The timeline presented in Figure 3.4 outlines the implementation process for payload development. HH customer payloads will be delivered to GSFC where they will be electrically and mechanically integrated into the carrier. System checks and EMI tests will then be performed using CGSE and personnel. Following these activities, the integrated payload will be shipped to the launch site where it will be unpacked, inspected, and integrated into the Shuttle Orbiter in the OPF or on the launch pad. Protective covers will be removed and an Orbiter Integration Test (OIT) will be performed by Launch Site personnel with assistance from the HH and customer organization teams. The OIT is intended only to verify Orbiter interfaces and will be supported by a subset of the carrier ground equipment. Some remote transmission of customer data to GSFC may be possible depending on requirements.

The Orbiter will then be transported to the Vehicle Assembly Building (VAB) where the Orbiter is mated to the liquid and solid fuel rockets. Then the Orbiter is taken to the launch pad. Final countdown tests will be performed with generally no testing or access to the HH.

Once on orbit, the payload bay doors will be opened and flight operations activities will begin. Typical cargos will include one or more spacecraft to be launched into higher orbit using a Payload Assist Module (PAM) or similar upper stage rocket booster. Up to four primary payloads can be accommodated in addition to the HH. If all four are flown, the HH will be sharing power with one of the primary payloads and available power for HH operations may, therefore, be limited during portions of the flight. Many communications spacecraft cannot stand operation of the Ku band transmitter because of the presence of sensitive receivers; therefore, use of the Ku band system is restricted until such spacecraft have been launched.

Orbiter attitudes during a flight may contain more than 30 minutes of bay-to-sun attitude at a time, up to one hour of bay-to-space at a time, and indefinite periods in bay-to-Earth or Passive Thermal Control (PTC - - slowly rotating along the axis perpendicular to sun line). HH payloads must be designed to withstand at least these minimum thermal attitude requirements which might be increased on any given flight depending on HH or other payload observing requirements.

MILESTONE SCHEDULE FOR HITCHHIKER PAYLOADS

STANDARD SERVICES	DATE TO BE COMPLETED	
	HITCHHIKER	HITCHHIKER-JR
CUSTOMER ORGANIZATION SUBMITS FORM 1628	L-24	L-18
CUSTOMER SUBMITS CPR TO GSFC/SSPP	L-24	L-28
CUSTOMER ACCOMMODATION MEETING AT GSFC	L-23	L-18
CUSTOMER SUBMITS PRELIMINARY SAFETY DATA AND STRUCTURAL INTEGRITY VERIFICATION PLAN	L-20	L-16
CUSTOMER SUBMITS STRUCTURAL INTEGRITY VERIFICATION REPORT	L-13	L-11
CUSTOMER SUBMITS FINAL SAFETY DATA	L-6	L-5
CUSTOMER HARDWARE DELIVERED TO GSFC	L-6	L-5
CUSTOMER/CARRIER INTEGRATION COMPLETED	L-4	L-3
HITCHHIKER PAYLOAD SHIPPED TO LAUNCH SITE	L-3	L-3
HITCHHIKER PAYLOAD INSTALLED IN ORBITER	L-2	L-2

LAUNCH	L-0	L-0
CUSTOMER EQUIPMENT RETURNED	L+1	L+1

FIGURE 3.4

Following or in-between, primary cargo operations attitude maneuvers may be scheduled in support of HH observations. These maneuvers must not result in any impact to flight planning such as requiring excessive crew activity or use of propellants; in addition, they must not violate the constraints of any primary cargo. In general, a relatively small number of maneuvers consuming a relatively small amount of total time (hours) within the previously described thermal attitudes will probably be acceptable.

The Orbiter attitude control system employs vernier thrusters operating in a "bang-bang" mode around a deadband which can be as small as +/- six arc minutes (+/- .1 degree). Additional errors can be introduced by misalignment between the payload and the Orbiter reference frame and by drift in the gyro system. The gyro system is updated approximately twice a day by use of Orbiter star trackers. These updates require the Orbiter to point at the chosen star for several minutes. Attitude maneuvers are generally performed by means of crew inputs to the Digital Autopilot (DAP) which can be with reference to Aries mean of 1950 (A50), True Of Date (TOD), or Local Vertical/Local Horizontal (LVLH). The DAP can also be used to scan the Orbiter pointing reference at rates of as little as .008 degrees per minute.

During on-orbit operations, CGSE may be used to send commands to the customer payload as well as display customer data for use of the customer. Attitude, orbit position and ancillary data will be available in real time for use by CGSE as well as via NASA-provided displays.

The doors will generally be closed several hours prior to reentry. Following landing at KSC or Edwards Air Force Base (EAFB), cooling air will be provided within about 15 minutes. Considerable temperature rise in the ambient air still occurs during the landing process. If landing occurs at a location other than KSC (which occurs frequently), the Orbiter is carried by ferry aircraft to KSC for deintegration. Minimal, if any, access is possible at the initial landing site. Following return of the Orbiter to the KSC OPF, the payload will be removed and shipped to GSFC for deintegration. All data products should be available within 30 days of landing.

In preparing for the flight operations, each customer will need to develop a plan describing operations of his payload as a function of MET during the flight. In connection with this he/she will eventually develop a computer file in a format to be specified by GSFC. This file will contain at least the payload's power and energy requirements, required relationship of any operations to orbit position, targets, day/night, crew activity, attitude, etc. and will be used to generate a MET sequenced data base of trajectory driven parameters as shown in Figure 3.5.

Figure 3.5

HH Operations Data Base

Additional files defining the predicted attitude profile, crew activities, and carrier operations will be generated and finally merged with the customer files to produce the HH Timeline which will be available as a printout and also for access by computer terminal prior to and during the flight. The timeline will be used by customer, HH and JSC operations staff to execute the mission operations. The data base also allows generation of the HH mission power and energy profile which is used by JSC to develop the complete Orbiter power, energy, and consumable (fuel cell hydrogen/oxygen) predictions. The timeline also defines HH requirements for medium-rate telemetry, command activity, unique attitude requirements, unique restraints on Orbiter operations (such as water dumps), or other requirements on crew or other payload operations. During the flight, the data base may be updated to accommodate contingency replanning and actual trajectory.