Hitchhiker

Customer Accommodations & Requirements Specifications

740-SPEC-008

1999

(formerly HHG-730-1503-07)

APPROVED BY:

Signature of Joanne Baker Electrical Systems (Flight)	7/26/99
Signature of Barbara Milner Electrical Systems (Ground)	7/22/99
Signature of Gerard Daelemans Systems Engineering	7/29/99
Signature of Steve Wasserzug Mechanical Systems	7/22/99
Signature of Roger Counts Flight Assurance	7/22/99
Signature of James T. Harper Systems Safety	7/26/99
Signature of Theodore Michalek Thermal Systems	7/27/99
Signature of B. Thomas Dixon II Missions Operations	7/23/99
Signature of G.J. Daelmans ISO 9000 Compliance	7/26/99
Signature of Michael R. Wright I&T	7/26/99

Signature of *7/30/99*

Chris Dunker
Office Chief
Shuttle Small Payloads Project Office

REVISION *	DESCRIPTION	DATE	APPROVAL
B	COMPLETE REWRITE PER CCR #SSPP-918	7/30/99	C. Dunker (*signature*)
C	RESISTANCE VALUE CORRECTION PER CCR# SSPP-919	10/18/99	J. Baker (*signature*)

* Original release of CARS: HHG-730-1503-07, 1991, (Yellow Cover)
REV “A” of CARS: HHG-730-1503-07, 1994, (Pink Cover)

SECTION 1

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1. INTRODUCTION

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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.

Upon signature of the CPR, Appendix E to this document, the customer agrees to meet all the applicable customer requirements, (i.e. mechanical, electrical and thermal interfaces and deliverables, safety assessments and deliverables, etc.) as specified herein, for flight as a Hitchhiker payload.

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 MO
Washington, DC 20546
Facsimile: (202) 358-2889
Program Office:(202) 358-4413

HH Project Office

Code 870
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 MO
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 Assignment, Form 1628 (Figures 1.1 and 1.1a) 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.

National Aeronautics and Space Administration — **Request for Flight Assignment**	Form Approved O.M.B. No. 2700-0040
Note - Please read and detach instructions before completing this request.	CONTROL NO. *(MC Use)*

TO	National Aeronautics and Space Administration Customer Services Code MC Washington, D.C. 20546	FROM	DEVELOPMENT COMPANY/AGENCY NAME AND ADDRESS PRINCIPAL CONTACT (Name and Phone, incl. Area Code)

I-BASIC PAYLOAD AND FLIGHT DATA

1. PAYLOAD TITLE

2. PAYLOAD OBJECTIVES

3. CATEGORY

☐ a. U.S. COMMERCIAL ☐ b. DOD ☐ c. NASA ☐ d. FOREIGN COMMERCIAL

☐ e. FOREIGN GOVERNMENT ☐ f. OTHER U.S. GOVT. ☐ g. JEA/OTHER

4. FLIGHT INFORMATION (Check at least one in items 1-4)

1. ☐ a. SHARED ☐ b. DEDICATED
2. ☐ a. CARGO BAY ☐ b. MIDDECK *(Specify locker volume)*:____________
3. ☐ a. ATTACHED ☐ b. DEPLOYABLE ☐ c. RETRIEVAL ☐ d. REVISIT/SERVICE
4. ☐ a. KSC ☐ b. VLS

5. CARRIER

☐ a. PAM D ☐ b. PAM DII ☐ c. IUS

☐ d. MPESS ☐ e. HITCHHIKER-G ☐ f. HITCHHIKER-M

☐ g. SPACELAB *(Specify: e.g., LM&P)* ________ ☐ h. OTHER *(Specify)*__________

II-PAYLOAD REQUIREMENTS

6. PAYLOAD ORBIT REQUIREMENTS

☐ a. 160NM ALTITUDE/28.5 INCLINATION ☐ b. 160NM ALTITUDE/57 INCLINATION

☐ c. OTHER: (1) NM ALTITUDE ____; (2) DEGREES INCLINATION____ ☐ d. ORBIT INSENSITIVE

7. PAYLOAD LAUNCH REQUESTED (Total launch(es) and date(s)) (Enter month and year only)

a. NUMBER OF LAUNCHES________________________

b. FIRST LAUNCH *(Scheduled, stand-by, or short-term call-up)*________________________

c. SUBSEQUENT LAUNCH(ES)________________________

____

d. MINIMUM INTERVAL REQUIRED BETWEEN LAUNCHES________________________

NASA FORM 1628 SEP 86 *(Formerly STS Form 100)*

FIGURE 1.1 NASA FORM 1628

II-PAYLOAD REQUIREMENTS (*Continued*)

8. UNIQUE PAYLOAD CONSTRAINTS ***(e.g., launch window, late servicing, early access, etc.)***

9. REMOTE MANIPULATOR SYSTEM REQUIRED ☐ a. YES ☐ b. NO	**10. PAYLOAD MISSION DURATION REQUIRED** ☐ a. YES (Indicate hours/days)____ ☐ b. NO

III-PAYLOAD REQUIREMENTS CHARACTERISTICS

(The term payload refers to all customer provided equipment and associated carrier)

11. LAUNCH	**a. WEIGHT** ***(LB/KG)***	**b. MAX. DIAMETER** ***(IN/CM)***	**c. MAX. LENGTH** ***(IN/CM)***	**d. CG** ***(IN/CM)***
12. LANDING	**a. WEIGHT** ***(LB/KG)***	**b. MAX. DIAMETER** ***(IN/CM)***	**c. MAX. LENGTH** ***(IN/CM)***	**d. CG** ***(IN/CM)***

IV-QUESTIONNAIRE AND SERVICE REQUIREMENTS

DESCRIPTION	YES a.	NO b.
13. HAS EARNEST MONEY BEEN SUBMITTED?	☐	☐
14. DOES YOUR ORGANIZATION REQUIRE COPIES OF STANDARD STS DOCUMENTATION?	☐	☐

15. SERVICES ***(List any anticipated special services required)***

16. REMARKS

17. TYPED NAME AND TITLE	**18. SIGNATURE**	**19. DATE**

FIGURE 1.1A NASA FORM 1628

GUIDELINES FOR COMPLETION 0F NASA FORM 1628
(Formerly STS Form 100)

A completed NASA Form 1628 enables a payload developer to inform NASA of his or her intentions to use the National Space Transportation System (NSTS). Information contained in this form permits NASA to become familiar with general payload requirements and develop a preliminary STS cargo manifest which assigns the identified payload to a particular orbiter flight.

This form should be completed for a single payload entity rather than for individual experiments which would fly on a common carrier. Instructions listed below are intended to assist the payload developer in completing this form.

1. Payload Title - Enter the name you plan to use when referring to your payload.

2. Payload Objectives - Identify the major objectives for this payload program. For example, "This payload will map the surface of Venus using radar from orbiting spacecraft. Instruments will include imaging radar and microwave radiometers."

3. Category - Select the appropriate customer category by placing an "x" in the proper box.

4. Flight Information - Select at least one category for each item listed. For example, a company requests a launch to deploy its satel-lite and a later launch to service it, in which the spaces designated as "Cargo Bay," "Deployable," and "Revisit/Service" would be checked.

5. Carrier - Specify the type of carrier or upper stage required for the payload. Upper stage options are PAM-D, PAM-DII, IUS, TOS, SCOTS, IRIS, UNIQUE STAGE, HITCHHIKER-G, HITCHHKER-M, SPACELAB (+ CONFIGURATION), MPESS, PALLET, SPOC, SPAS, SPECIAL STRUCTURE, etc.

6. Payload Orbit Requirements - Select the desired orbit for your payload. If item 6c. "Other" is selected, please identify both the degree altitude and inclination.

7. Payload Launch Requested (Total launch(es) and date(s).

a. Number of Launches - Enter the total number of flights required for this payload program.

b. First Launch - Enter the desired date for the first flight of this payload.

c. Subsequent Launch(es) - List the requested flight date for each additional launch.

d. Minimum Interval Required Between Launches - If you have requirements for a specific number of days, weeks, months, or years between your payload launches, identify the spacing timeframe.

8. Unique Payload Constraints - List any unique requirements for your payload. Identify launch window constraints, experiment operating time, satellite checkout time, etc.

9. Remote Manipulator System Required -Place an "x" in the appropriate box for use of Remote Manipulator System.

10. Payload Mission Duration Required - If your payload requires a certain number of operating days in order to obtain the proper data, please indicate the number of hours and/or days required.

Payload Characteristics - The term payload refers to all customer-provided equipment and associated carriers. Using U.S. or S.I. (Metric) measurement units, enter launch and landing weight, diameter and length of the payload as well as the center of gravity, if known, in items 11 and 12.

Questionnaire and Service Requirements. Items 13 and 14 are self-explanatory. List in item 15 any anticipated optional services required. Optional services are tasks performed for a charge using the existing capabilities of NASA. Some examples of optional services which would be listed in this block are: extravehicular activity, non-standard altitude and inclination, payload retrieval packages, etc.

16. Remarks - Enter any further comments that concern your payload program.

17, 18 and 19 - This request is to be signed by an official within the company who can authenticate the information provided. NASA payloads require the signature of an Associate Administrator.

NOTE - If you need any additional assistance in completing this request, mail your inquiries to the address shown on the face of the form, or call (202) 534-2347.

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	SPA Switch Panel	Standard Switch 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 MO.

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 MO 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.

1.8 Customer Survey

As part of standard post-flight customer processing, the HH Project Office will distribute a Shuttle Small Payloads Project Customer Survey form (Figure 1.2), to be completed and returned at the customer's discretion.

1.9 Internet Information

The Project maintains an Internet web site for distribution of project related information including documentation, manifest data, photographs of carriers and payloads, information on symposia and workshops, and daily mission updates during flight operations. We will be happy to provide links to web pages of SSPP customers containing information of interest to the Shuttle payload community. The Internet address is: http://sspp.gsfc.nasa.gov.

Shuttle Small Payloads Project

Customer Survey

Mission: Payload: Date:

Name/Title (optional):

Organization/Company: Phone:

Please rate the following on a 1 - 10 scale (0 = n/a, 1 = poor, 10 = excellent, ? = not sure):

1. Mission and pre-integration planning support from GSFC/SSPP:
2. Integration & Test support provided by GSFC/SSPP personnel:
3. Launch site support provided by KSC personnel:
4. Mission ops support provided by GSFC/SSPP personnel:
5. GSFC/SSPP response to special or new customer requests for support:
6. Effectiveness of TIM's, design & safety reviews:
7. Value added by having GSFC/SSPP personnel visit customer facility:
8. GSFC/SSPP understanding and documentation of your requirements:
9. GSFC/SSPP implementation of your requirements:
10. Effectiveness of the training and security programs:

Please respond to the following questions (continue on other side if necessary):

1. What have you enjoyed most about working with GSFC/SSPP?
2. What have you enjoyed least about working with GSFC/SSPP?
3. What processes or services provided by GSFC/SSPP have helped the most?
4. What could have been done more effectively or efficiently?
5. What did not add value to your operations, or caused "unnecessary" work?
6. What could have been done to improve your payload operations?
7. What additional comments do you have?

FIGURE 1.2 CUSTOMER SURVEY

APPROVED BY:

Signature of Joanne Baker Electrical Systems (Flight)	7/26/99
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HH Project Office

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

Facsimile: (301) 286-1694
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Request for Flight Assignment

National Aeronautics and Space Administration

Form Approved
O.M.B. No. 2700-0040

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NASA FORM 1628 SEP 86 *(Formerly STS Form 100)*

FIGURE 1.1 NASA FORM 1628

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9. REMOTE MANIPULATOR SYSTEM REQUIRED ☐ a. YES ☐ b. NO		10. PAYLOAD MISSION DURATION REQUIRED ☐ a. YES (Indicate hours/days)____ ☐ b. NO		
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15. SERVICES *(List any anticipated special services required)*		
16. REMARKS		

17. TYPED NAME AND TITLE	18. SIGNATURE	19. DATE

FIGURE 1.1A NASA FORM 1628

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2. Payload Objectives - Identify the major objectives for this payload program. For example, "This payload will map the surface of Venus using radar from orbiting spacecraft. Instruments will include imaging radar and microwave radiometers."

3. Category - Select the appropriate customer category by placing an "x" in the proper box.

4. Flight Information - Select at least one category for each item listed. For example, a company requests a launch to deploy its satel-lite and a later launch to service it, in which the spaces designated as "Cargo Bay," "Deployable," and "Revisit/Service" would be checked.

5. Carrier - Specify the type of carrier or upper stage required for the payload. Upper stage options are PAM-D, PAM-DII, IUS, TOS, SCOTS, IRIS, UNIQUE STAGE, HITCHHIKER-G, HITCHHKER-M, SPACELAB (+ CONFIGURATION), MPESS, PALLET, SPOC, SPAS, SPECIAL STRUCTURE, etc.

6. Payload Orbit Requirements - Select the desired orbit for your payload. If item 6c. "Other" is selected, please identify both the degree altitude and inclination.

7. Payload Launch Requested (Total launch(es) and date(s).

a. Number of Launches - Enter the total number of flights required for this payload program.

b. First Launch - Enter the desired date for the first flight of this payload.

c. Subsequent Launch(es) - List the requested flight date for each additional launch.

d. Minimum Interval Required Between Launches - If you have requirements for a specific number of days, weeks, months, or years between your payload launches, identify the spacing timeframe.

8. Unique Payload Constraints - List any unique requirements for your payload. Identify launch window constraints, experiment operating time, satellite checkout time, etc.

9. Remote Manipulator System Required -Place an "x" in the appropriate box for use of Remote Manipulator System.

10. Payload Mission Duration Required - If your payload requires a certain number of operating days in order to obtain the proper data, please indicate the number of hours and/or days required.

Payload Characteristics - The term payload refers to all customer-provided equipment and associated carriers. Using U.S. or S.I. (Metric) measurement units, enter launch and landing weight, diameter and length of the payload as well as the center of gravity, if known, in items 11 and 12.

Questionnaire and Service Requirements. Items 13 and 14 are self-explanatory. List in item 15 any anticipated optional services required. Optional services are tasks performed for a charge using the existing capabilities of NASA. Some examples of optional services which would be listed in this block are: extravehicular activity, non-standard altitude and inclination, payload retrieval packages, etc.

16. Remarks - Enter any further comments that concern your payload program.

17, 18 and 19 - This request is to be signed by an official within the company who can authenticate the information provided. NASA payloads require the signature of an Associate Administrator.

NOTE - If you need any additional assistance in completing this request, mail your inquiries to the address shown on the face of the form, or call (202) 534-2347.

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	SPA Switch Panel	Standard Switch 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 MO.

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 MO 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.

1.8 Customer Survey

As part of standard post-flight customer processing, the HH Project Office will distribute a Shuttle Small Payloads Project Customer Survey form (Figure 1.2), to be completed and returned at the customer's discretion.

1.9 Internet Information

The Project maintains an Internet web site for distribution of project related information including documentation, manifest data, photographs of carriers and payloads, information on symposia and workshops, and daily mission updates during flight operations. We will be happy to provide links to web pages of SSPP customers containing information of interest to the Shuttle payload community. The Internet address is: http://sspp.gsfc.nasa.gov.

Shuttle Small Payloads Project

Customer Survey

Mission: Payload: Date:

Name/Title (optional):

Organization/Company: Phone:

Please rate the following on a 1 - 10 scale (0 = n/a, 1 = poor, 10 = excellent, ? = not sure):

1. Mission and pre-integration planning support from GSFC/SSPP:
2. Integration & Test support provided by GSFC/SSPP personnel:
3. Launch site support provided by KSC personnel:
4. Mission ops support provided by GSFC/SSPP personnel:
5. GSFC/SSPP response to special or new customer requests for support:
6. Effectiveness of TIM's, design & safety reviews:
7. Value added by having GSFC/SSPP personnel visit customer facility:
8. GSFC/SSPP understanding and documentation of your requirements:
9. GSFC/SSPP implementation of your requirements:
10. Effectiveness of the training and security programs:

Please respond to the following questions (continue on other side if necessary):

1. What have you enjoyed most about working with GSFC/SSPP?
2. What have you enjoyed least about working with GSFC/SSPP?
3. What processes or services provided by GSFC/SSPP have helped the most?
4. What could have been done more effectively or efficiently?
5. What did not add value to your operations, or caused "unnecessary" work?
6. What could have been done to improve your payload operations?
7. What additional comments do you have?

FIGURE 1.2 CUSTOMER SURVEY

SECTION 2

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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 reimbursement 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	Maximum Carrier Weight (lbs)	Customer Weight (lbs)	Mounting Surface
Sealed Canister (insulated top plate)	160	200	19.75" Dia.
Sealed Canister (uninsulated top plate)	140	200	19.75" 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	70 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.

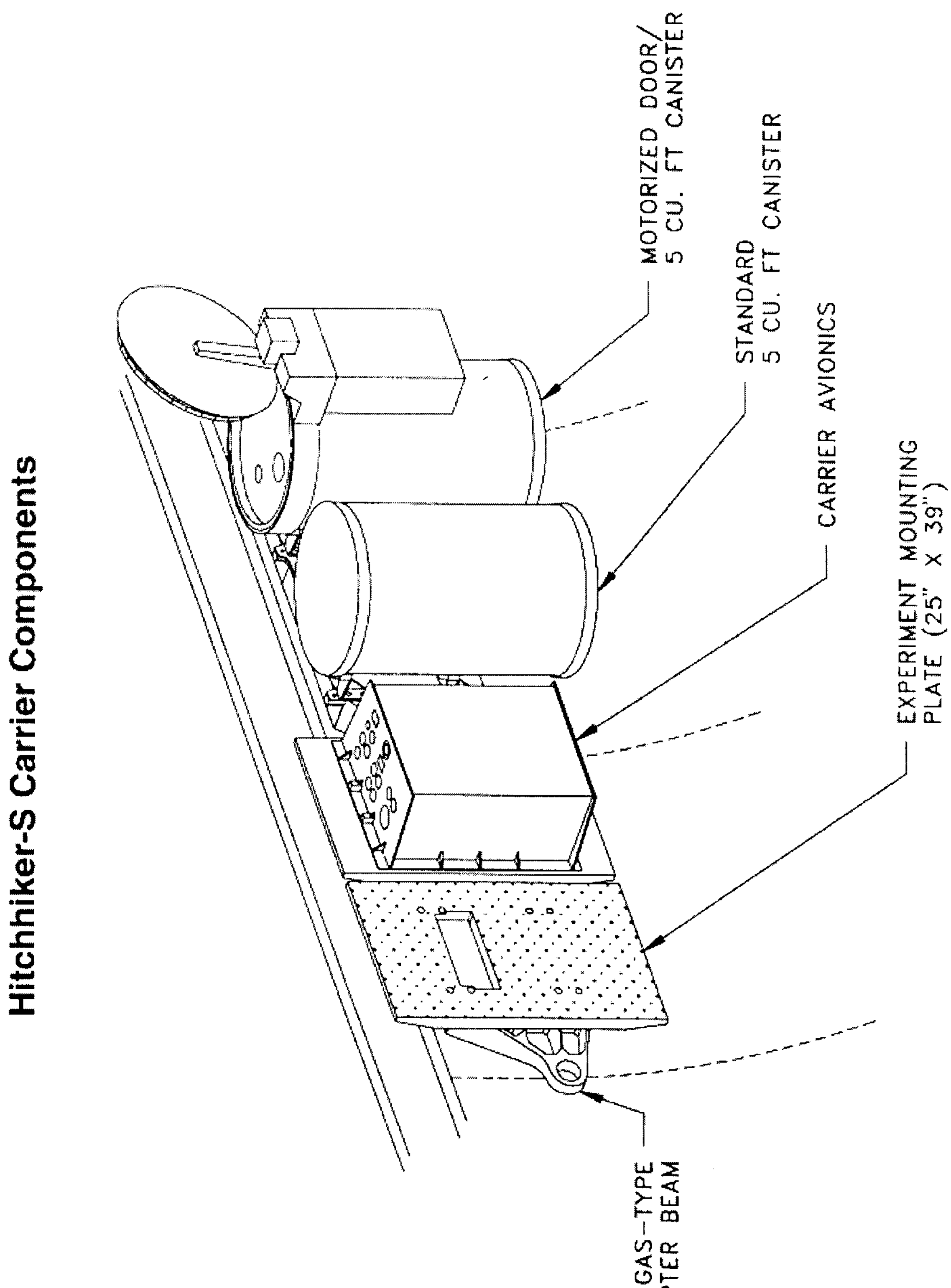


FIGURE 2.1 HITCHHIKER-S CARRIER COMPONENTS

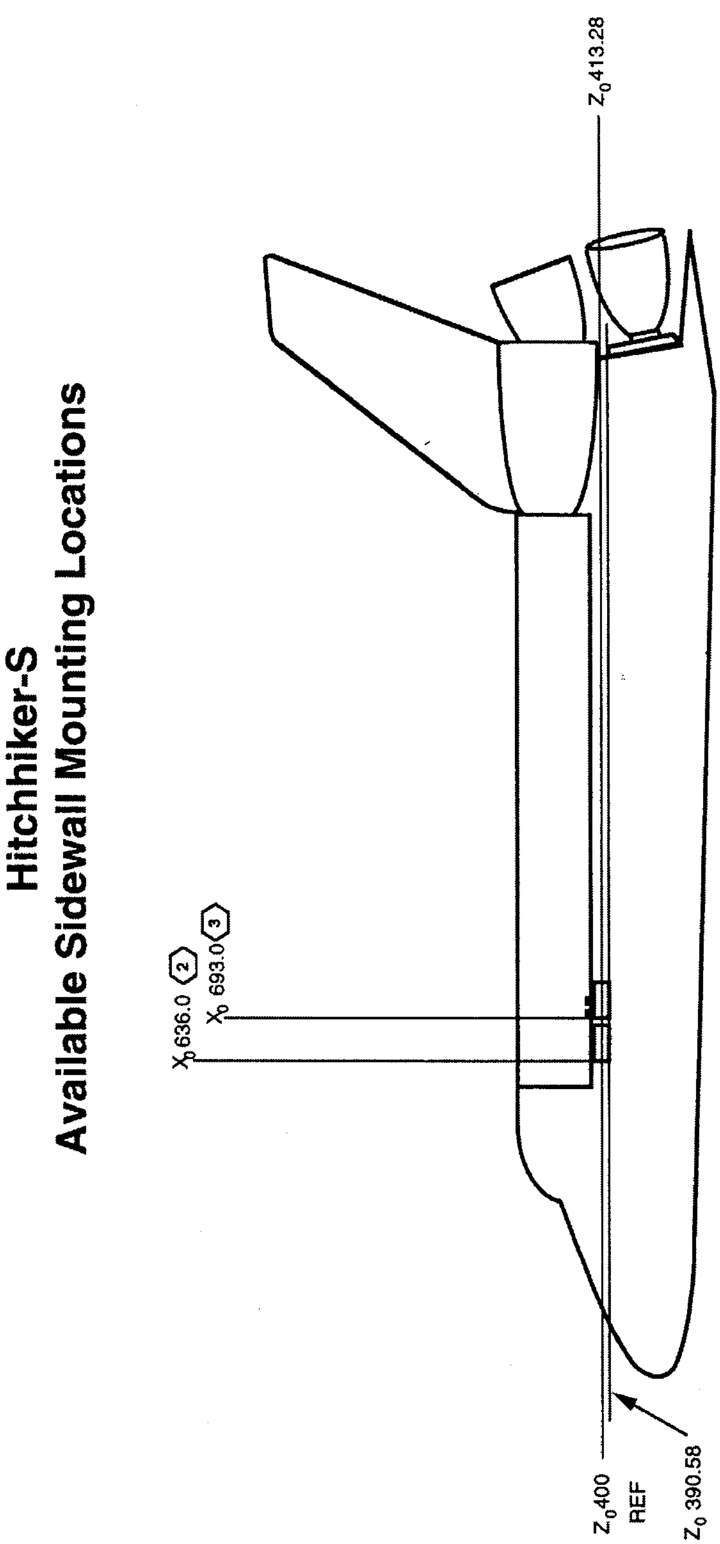


FIGURE 2.2 HITCHHIKER-S AVAILABLE SIDEWALL MOUNTING LOCATIONS

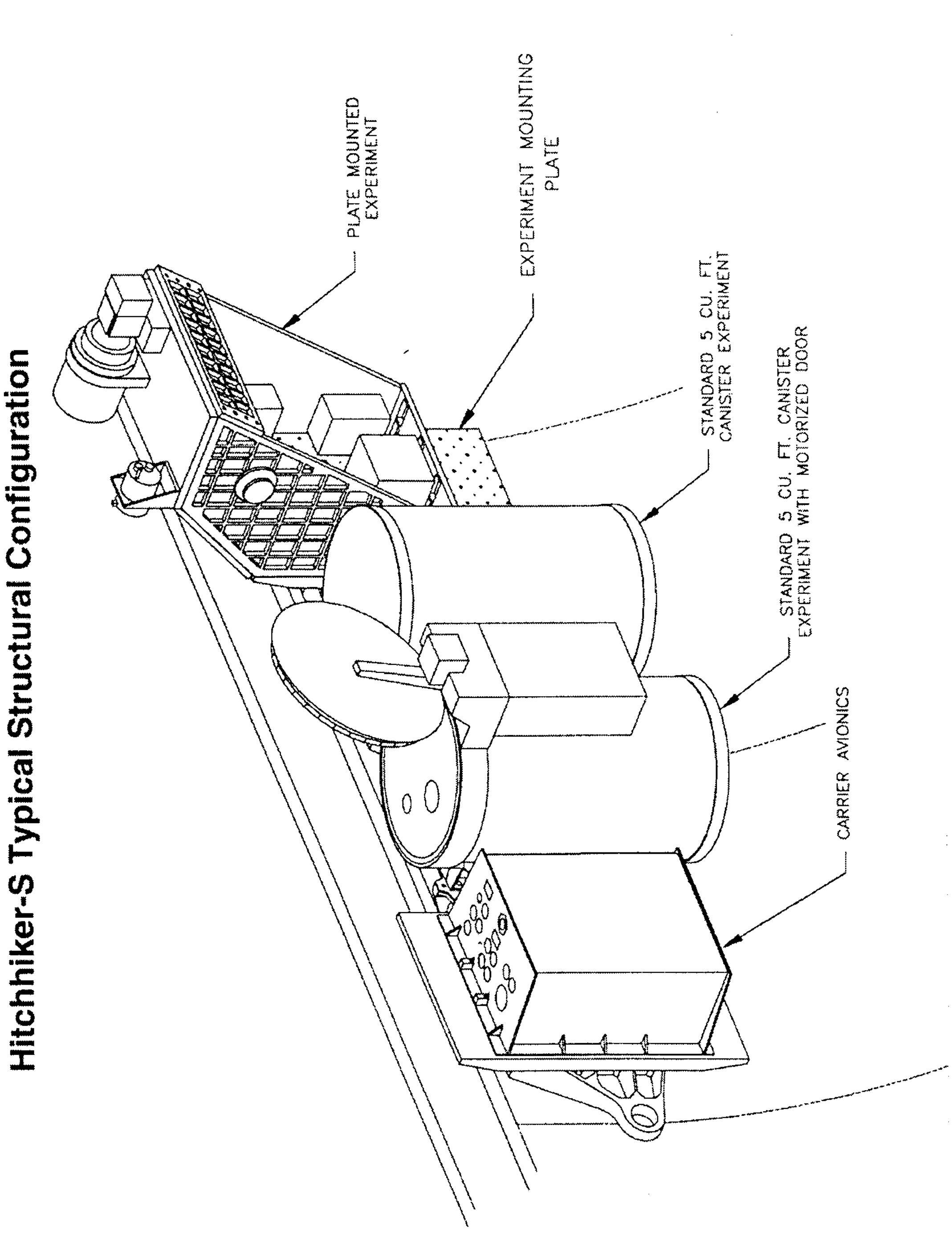
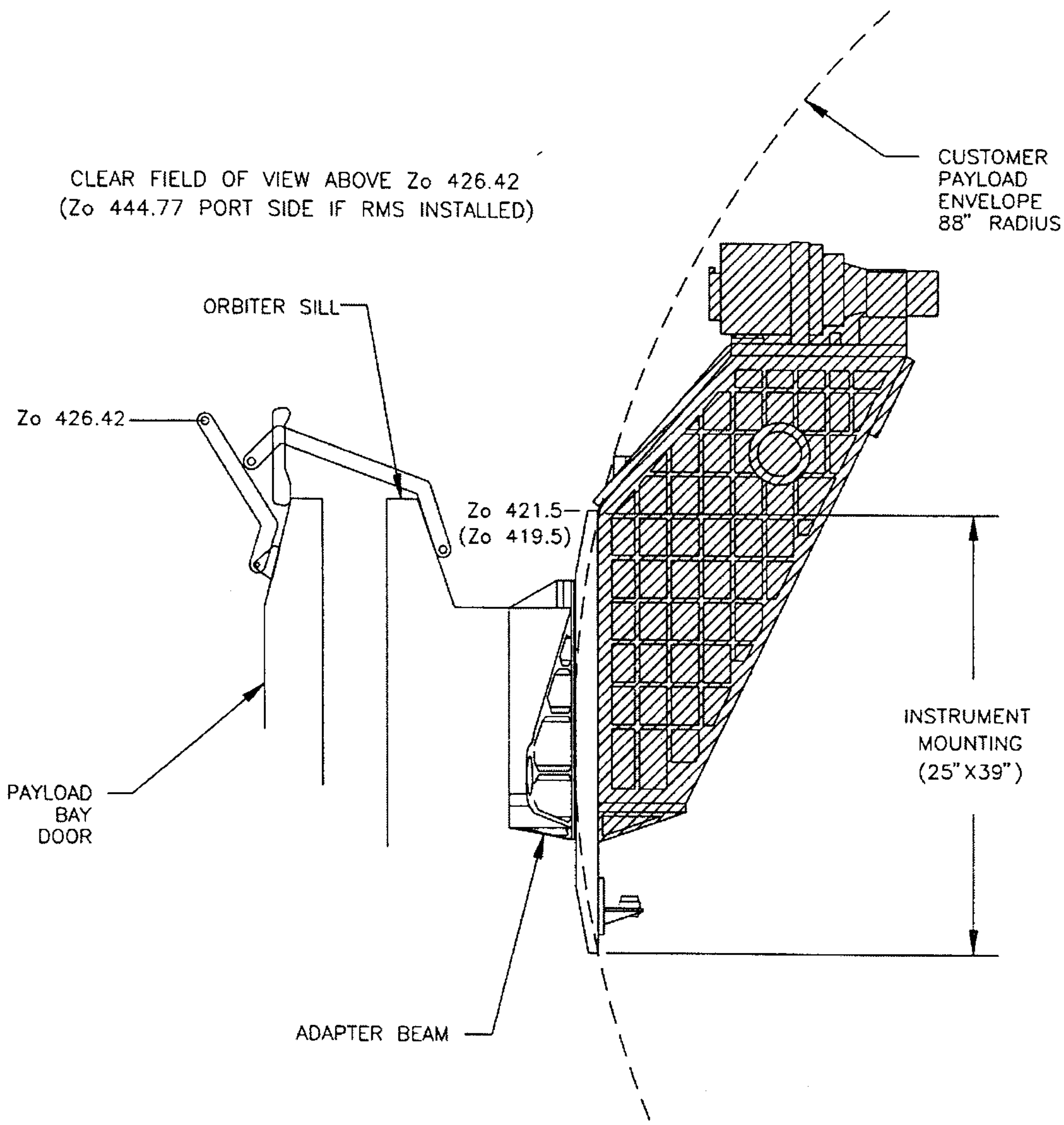


FIGURE 2.3 HITCHHIKER-S TYPICAL STRUCTURAL CONFIGURATION

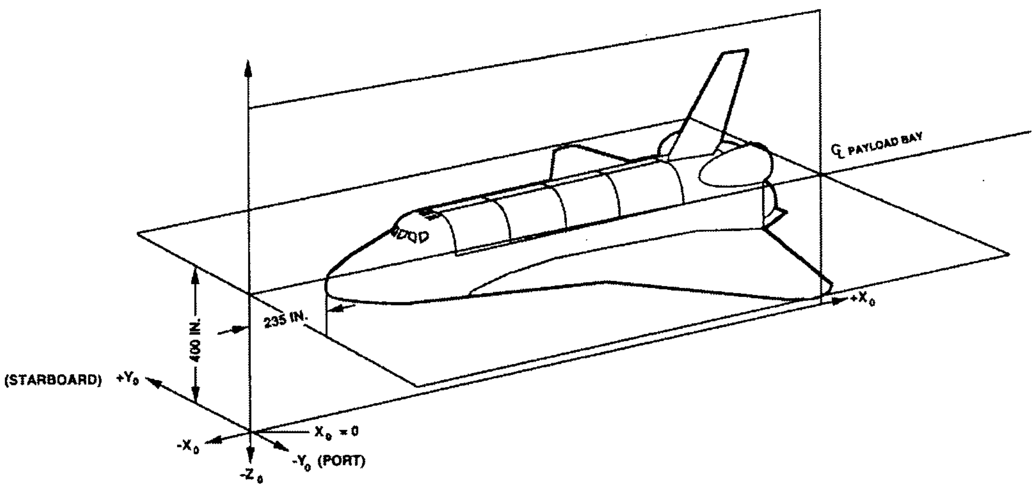
Hitchhiker-S Payload Mounting Concept (Sideview)



NOTE: Zo Coordinate in parenthesis indicates lower mounting position.

FIGURE 2.4 HITCHHIKER-S PAYLOAD MOUNTING CONCEPT (SIDEVIEW)

Orbiter Coordinate System



ORIGIN:	**IN THE ORBITER PLANE OF SYMMETRY, 400 INCHES BELOW THE CENTER LINE OF THE PAYLOAD BAY AND AT ORBITER X STATION = 0.**
ORIENTATION:	**THE X_0 AXIS IS IN THE VEHICLE PLANE OF SYMMETRY. PARALLEL TO AND 400 INCHES BELOW THE PAYLOAD BAY CENTER-LINE. POSITIVE SENSE IS FROM THE NOSE OF THE VEHICLE TOWARD THE TAIL.**
	THE Z_0 AXIS IS IN 0THE VEHICLE PLANE OF SYMMETRY, PERPENDICULAR TO THE X_0 AXIS POSITIVE UPWARD IN LANDING ATTITUDE.
	THE Y_0 AXIS COMPLETES A RIGHT-HANDED SYSTEM.
CHARACTERISTICS:	**ROTATING RIGHT-HANDED CARTESIAN. THE STANDARD SUBSCRIPT IS 0 (e.g. X_0)**

FIGURE 2.5 ORBITER COORDINATE SYSTEM

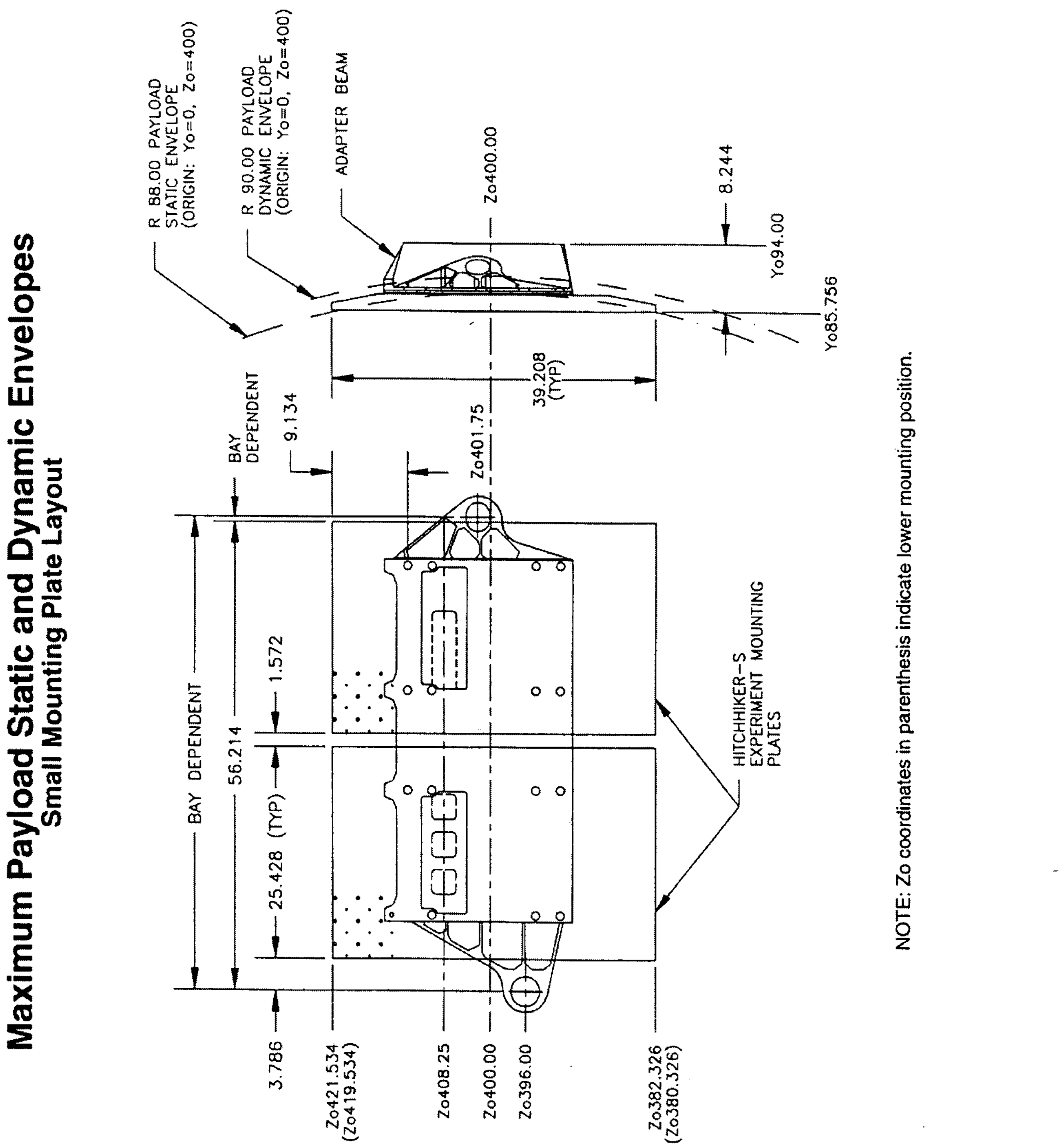


FIGURE 2.6 MAXIMUM PAYLOAD STATIC AND DYNAMIC ENVELOPES

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.

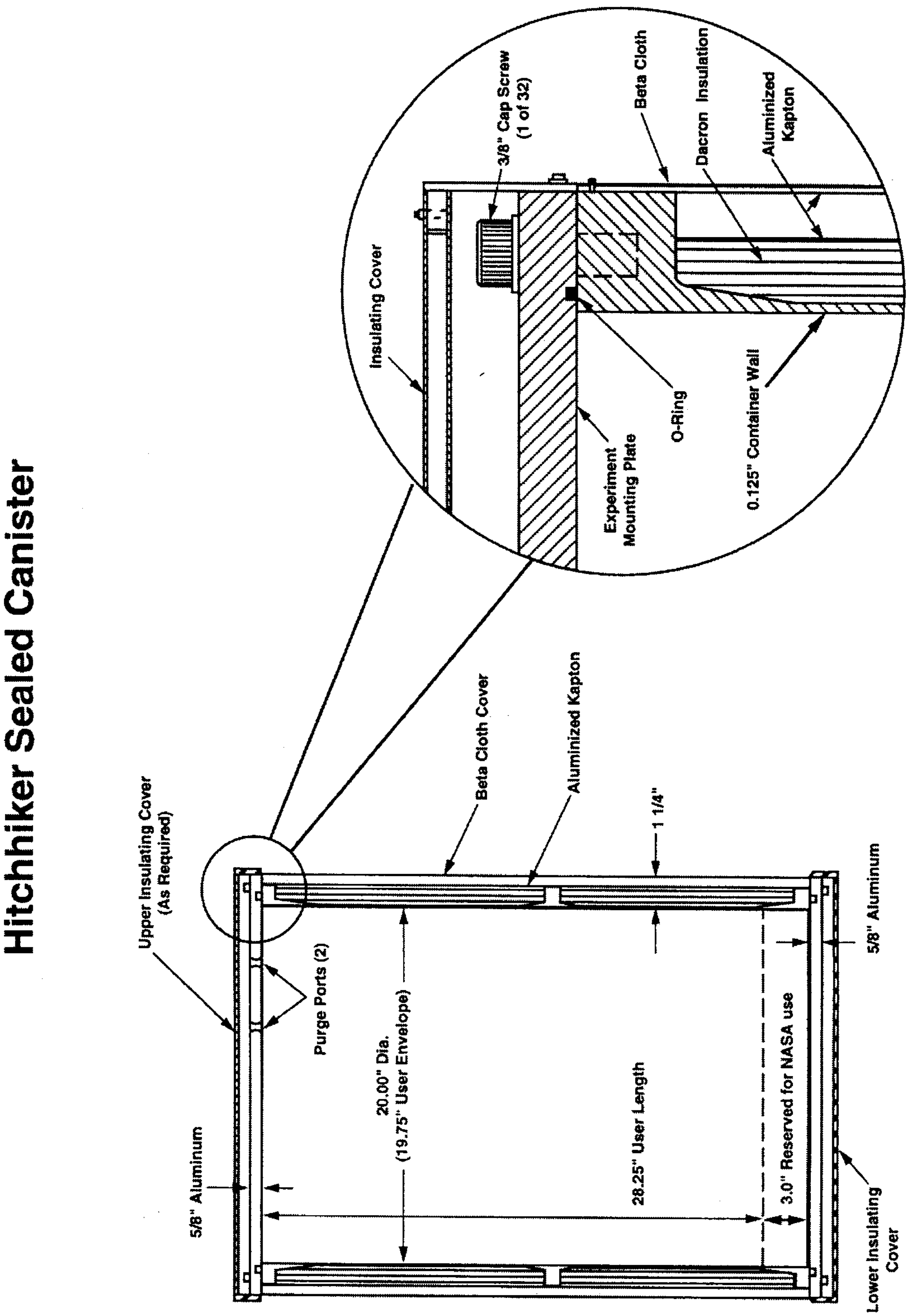


FIGURE 2.7 HITCHHIKER SEALED CANISTER

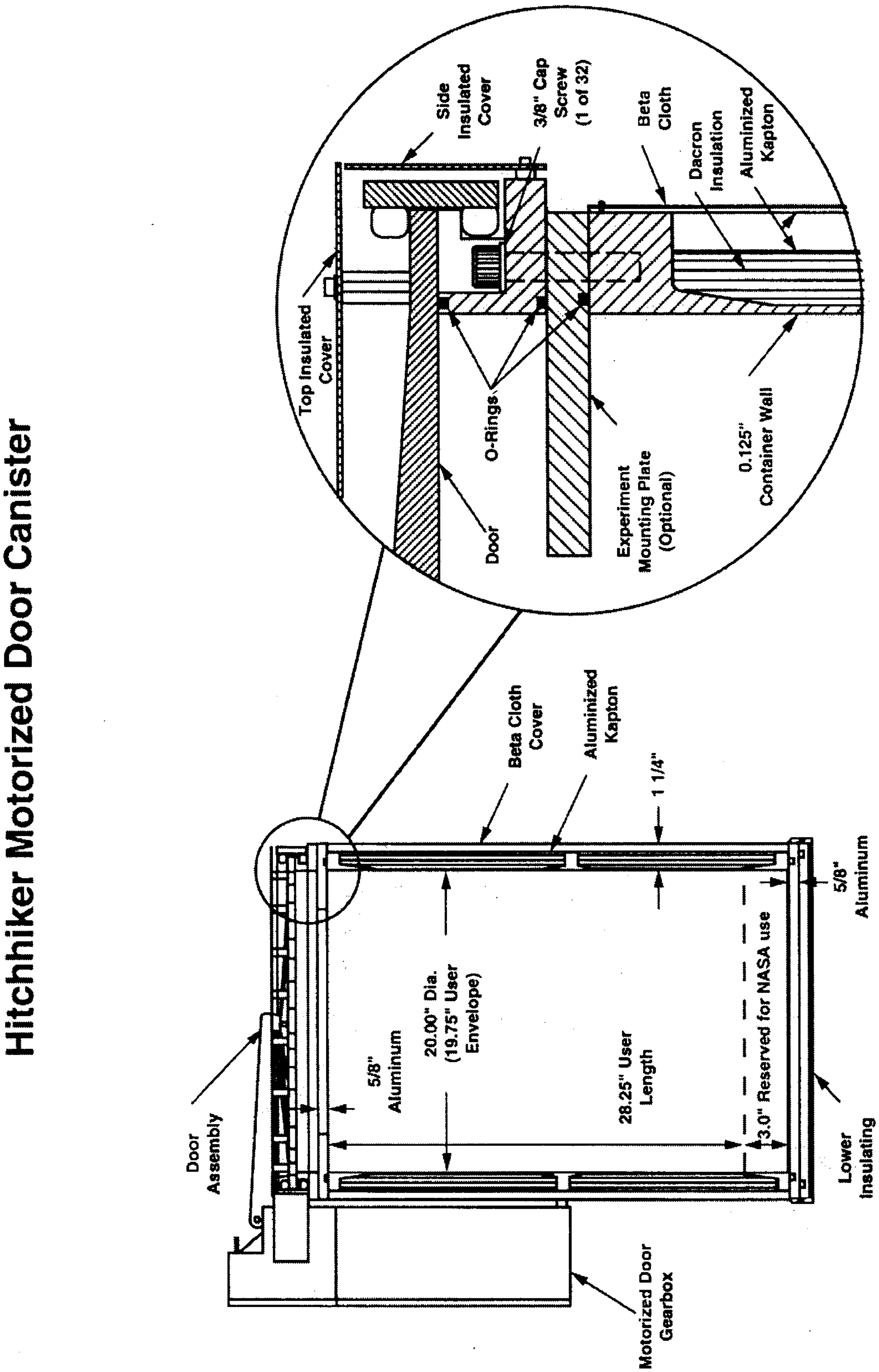


FIGURE 2.8 HITCHHIKER MOTORIZED DOOR CANISTER

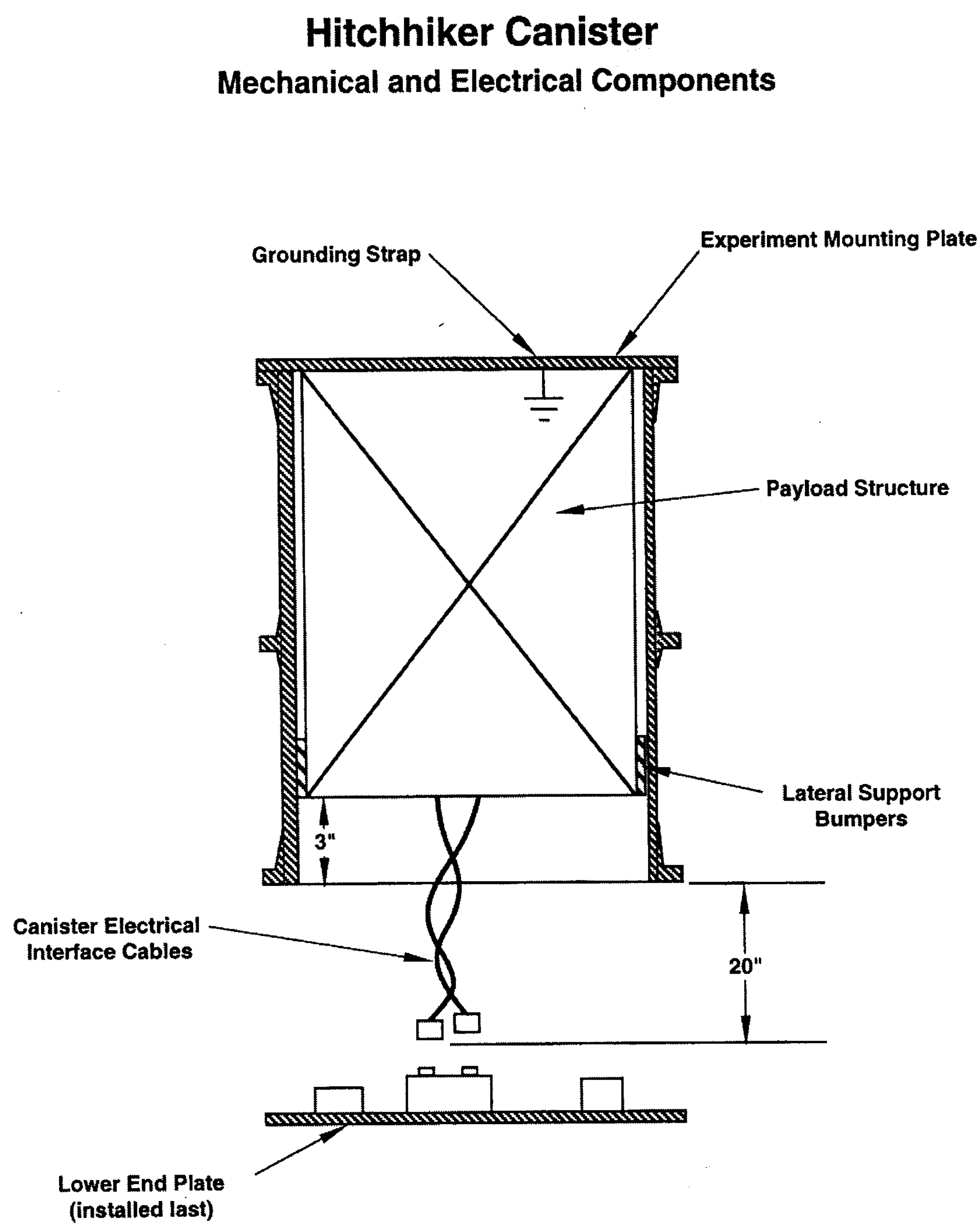


FIGURE 2.9 HITCHHIKER CANISTER

Hitchhiker-S Canister Mounting To Orbiter
View Looking Forward - Port Side

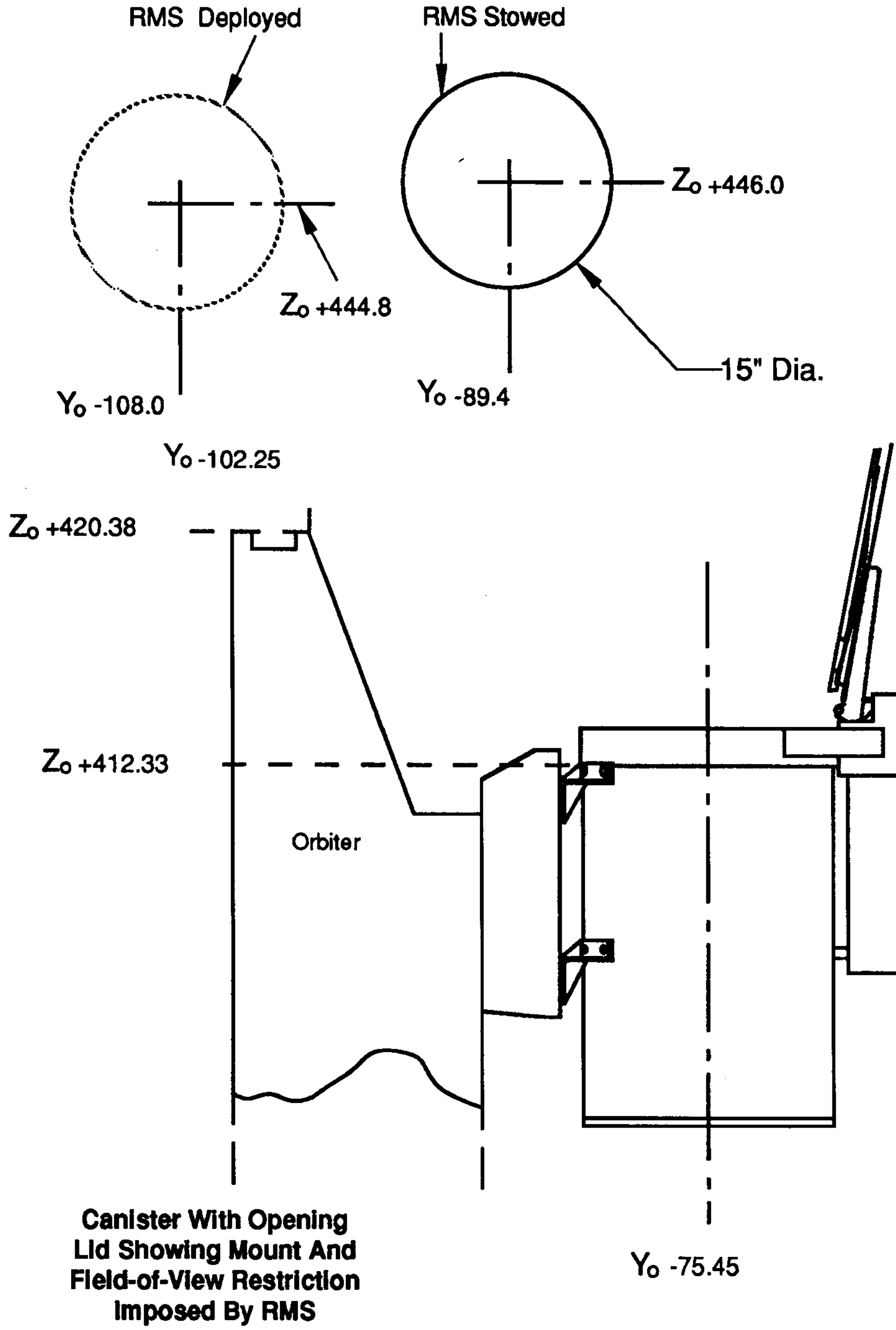


FIGURE 2.10 HITCHHIKER-S CANISTER MOUNTING TO ORBITER

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.

Hitchhiker Sealed Canister
Standard Experiment Mounting Plate
(Upper End Plate)

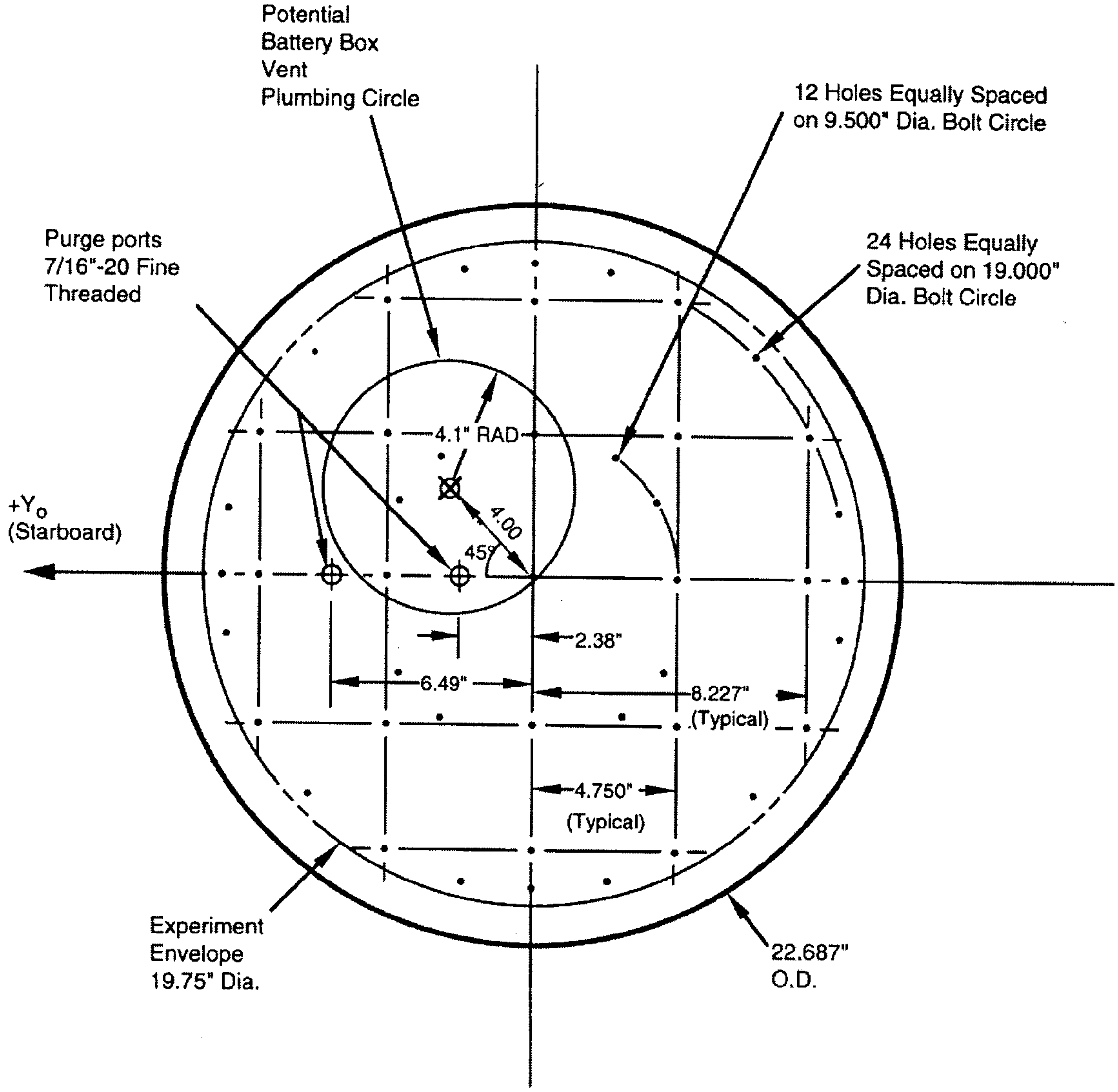


FIGURE 2.11 HITCHHIKER SEALED CANISTER (UPPER END PLATE)

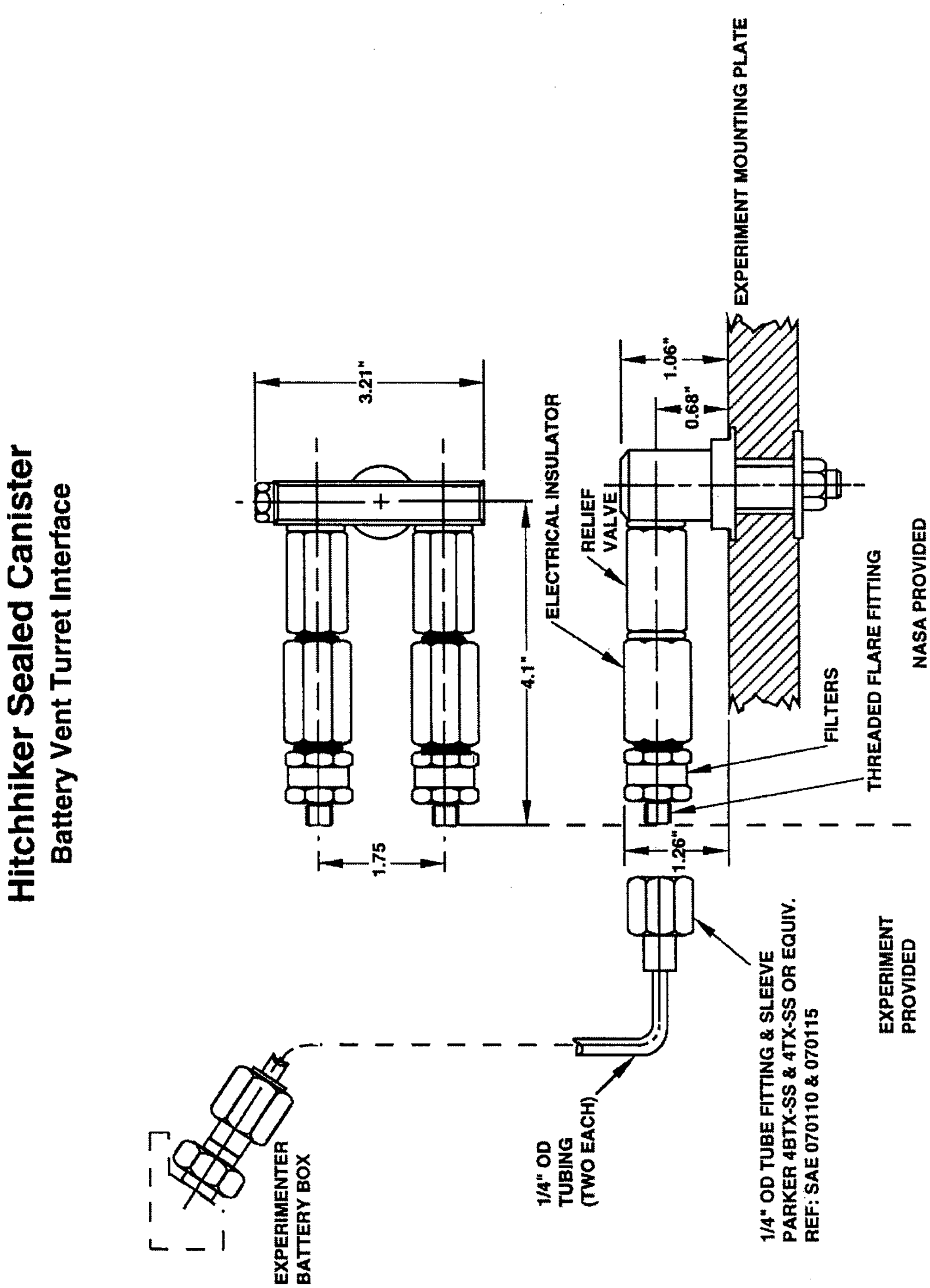


FIGURE 2.12 HITCHHIKER SEALED CANISTER – BATTERY VENT TURRET INTERFACE

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 Center of Gravity (CG) Considerations

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.

Opening Lid Canister
Experiment Mounting Plate

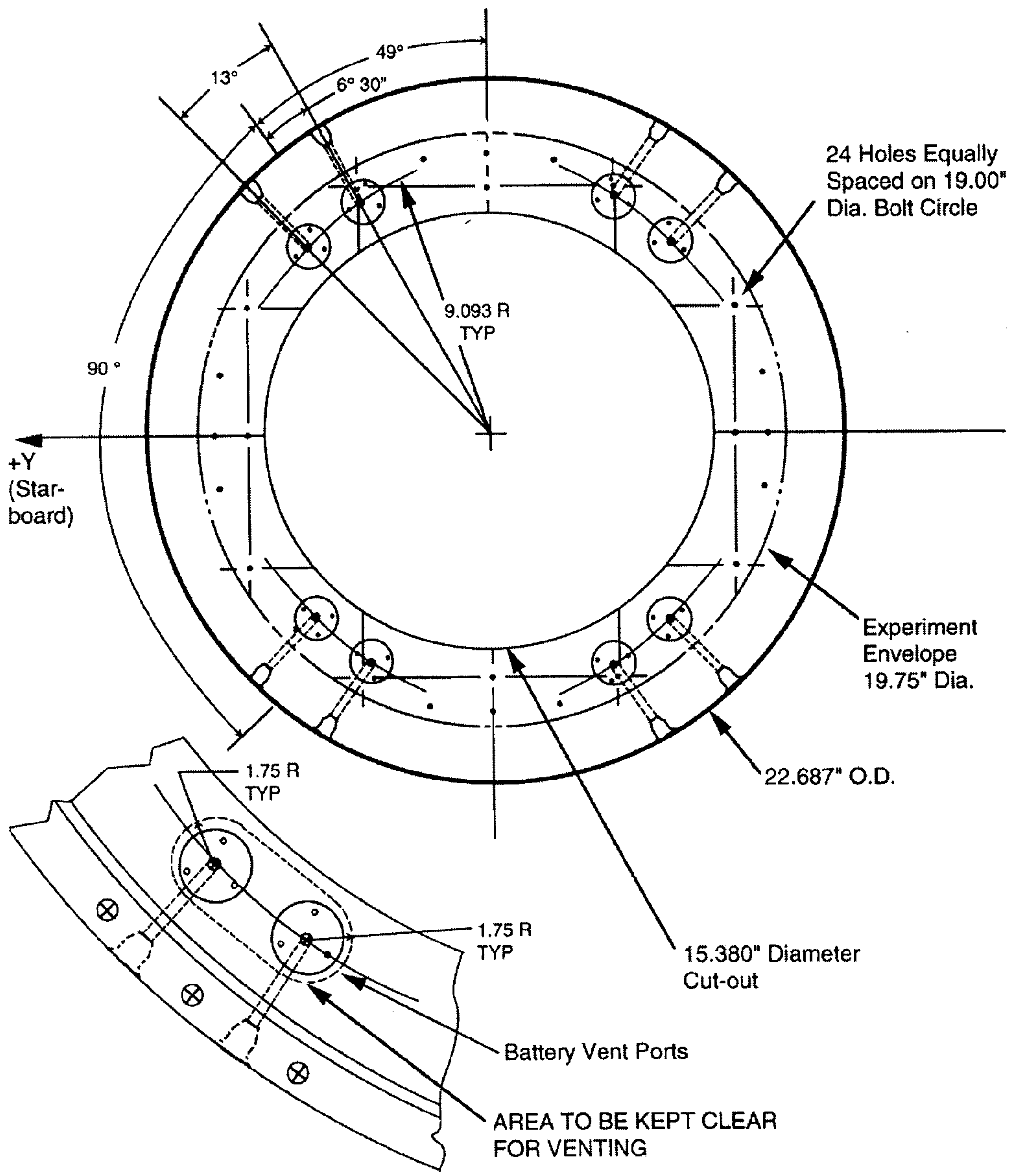


FIGURE 2.13 OPENING LID CANISTER – EXPERIMENT MOUNTING PLATE

Canister CG Envelope
Adapter Beam or Bridge Mounting

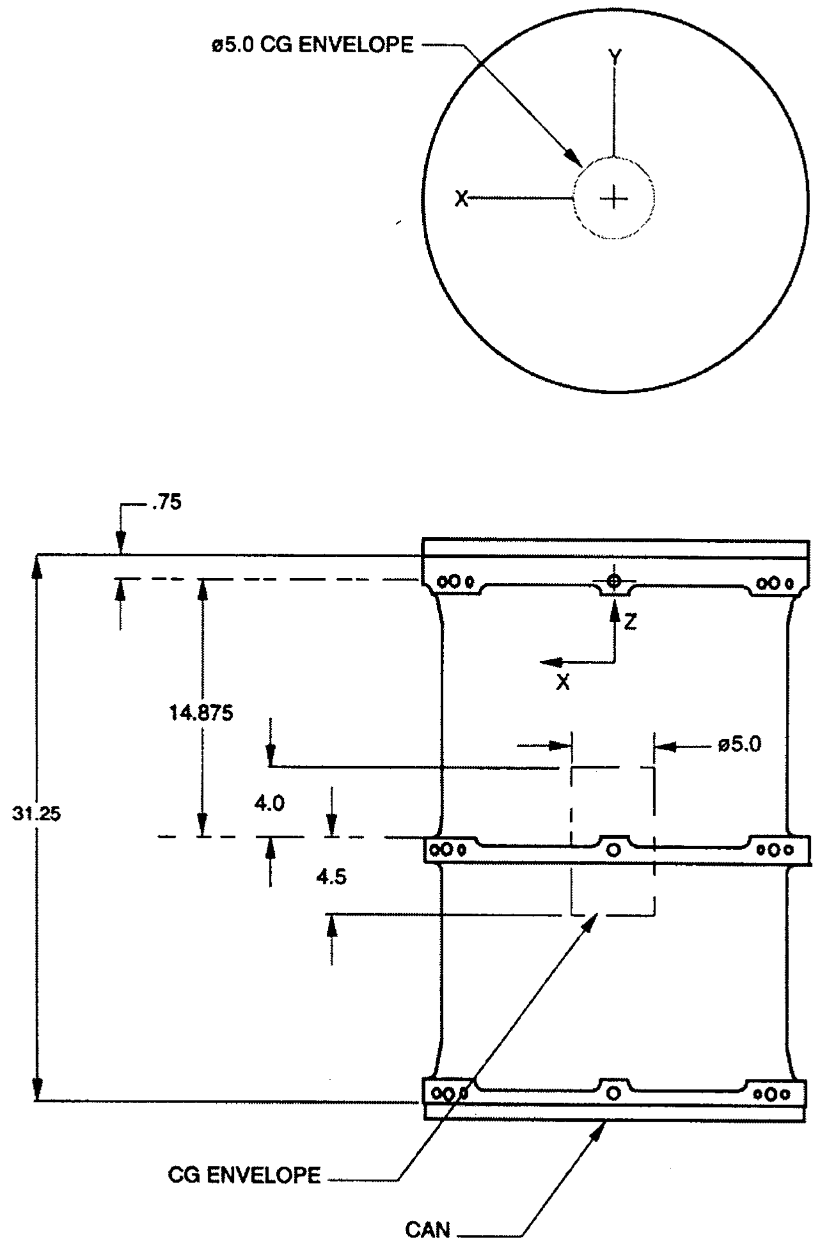


FIGURE 2.14 CANISTER CG ENVELOPE-ADAPTER BEAM OR BRIDGE MOUNTING

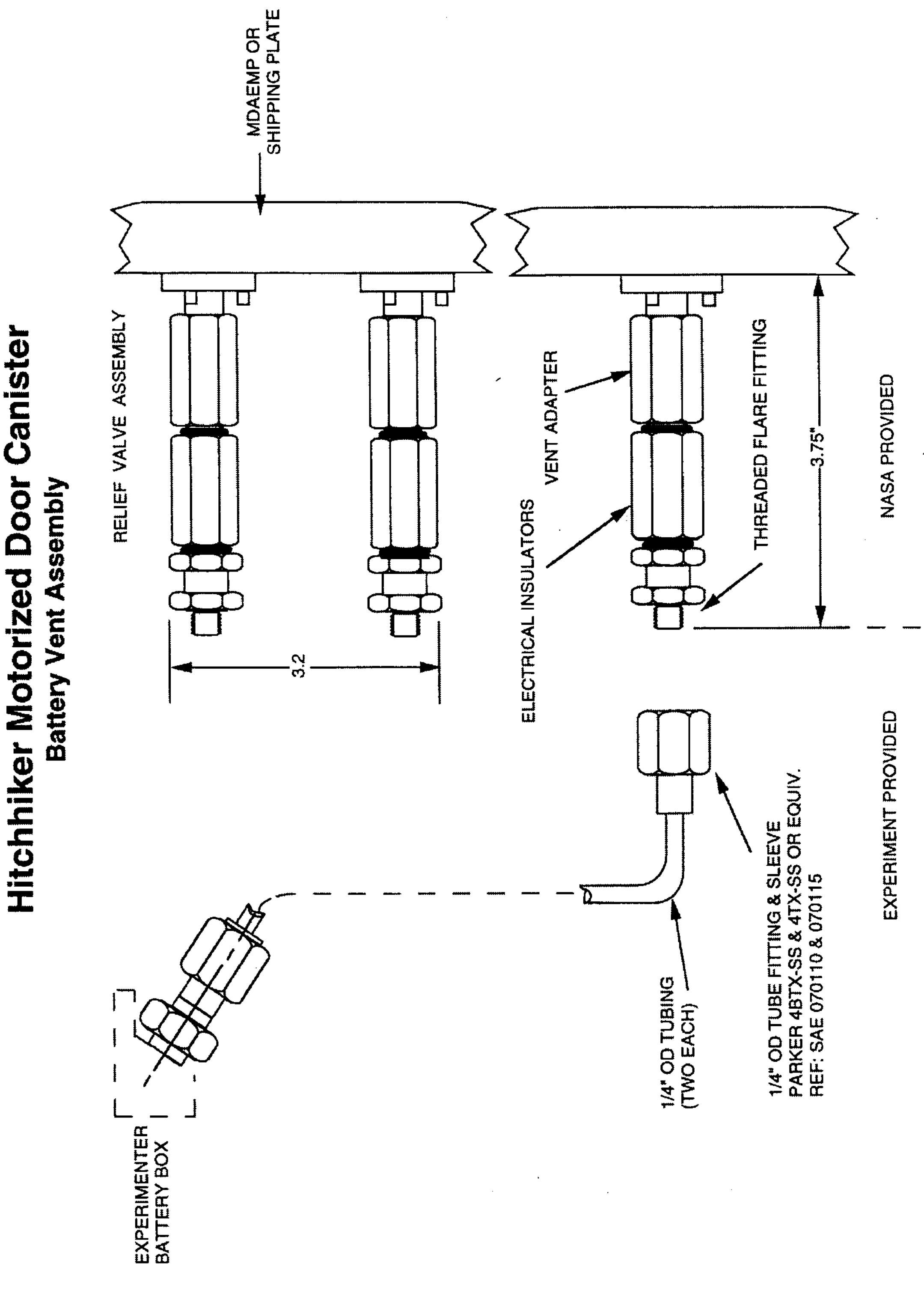


FIGURE 2.15 HITCHHIKER MOTORIZED DOOR CANISTER – BATTERY VENT ASSEMBLY

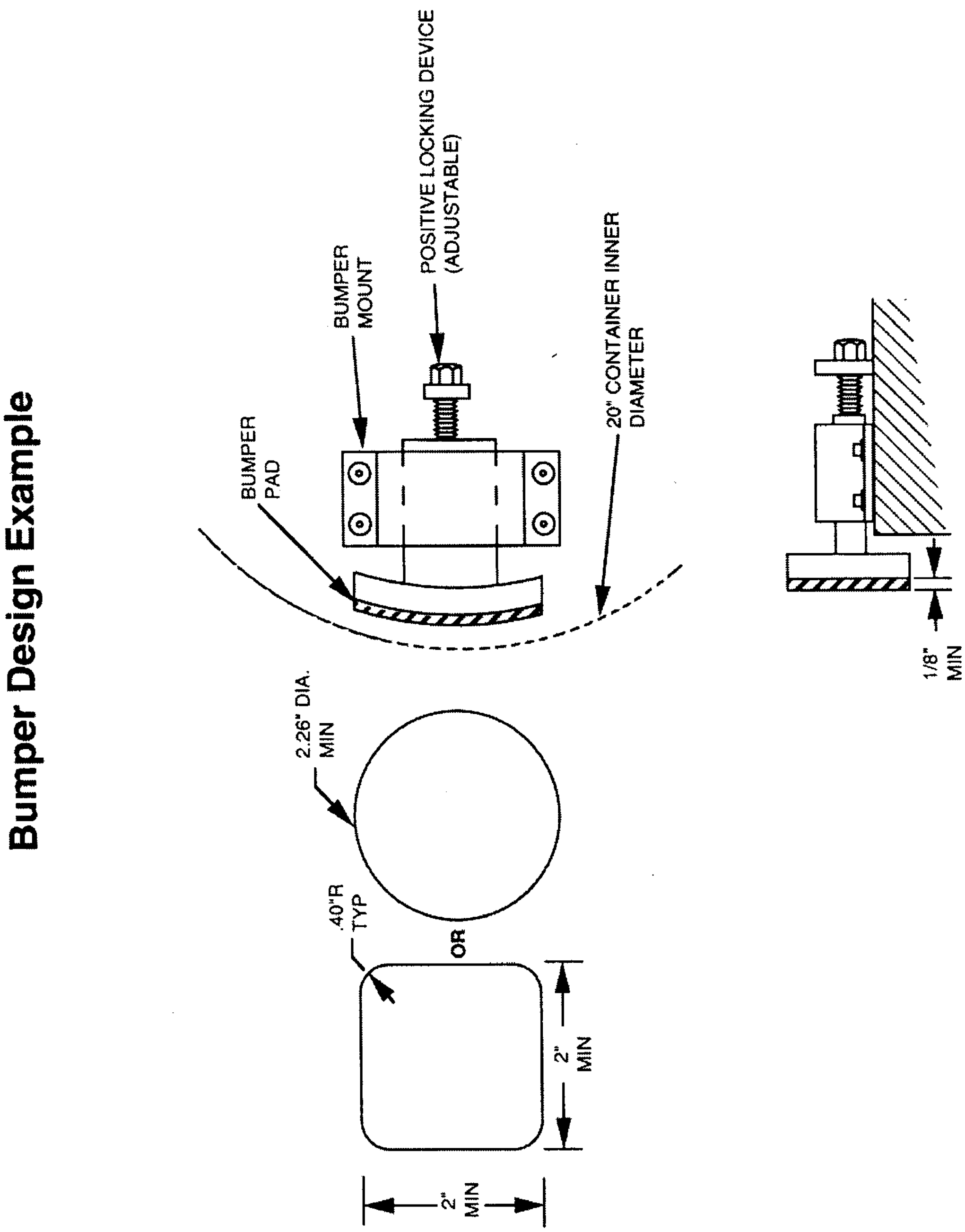


FIGURE 2.16 BUMPER DESIGN EXAMPLE

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.

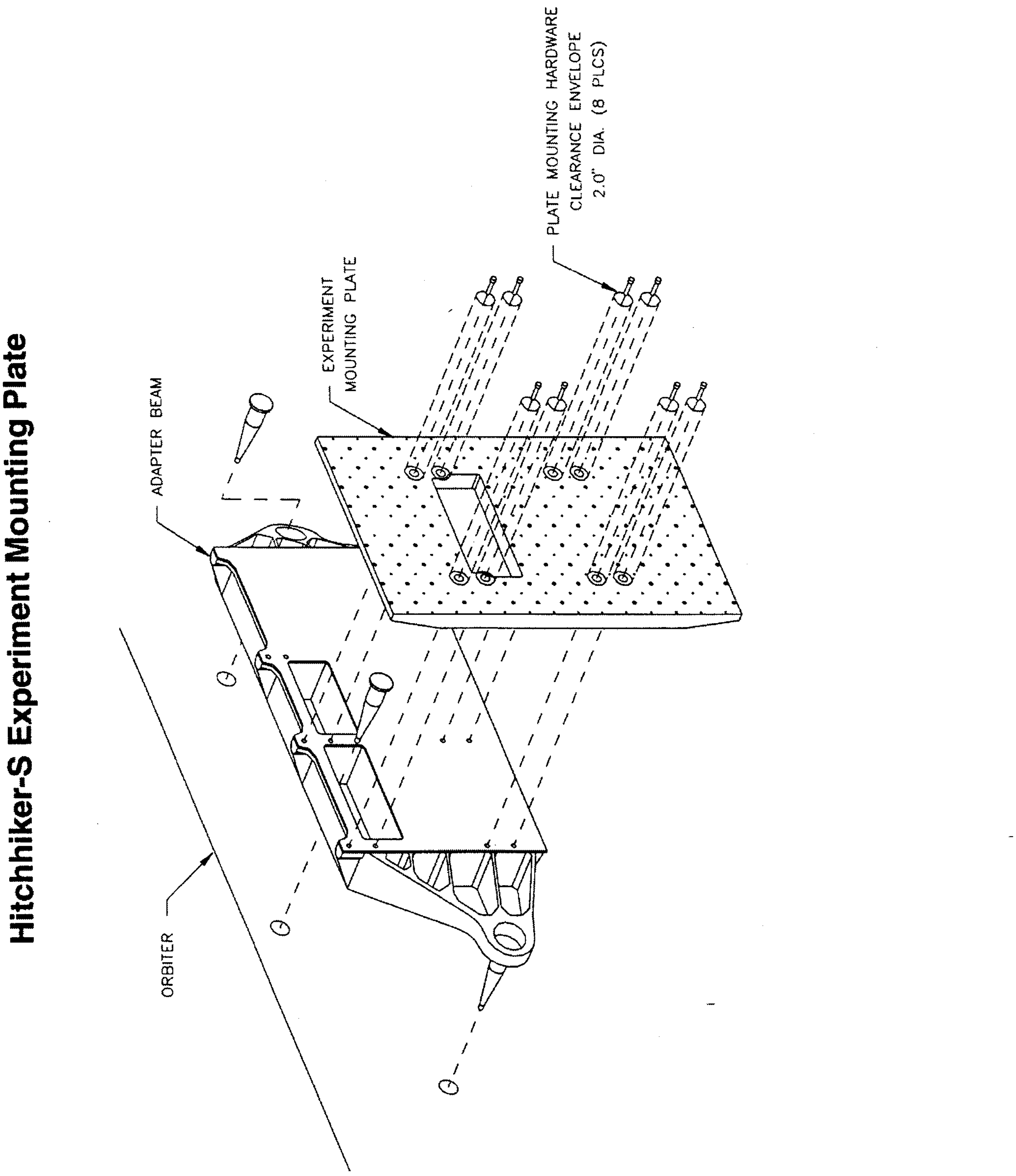


FIGURE 2.17 HITCHHIKER-S EXPERIMENT MOUNTING PLATE

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.

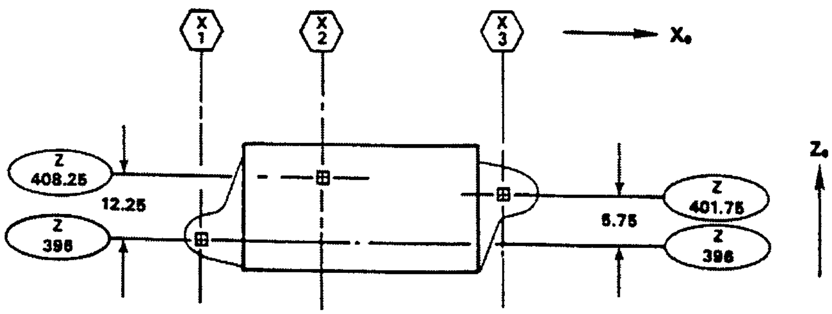
2.1.3.2 Experiment Package Volume and Mounting Limitations

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

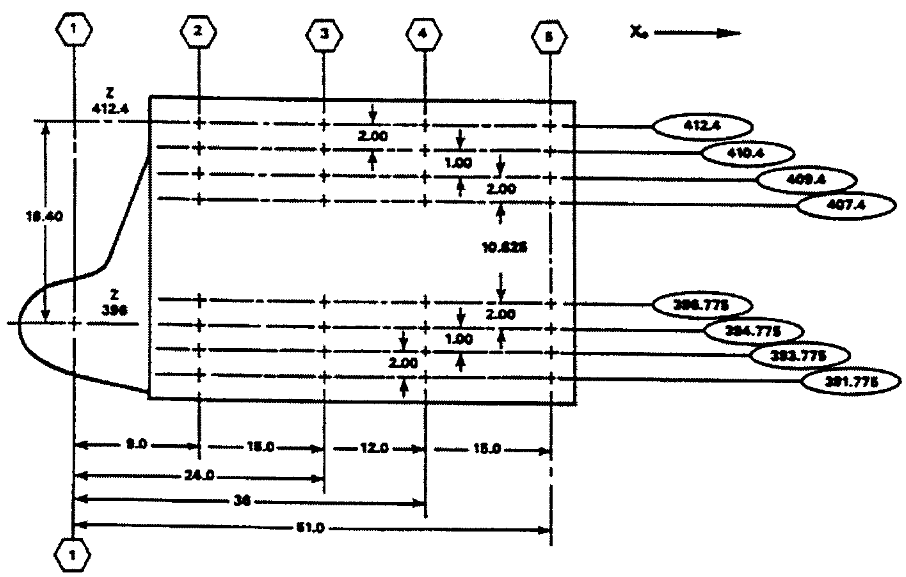
The HH-C cross-bay carrier is implemented using a truss structure (Figure 2.19) called the Hitchhiker Bridge Assembly (HHBA). The HHBA is similar to other Mission Peculiar Experiment Support Structure (MPESS) structures used on Spartan, GAS, Materials Science Laboratory (MSL), and other NASA payload 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.

Adapter Beam Mounting Interfaces



X	X AXIS BAY							
	1	2	3	4	5	6	7	8
1		636.0	693.0	750.0	807.0	863.0	919.0	979.5
2		649.0	715.0	776.90	833.0	892.5	951.0	1011.40
3		693.0	750.0	807.0	863.0	919.0	979.5	1040.0

Longeron Bolt Access Locations



X	X AXIS BAY							
	1	2	3	4	5	6	7	8
1		636.0	693.0	750.0	807.0	863.0	919.0	979.5
2		645.0	702.0	759.0	816.0	872.0	928.0	988.5
3		660.0	717.0	774.0	831.0	887.0	943.0	1003.5
4		672.0	729.0	786.0	843.0	899.0	955.0	1015.5
5		687.0	744.0	801.0	858.0	914.0	970.0	1030.5

Adapter Beam Mounting Locations

FIGURE 2.18 ADAPTER BEAM MOUNTING INTERFACES

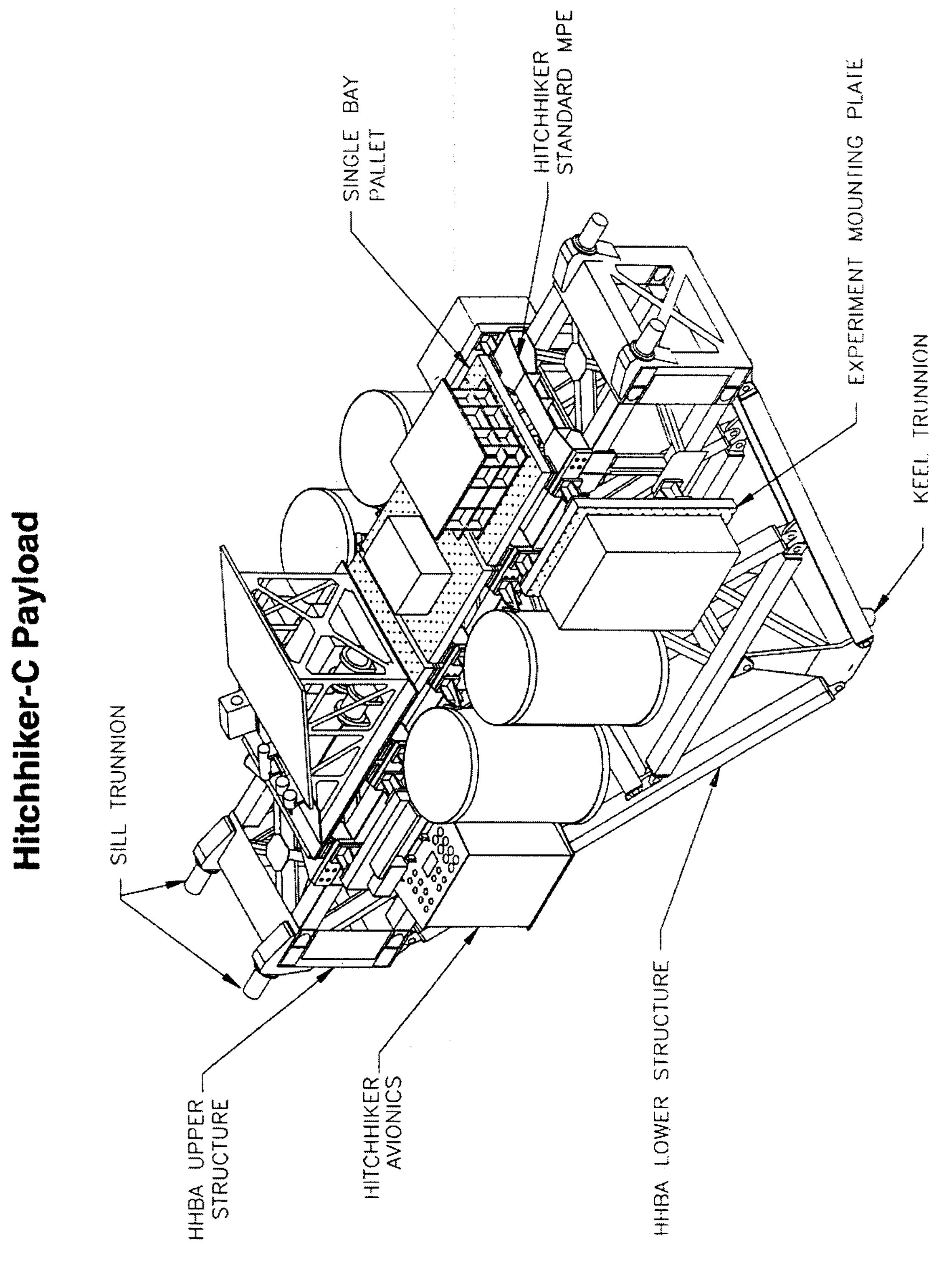


FIGURE 2.19 HITCHHIKER-C PAYLOAD

HHBA Upper Structure on Shipping Dolly

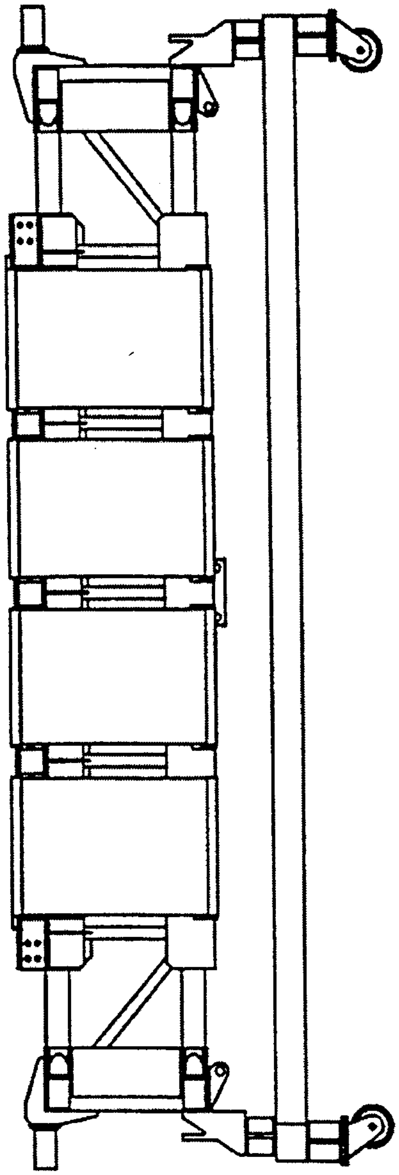


FIGURE 2.20 HHBA UPPER STRUCTURE ON SHIPPING DOLLY

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 accommodation on the HHBA should request drawing number GE1550253 from the HH Project for additional detailed information beyond what is listed in the following sections.

2.1.4.3 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

2.1.4.4 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.

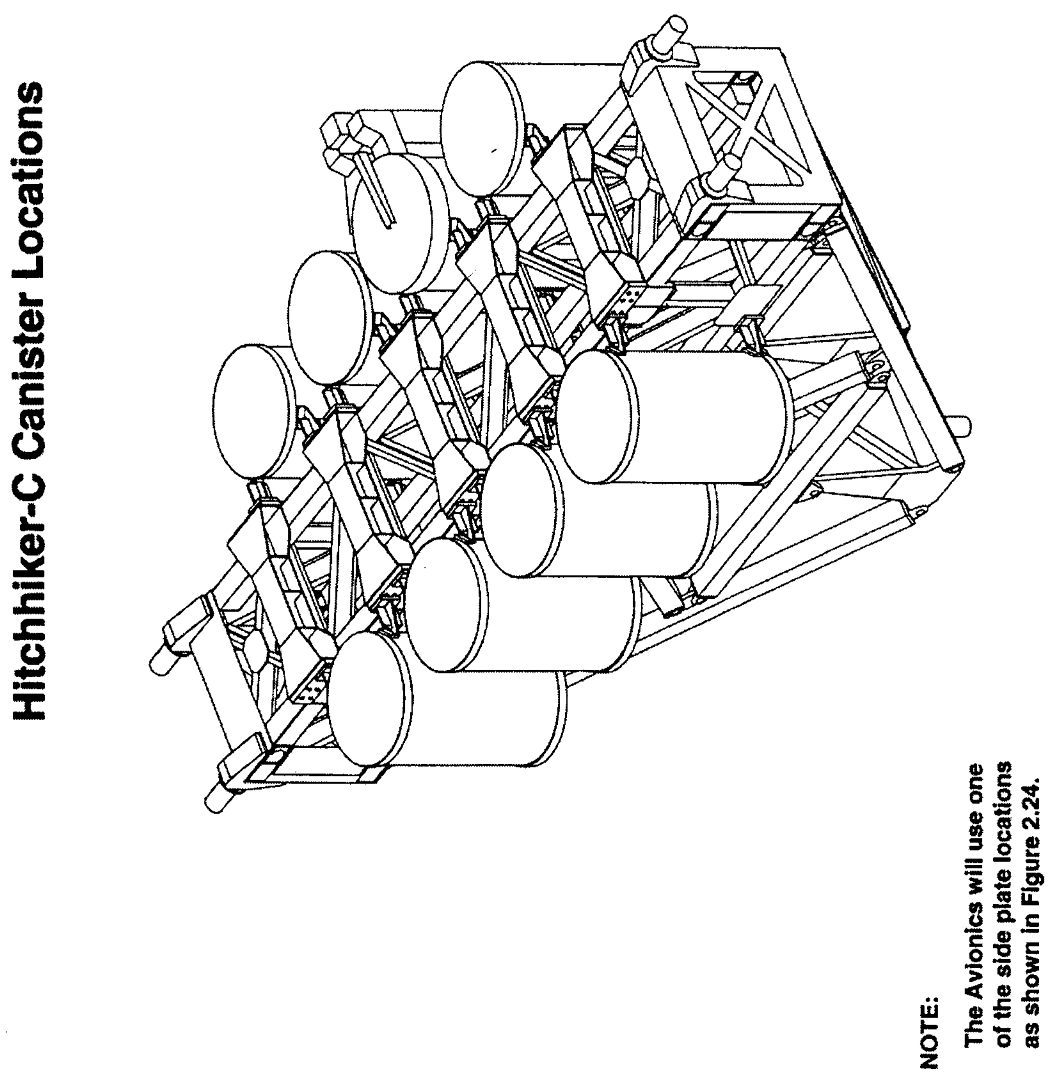


FIGURE 2.21 HITCHHIKER-C CANISTER LOCATIONS

Hitchhiker-C Canister and Mounting Plates

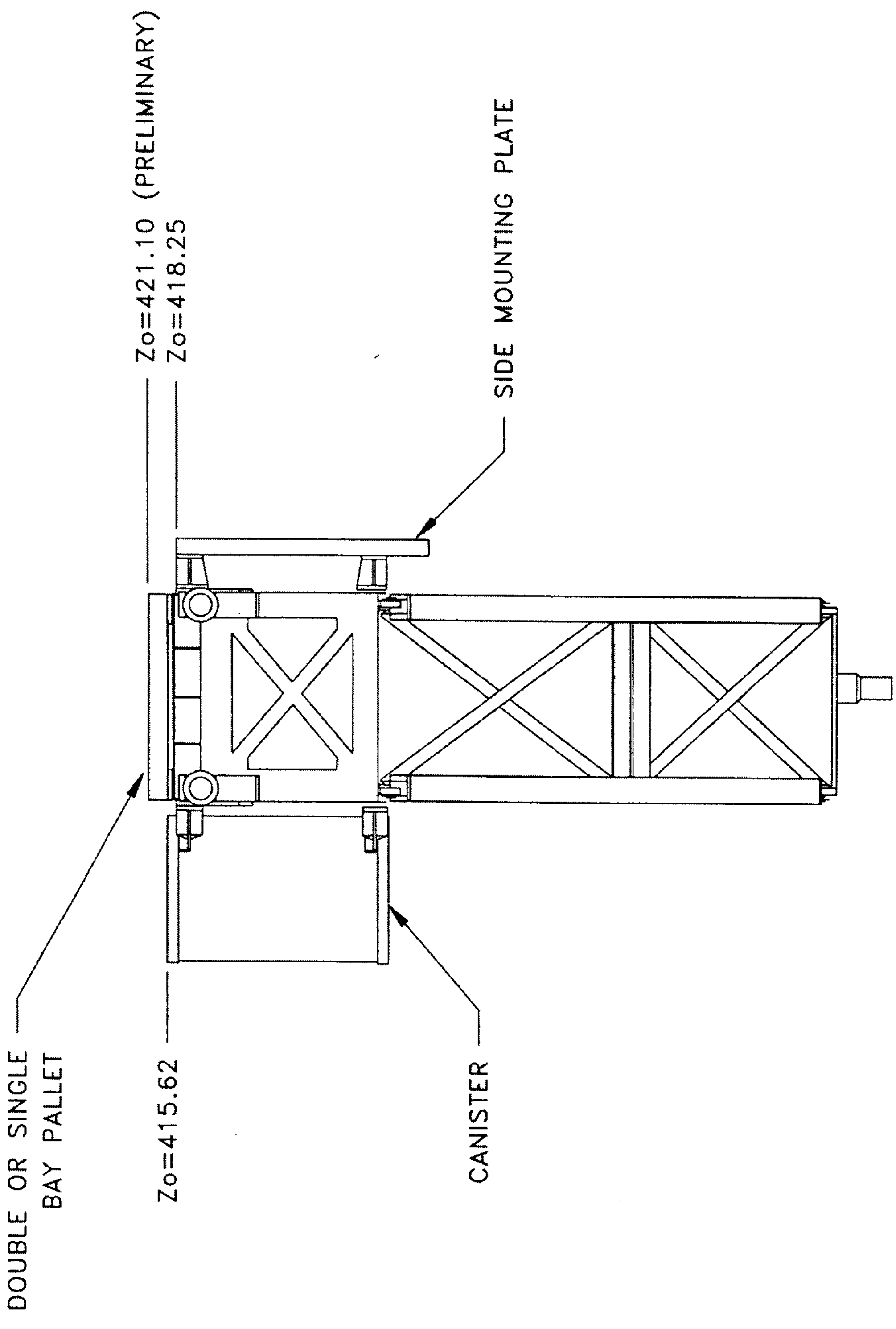


FIGURE 2.22 HITCHHIKER-C CANISTER AND MOUNTING PLATES

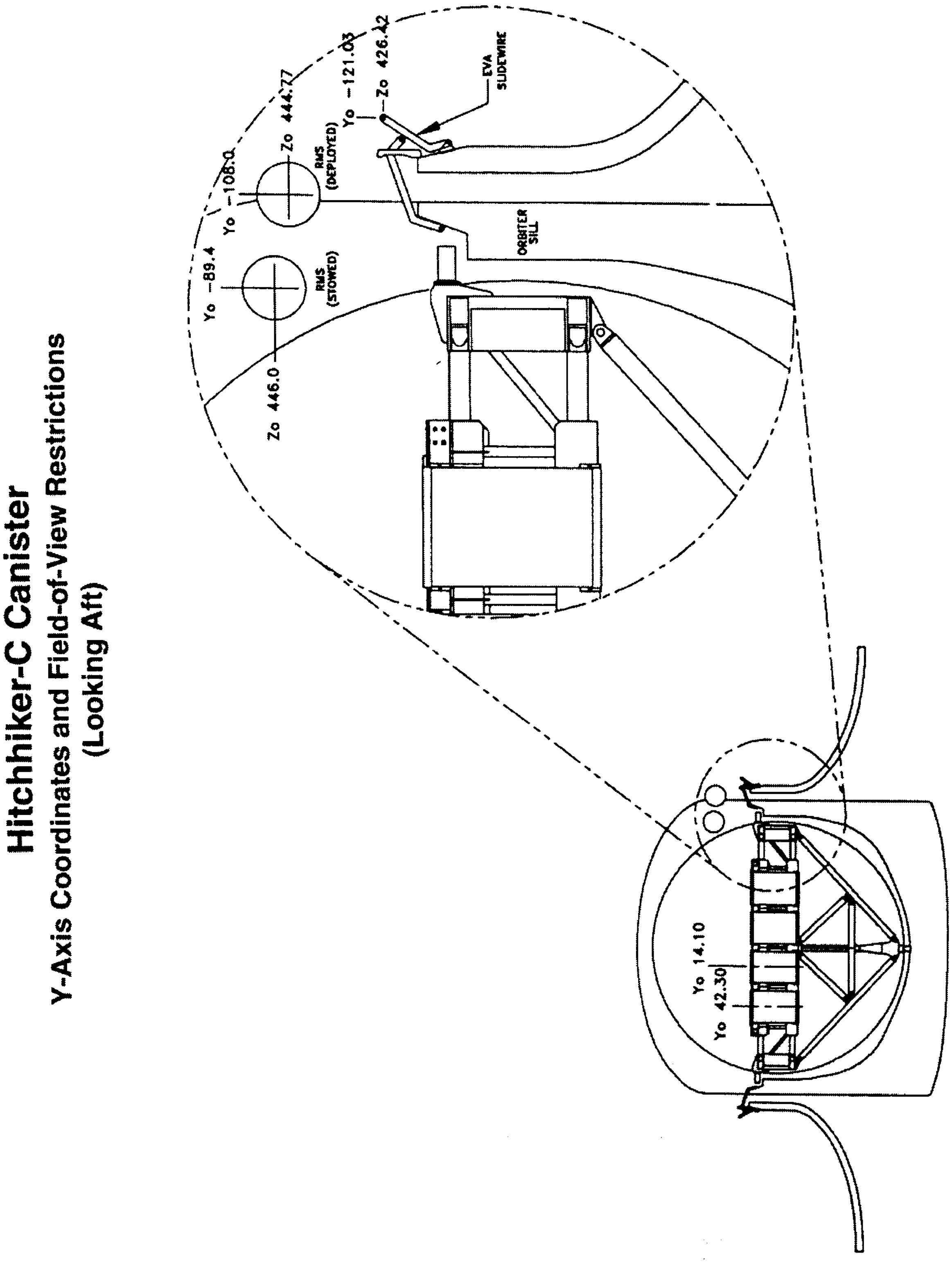


FIGURE 2.23 HITCHHIKER-C CANISTER

Hitchhiker-C Mounting Plate Locations

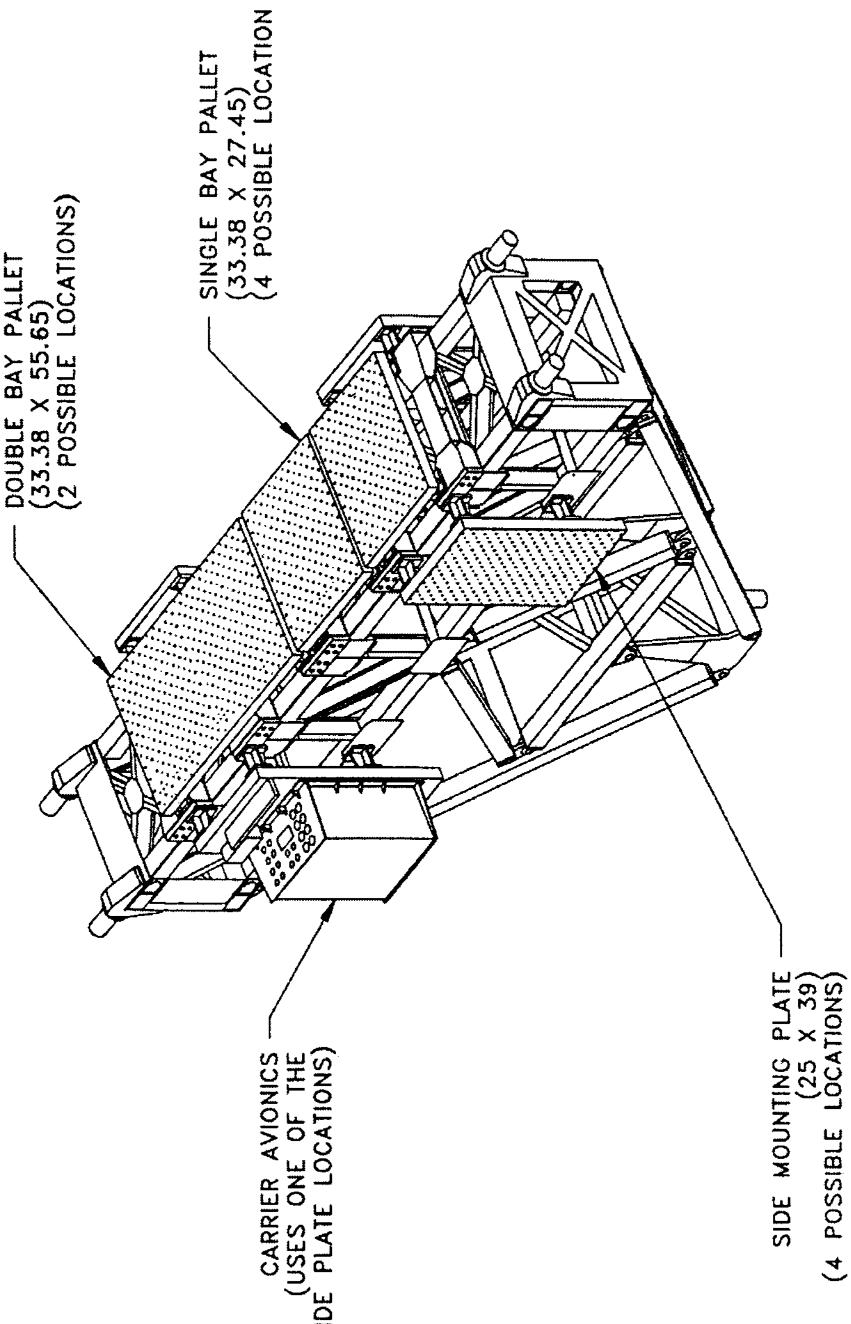


FIGURE 2.24 HITCHHIKER-C MOUNTING PLATE LOCATIONS

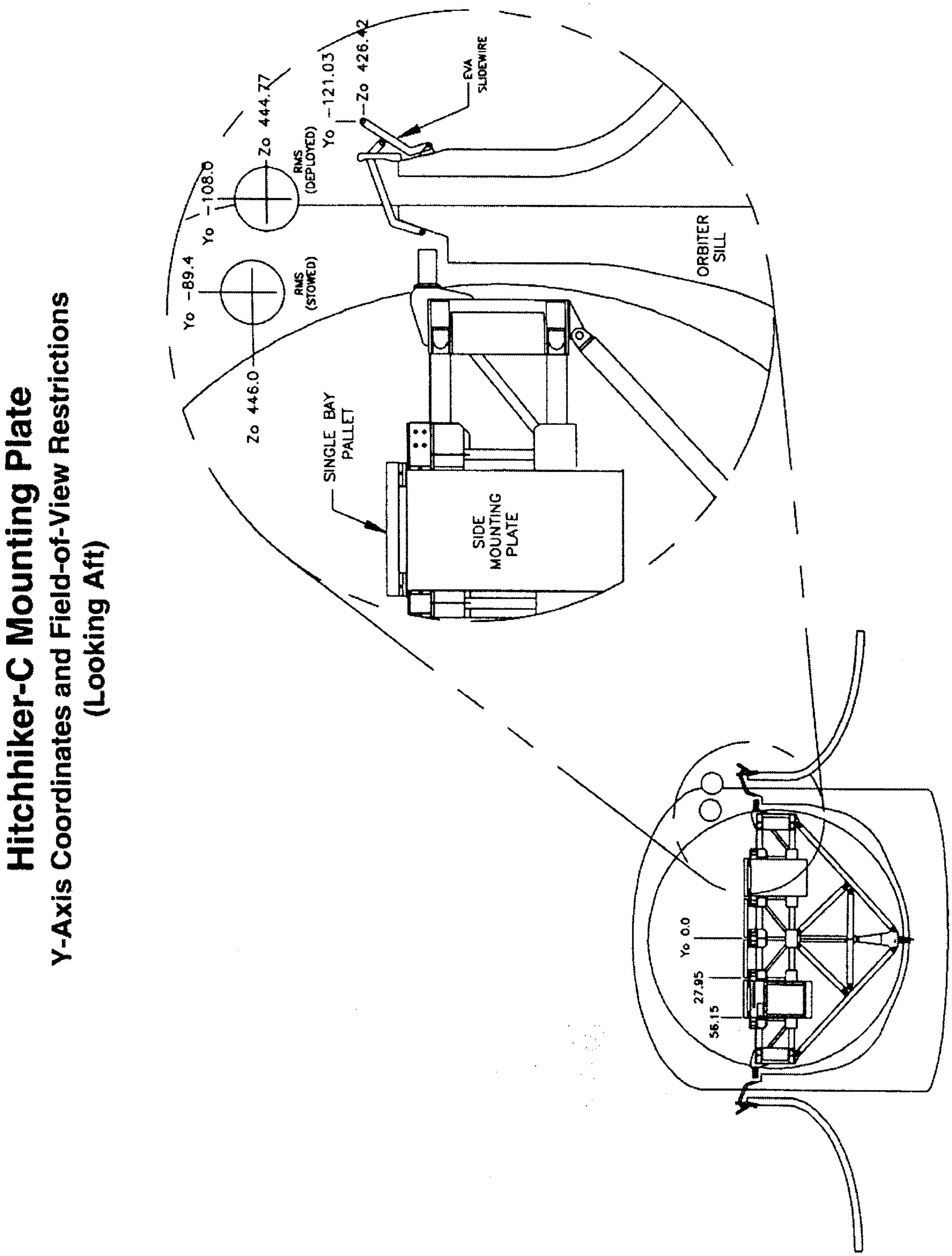


FIGURE 2.25 HITCHHIKER-C MOUNTING PLATE

2.1.4.5 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.

2.1.4.6 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.

CG Envelope & Positions

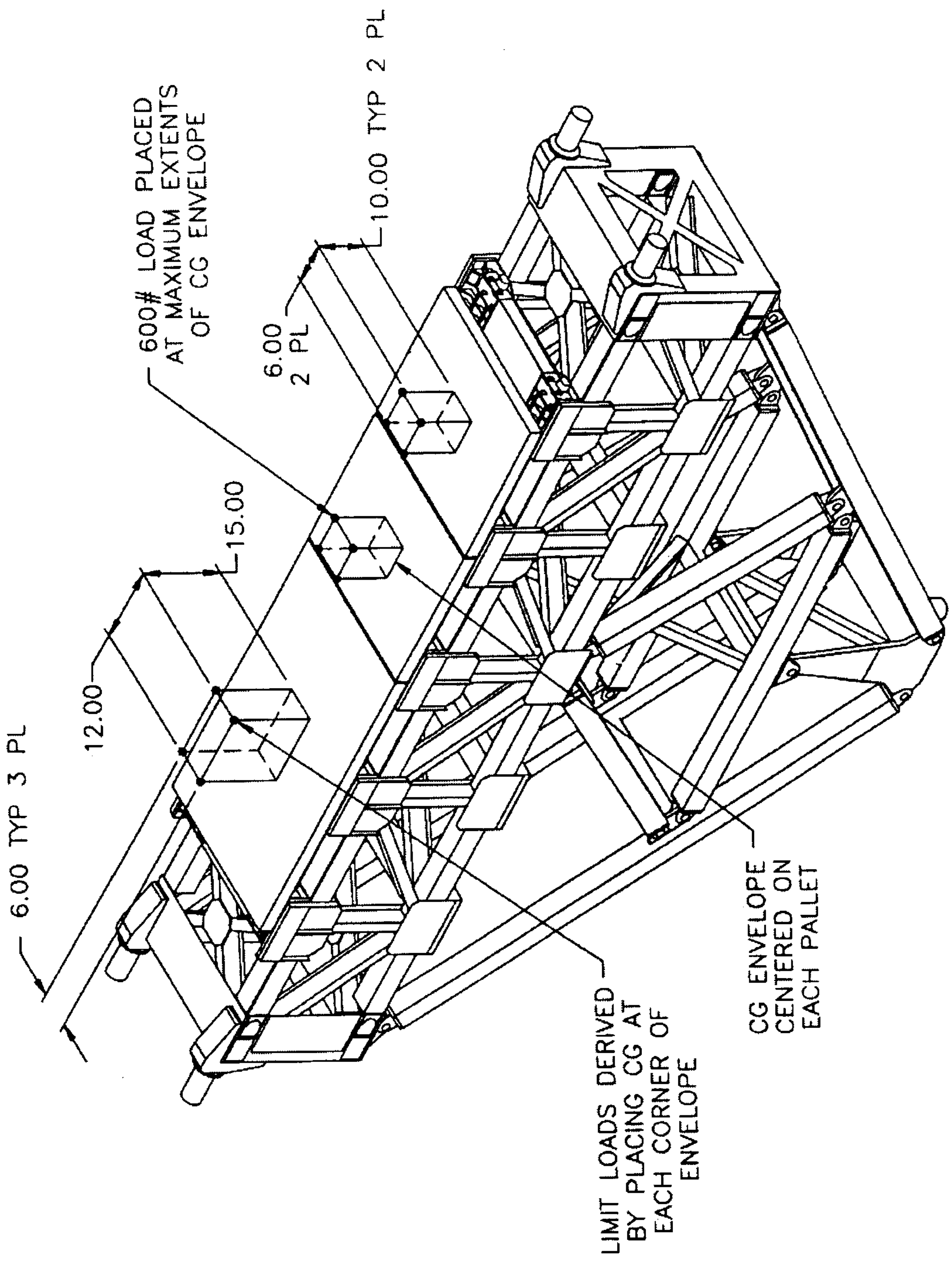


FIGURE 2.26 CG ENVELOPE & POSITIONS

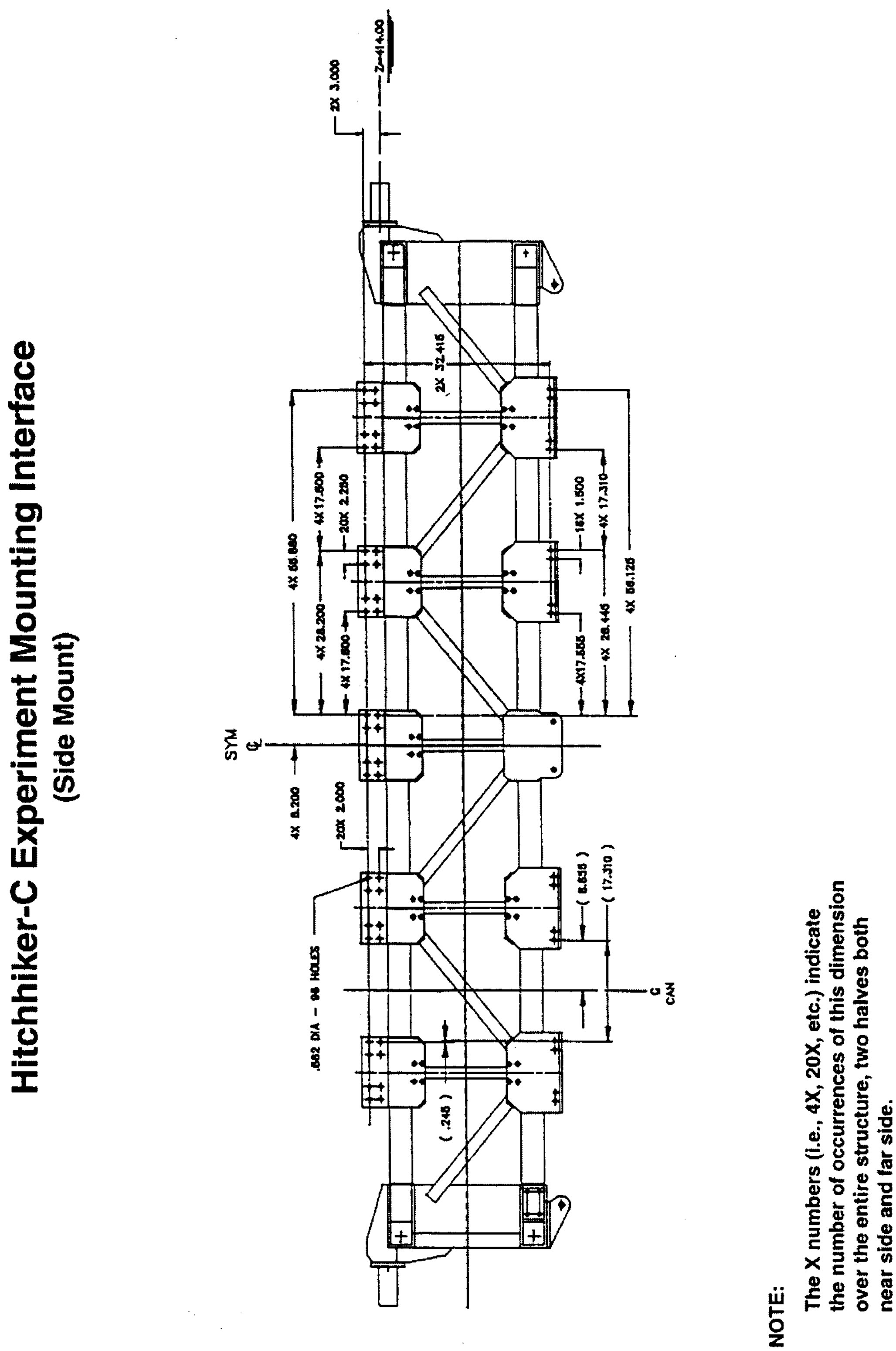


FIGURE 2.27 HITCHHIKER-C EXPERIMENT MOUNTING INTERFACE

2.2 Thermal Considerations

2.2.1 Thermal Design Requirements

The Hitchhiker carrier and customer equipment relies primarily on a passive thermal design consisting of multilayer insulating blankets (MLI) and selected surface-finish applications. The MLI will be used to reduce energy losses and gains from the environment. Thermostatically controlled heaters will be used where tighter thermal control is needed, and passive radiators will be used to dump excess heat from instruments. This cold-bias design philosophy incorporates a low cost approach to maintaining temperature requirements throughout the HH payload.

The thermal design and analysis of each experiment is a customer responsibility. The customer shall determine all internal conduction, convection, and radiation within their experiment. They shall be responsible for the proper design and coupling of high power components. Reduced thermal models of the experiment and associated electronics are to be supplied to HH. Temperature limits as defined below shall also be provided for each node in the reduced thermal math model.

> Operating Temperature: The temperature at which a unit will successfully function and meet all specifications.
>
> Non-Operating Temperature: The temperature to which a unit may be exposed in a power OFF condition and if turned ON, will not be damaged. The unit does not have to meet its specification until it is within the operational temperature range.
>
> Survival Temperature: The temperature, if exceeded, at which the unit will suffer permanent damage.
>
> Safety Temperature: The temperature, if exceeded, at which the unit could potentially lead to catastrophic damage to the orbiter or injury to the crew members.

The customer shall also define any special temperature requirements, such as levels and gradients. Ground temperatures and humidity provided by the Orbiter and other ground processing locations at KSC are defined in ICD2-19001.

A list of the following external surface properties: area (size), thermal coatings, absorptivity (α), emissivity (ε), and reflectivity shall be provided. The customer will be responsible for obtaining approval from GSFC regarding any proposed thermal coatings not standard to HH. They shall also be responsible for providing heaters on the experiment provided hardware. The heater specification along with the predicted dissipation, duty cycle and HH bus usage shall be supplied to HH.

2.2.2 Thermal Safety Requirements

The customer must also be aware of all safety concerns of their payloads including that the experiment must be safe without services i.e. remain safe in the event of a power loss. Payloads must also be safe to land 40 minutes after payload bay door closure, occurring anytime during the mission. In addition to all safety analysis, all payloads must be able to fly in a bay-to-Earth attitude continuously and must be able to withstand 30 minute solar excursions and 90 minute deep space viewing at a minimum as stated in the Orbiter core ICD-2-19001. It is desirable to be able to withstand these extreme cases longer than the ICD requirement for manifesting reasons and longer runs are required for determining safety concerns such as the maximum design pressure (MDP) temperatures and battery limitations. The transient behavior of the experiment should be considered in all thermal analysis for the aforementioned cases.

2.2.3 Flammability Requirements for MLI Construction

Thermal control blankets are the most widely used materials in the payload bay that could be flammable. These blankets typically contain 12 to 40 layers of film (0.0005 to 0.002 inches in thickness) separated by some type of scrim cloth. Blanket materials are usually constructed of metal-coated polyethylene terephthalate or polyimide film, organic separator scrim, or beta cloth. Beta cloth and polyimides (at least 1.5 mil thick) are the only nonflammable materials.

Acceptable thermal control blankets are typically constructed as follows:

a. The outer layer is made of nonflammable material such as a polyimide film (at least 1.5 mil thick,) metal foil, or beta cloth.
b. Internal layers can be a combination of flammable films or scrims.
c. The innermost layer (adjacent to the outer surface of the payload) is also made of nonflammable materials.
d. Edges are hemmed or suitably finished so that the inner flammable layers are protected.

Reference: "Flammability Configuration Analysis for Spacecraft Applications" document NSTS 22648 dated October 1988.

2.2.4 Thermal System Design for a HH 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 lower 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. 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).

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. Average steady-state canister upper endplate temperatures for various Shuttle attitudes and customer payload power levels is given in Figure 2.28. The temperatures from Figure 2.28 are representative of internal experiment temperature levels. The corresponding Orbiter attitudes are defined in Figure 2.29.

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 (α = . 10, ϵ =.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. .

Option 3 is available to customers requiring a large heat rejection capability. In this case, the side walls of the canister are painted white (α =.24, ϵ = .86) and are allowed to radiate directly to the Shuttle bay and space. The average upper endplate temperature for various conditions is given in Figure 2.31. 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 if the experiment is operating at low levels. Transient response times are reduced as well.

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."

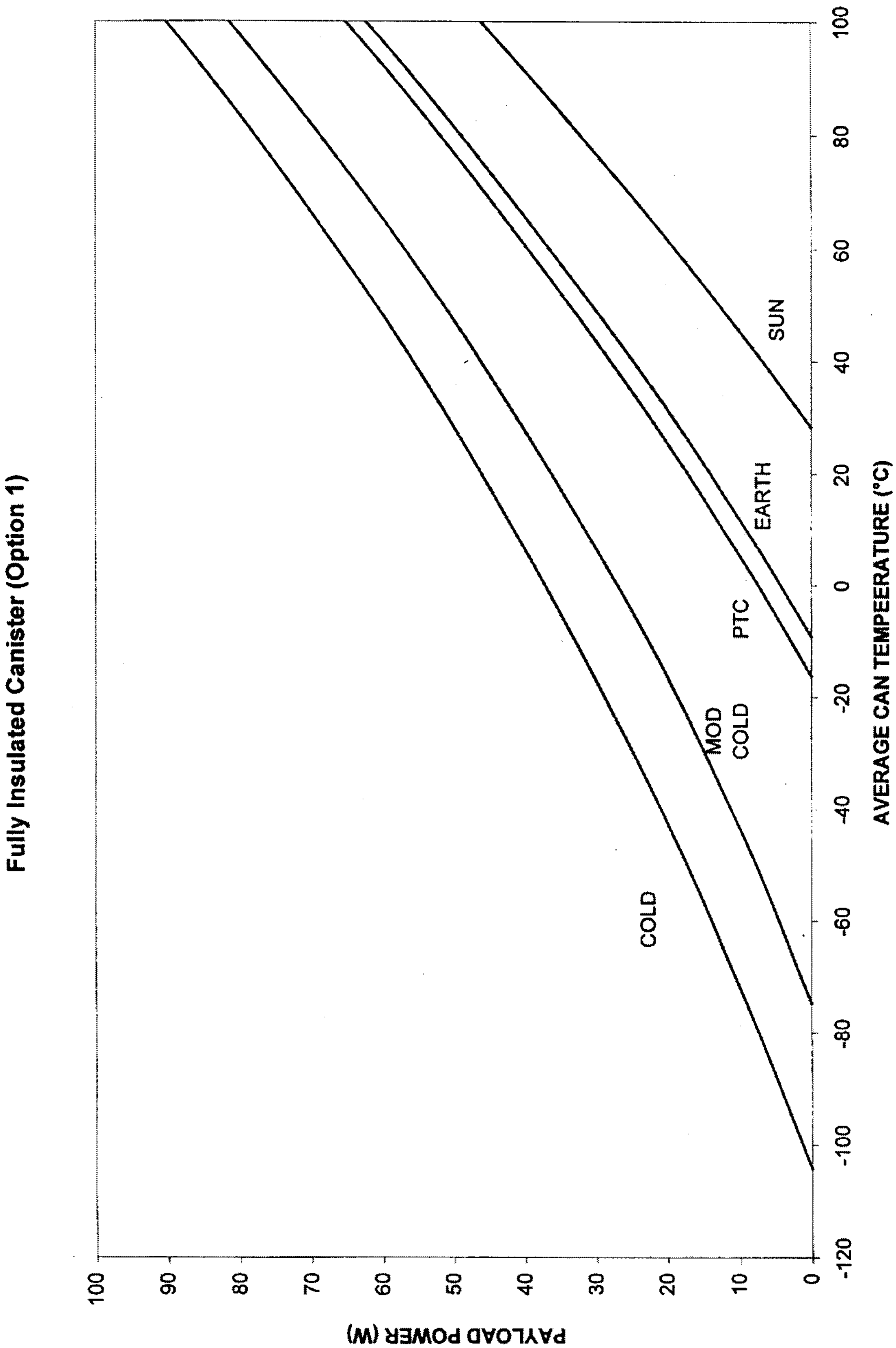
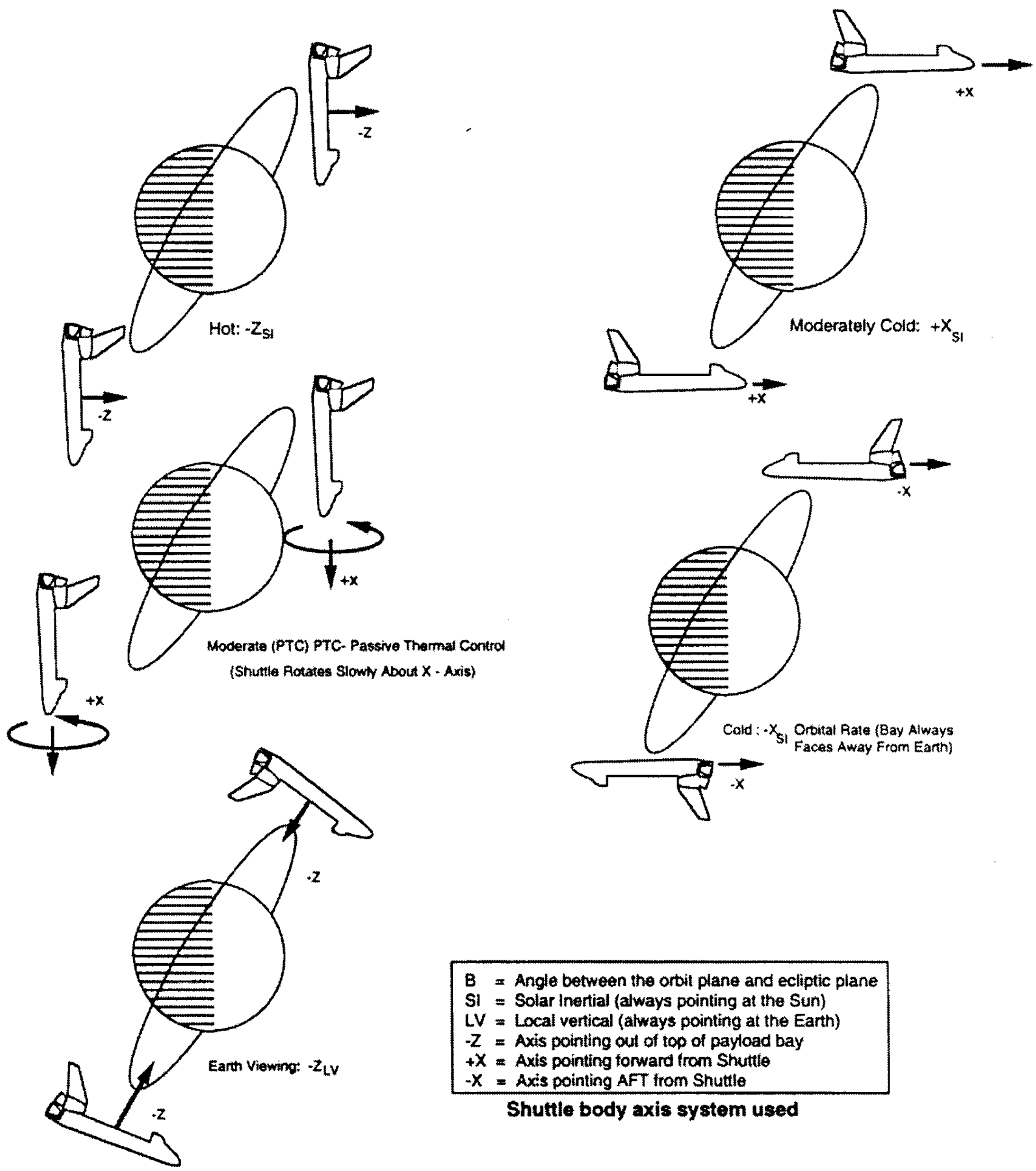


FIGURE 2.28 FULLY INSULATED CANISTER (OPTION1)

Typical Orbital Thermal Attitudes

(61% Sun, B=35°, and Altitude = 150 n.mi. (278km.)



B = Angle between the orbit plane and ecliptic plane
SI = Solar Inertial (always pointing at the Sun)
LV = Local vertical (always pointing at the Earth)
-Z = Axis pointing out of top of payload bay
+X = Axis pointing forward from Shuttle
-X = Axis pointing AFT from Shuttle

Shuttle body axis system used

FIGURE 2.29 TYPICAL ORBITAL THERMAL ATTITUDES

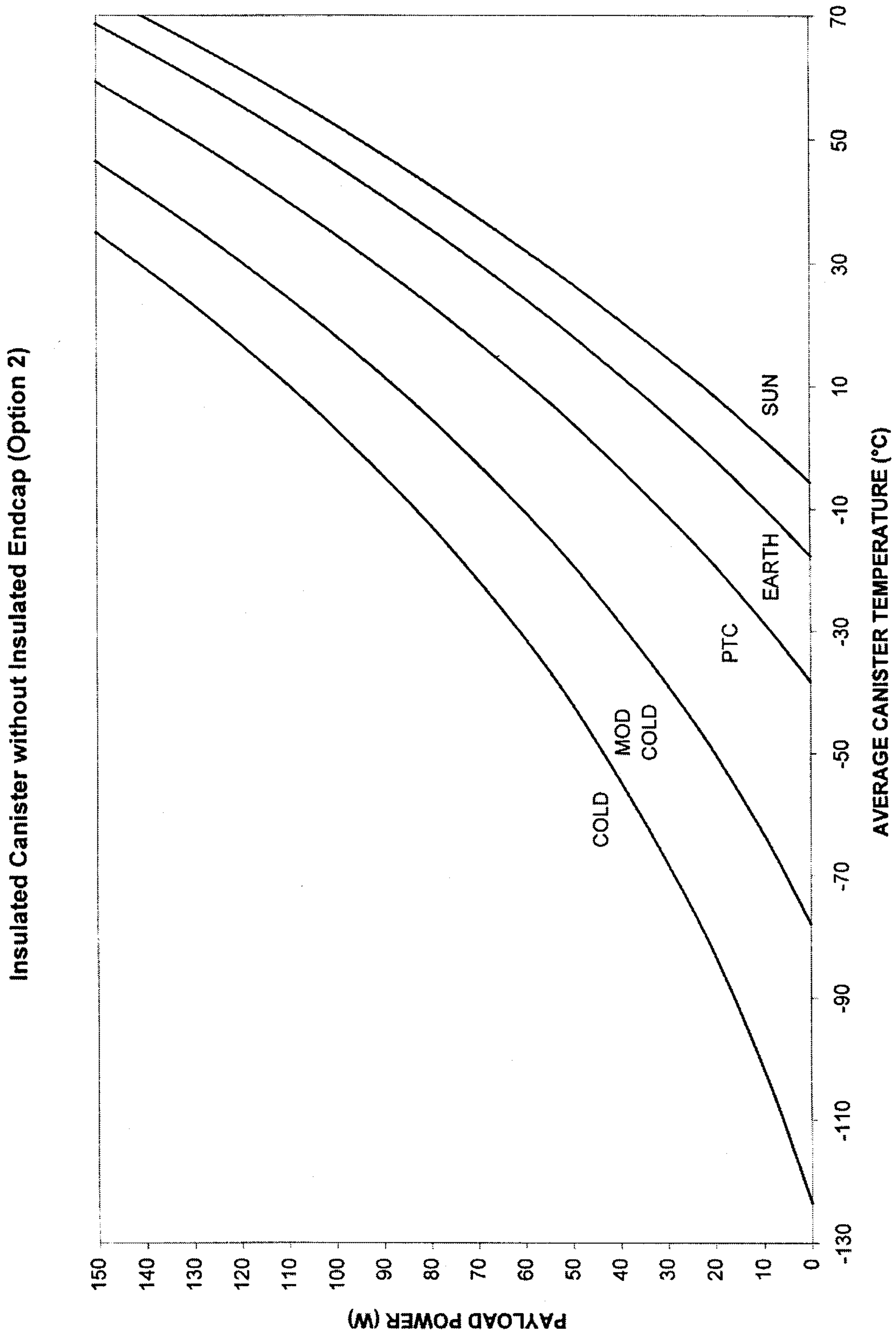


FIGURE 2.30 INSULATED CANISTER WITHOUT INSULATED ENDCAP (OPTION 2)

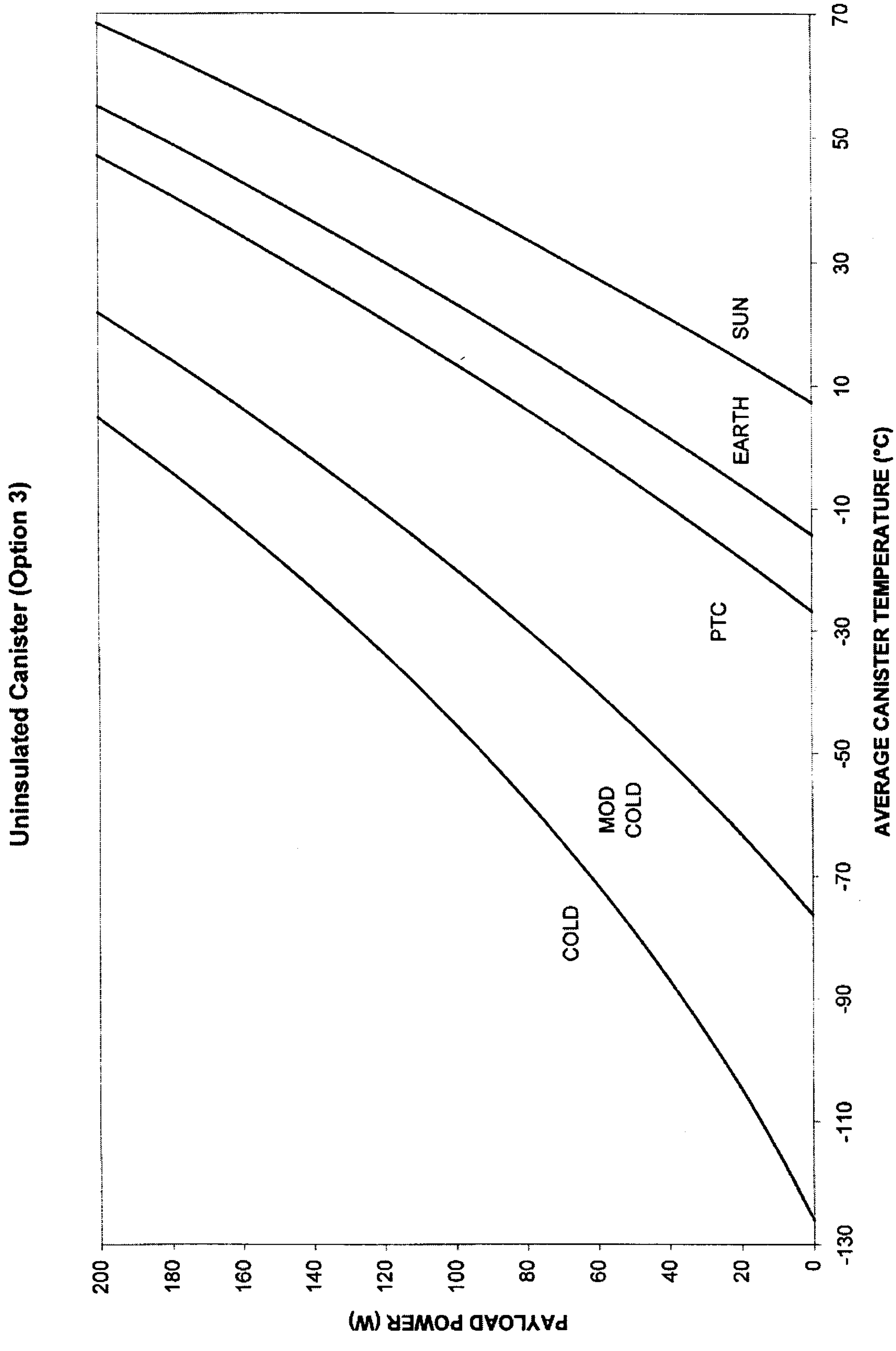


FIGURE 2.31 UNINSULATED CANISTER (OPTION 3)

Experimental data was 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 °C) From Gas Verification Payload

	HOT CASE		COLD CASE	
LOCATION	PREDICTED	ACTUAL	PREDICTED	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.

TABLE 2.3 GAS CONTAINER EXTERNAL THERMAL LEVELS AT STEADY STATE

	PREDICTIONS °C	FLIGHT °C
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

2.2.5 Thermal System Design for Pallet and Plate Mounting

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 that 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 white painted regions 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 three thermistors. For the top of the bridge single and double bay pallets, GSFC will also supply 104 watts of heater power. (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.

2.2.6 Thermistors

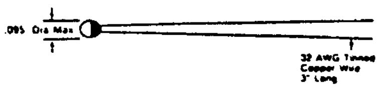
Three thermistors are available for each plate and pallet experiment. Opening can experiments have no thermistors except for one mounted on the lower endplate. Sealed canister experiments allow one thermistor to be used at the customer's discretion and one will be mounted on the lower end plate. Additional 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 2.33.

YSI PRECISION THERMISTOR

YSI 44006

RESISTANCE 10,000 OHMS @25°C



RESISTANCE VERSUS TEMPERATURE —80° to +150°C

TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES
−80	3558K	−50	441.3K	−20	78.91K	+10	18.79K	+40	5592	+70	1990	+100	816.8	+130	376.4
79	3296K	49	414.5K	19	74.91K	11	17.98K	41	5389	71	1928	101	794.6	131	367.4
78	3055K	48	389.4K	18	71.13K	12	17.22K	42	5193	72	1868	102	773.1	132	358.7
77	2833K	47	366.0K	17	67.57K	13	16.49K	43	5006	73	1810	103	752.3	133	350.3
76	2629K	46	344.1K	16	64.20K	14	15.79K	44	4827	74	1754	104	732.1	134	342.0
75	2440K	45	323.7K	15	61.02K	15	15.13K	45	4655	75	1700	105	712.6	135	334.0
74	2266K	44	304.6K	14	58.01K	16	14.50K	46	4489	76	1648	106	693.6	136	326.3
73	2106K	43	286.7K	13	55.17K	17	13.90K	47	4331	77	1598	107	675.3	137	318.7
72	1957K	42	270.0K	12	52.48K	18	13.33K	48	4179	78	1549	108	657.5	138	311.3
71	1821K	41	254.4K	11	49.94K	19	12.79K	49	4033	79	1503	109	640.3	139	304.2
−70	1694K	−40	239.8K	−10	47.54K	+20	12.26K	+50	3893	+80	1458	+110	623.5	+140	297.2
69	1577K	39	226.0K	9	45.27K	21	11.77K	51	3758	81	1414	111	607.3	141	290.4
68	1469K	38	213.2K	8	43.11K	22	11.29K	52	3629	82	1372	112	591.6	142	283.8
67	1369K	37	201.1K	7	41.07K	23	10.84K	53	3504	83	1332	113	576.4	143	277.4
66	1276K	36	189.8K	6	39.14K	24	10.41K	54	3385	84	1293	114	561.6	144	271.2
65	1190K	35	179.2K	5	37.31K	25	10.00K	55	3270	85	1255	115	547.3	145	265.1
64	1111K	34	169.3K	4	35.57K	26	9605	56	3160	86	1218	116	533.4	146	259.2
63	1037K	33	160.0K	3	33.93K	27	9227	57	3054	87	1183	117	519.9	147	253.4
62	968.4K	32	151.2K	2	32.37K	28	8867	58	2952	88	1149	118	506.8	148	247.8
61	904.9K	31	143.0K	−1	30.89K	29	8523	59	2854	89	1116	119	494.1	149	242.3
−60	845.9K	−30	135.2K	0	29.49K	+30	8194	+60	2760	+90	1084	+120	481.8	+150	237.0
59	791.1K	29	127.9K	+1	28.15K	31	7880	61	2669	91	1053	121	469.8		
58	740.2K	28	121.1K	2	26.89K	32	7579	62	2582	92	1023	122	458.2		
57	692.8K	27	114.6K	3	25.69K	33	7291	63	2497	93	994.2	123	446.9		
56	648.8K	26	108.6K	4	24.55K	34	7016	64	2417	94	966.3	124	435.9		
55	607.8K	25	102.9K	5	23.46K	35	6752	65	2339	95	939.3	125	425.3		
54	569.6K	24	97.49K	6	22.43K	36	6500	66	2264	96	913.2	126	414.9		
53	534.1K	23	92.43K	7	21.45K	37	6258	67	2191	97	887.9	127	404.9		
52	501.0K	22	87.66K	8	20.52K	38	6026	68	2122	98	863.4	128	395.1		
51	470.1K	21	83.16K	9	19.63K	39	5805	69	2056	99	839.7	129	385.6		

Interchangeability: ±0.2°C (See Tolerance Curves).

Max. Operating Temp: 150°C (300°F).

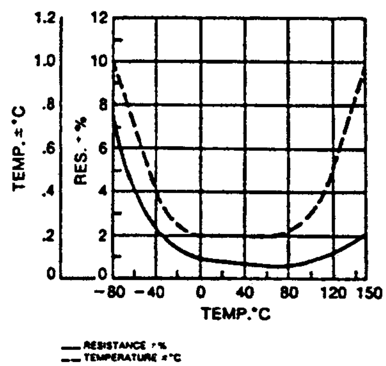
Time Constant, Max: 1 sec. in well stirred oil. 10 sec. in still air. Time constant is the time required for a thermistor to indicate 63% of a newly impressed temperature.

Dissipation Constant, Min: 8mW/°C in well stirred oil, 1mW/°C in still air. Dissipation constant is the power in milliwatts to raise a thermistor 1°C above surrounding temperature.

Color Code: Black epoxy body, blue end.

Storage Temperature: -80° to +120°C (-112° to +250°F).

Tolerance Curves: The following curves indicate conformance to standard resistance temperature values as a % of resistance, and as a maximum interchangeability error expressed as temperature.



WARNING

Use heat sinks when soldering or welding to thermistor leads.

FIGURE 2.32 YSI PRECISION THERMISTOR

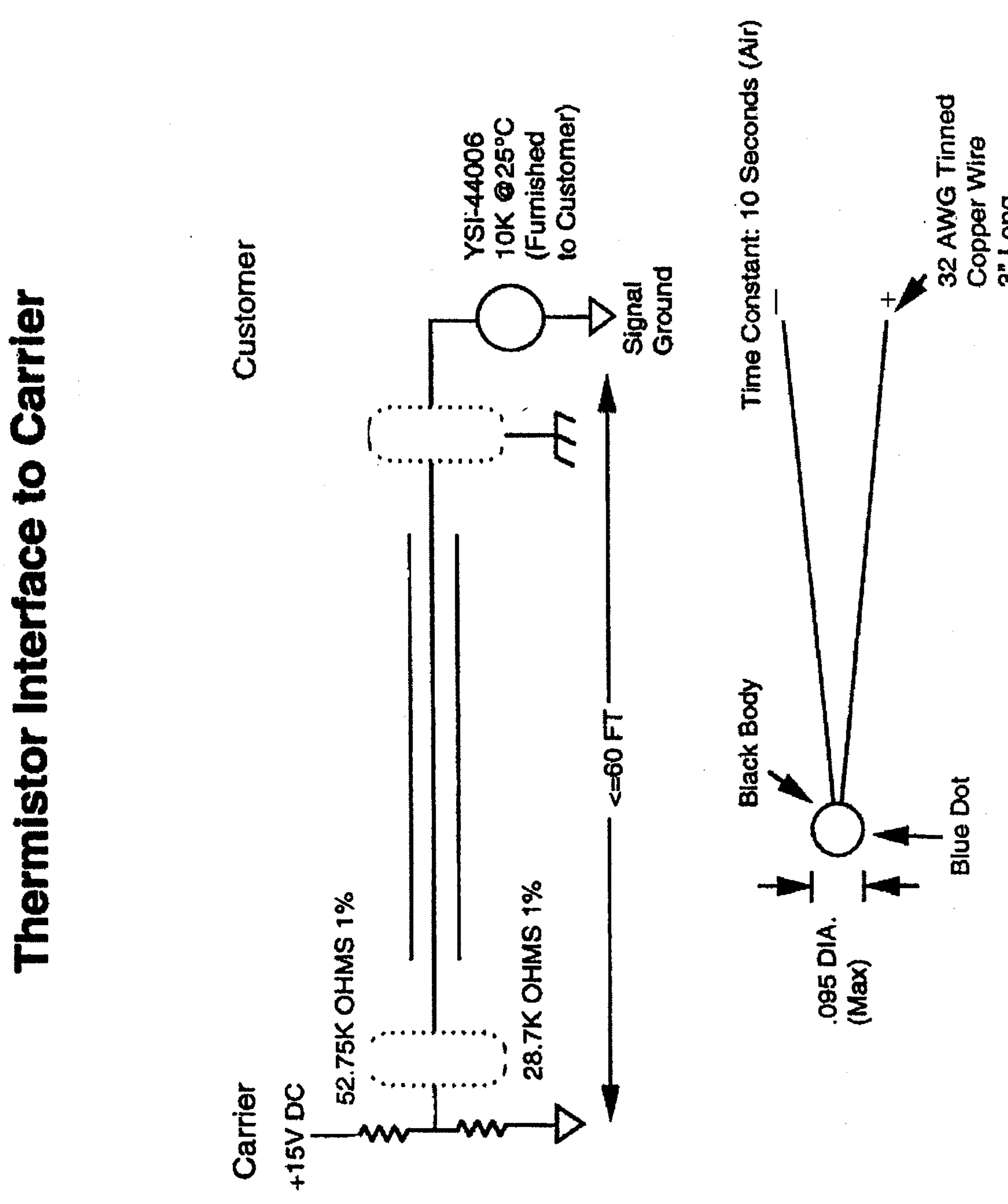


FIGURE 2.33 THERMISTOR INTERFACE TO CARRIER

2.3 Electrical/Power Support Systems

2.3.1 Electrical Design

The electrical interfaces for plate mount and canister customers differ slightly. Figure 2.34 and Table 2.4 give plate mounting details. Figure 2.35, 2.36, and Table 2.5 provide details on the canister mount. Figure 2.36 shows the Motorized Door Canister with the control and monitoring interface. Electrical designs interfaces are governed by ICD-2-19001. The electrical characteristics of the thermistors is defined in Section 2.2.6.

2.3.2 Power Characteristics

Each of the two 12 gauge 28V power lines is protected by a 20A fuse (vacuum derated to 10A), per figure 2.37. Customers must provide consistent wiring and fusing within their payloads. Smaller gauge wire for power service shall require an appropriately down-sized fuse to provide circuit protection. Table 2.6 shows acceptable wire and fuse sizes.

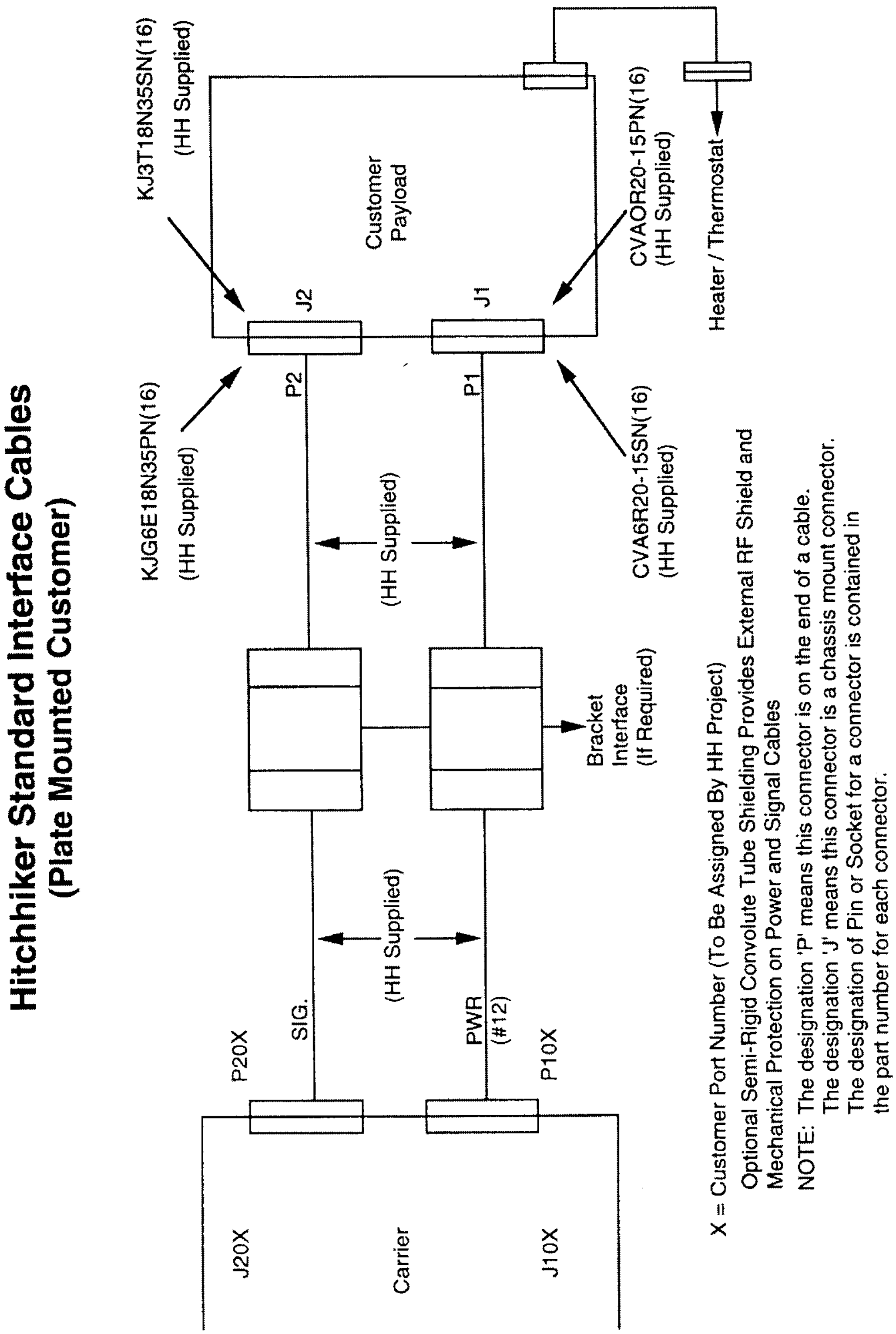


FIGURE 2.34 HITCHHIKER STANDARD INTERFACE CABLES

TABLE 2.4 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 (Note 5)
PCMENA	32	A	Serial Digital Enable A (Note 5)
PCMENB	33	A	Serial Digital Enable B (Note 5)
PCMDATA	3	A	Serial Digital Data A (Note 5)
PCMDATB	8	A	Serial Digital Data B (Note 5)
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
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 (Note 5)
SCMDENV	11	A	Serial Command Envelope (Note 5)
SCMDDAT	12	A	Serial Command Data (Note 5)
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 -

ID	Pin (Note 3)	Type (Note 2)	Function
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 + (Optional Video +)
UNDTSP1-	66	D	Undedicated TSP 1 - (Optional Video -)
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

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.

Note 5: These services are no longer available/offered.

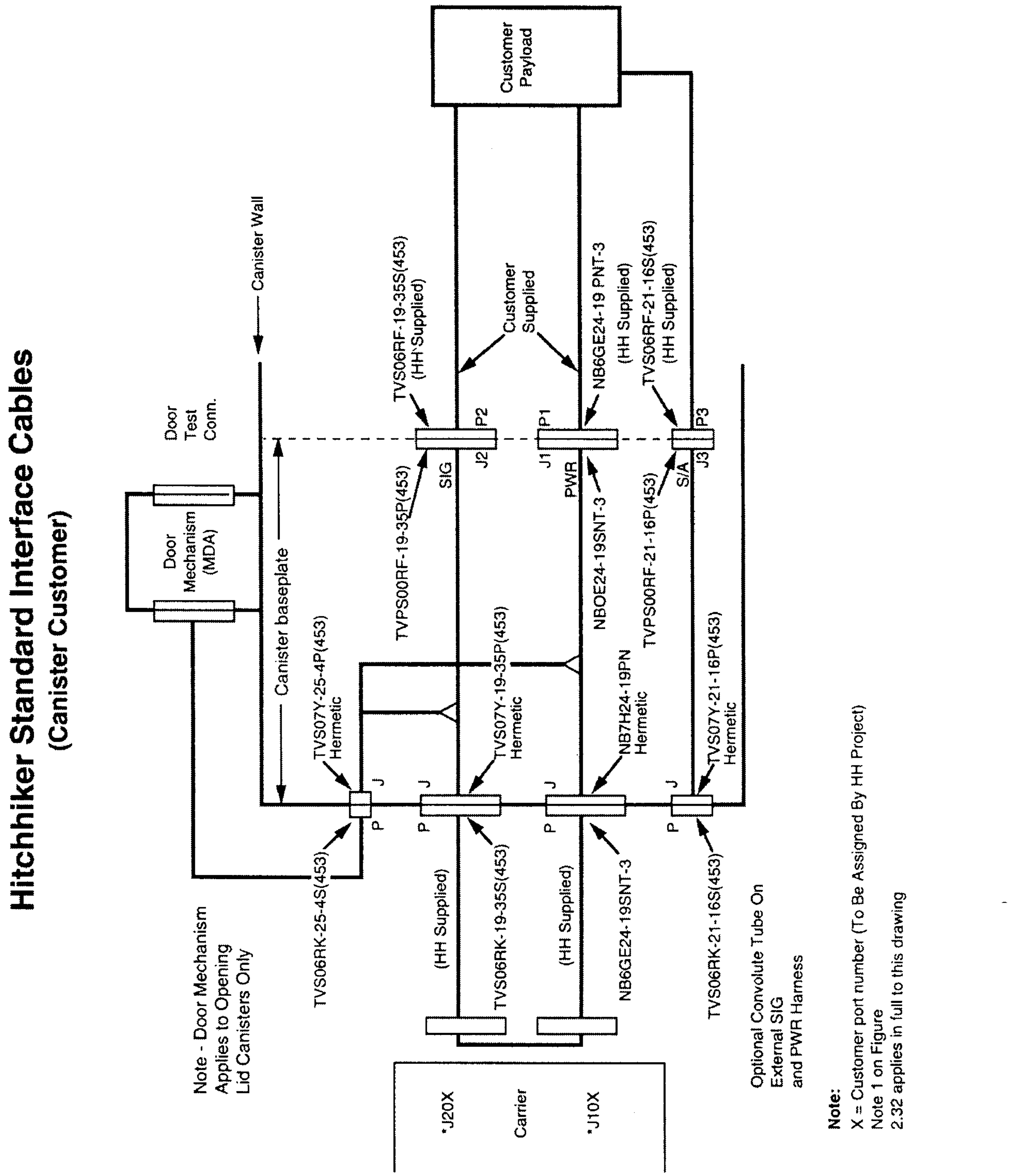


FIGURE 2.35 HITCHHIKER STANDARD INTERFACE CABLES

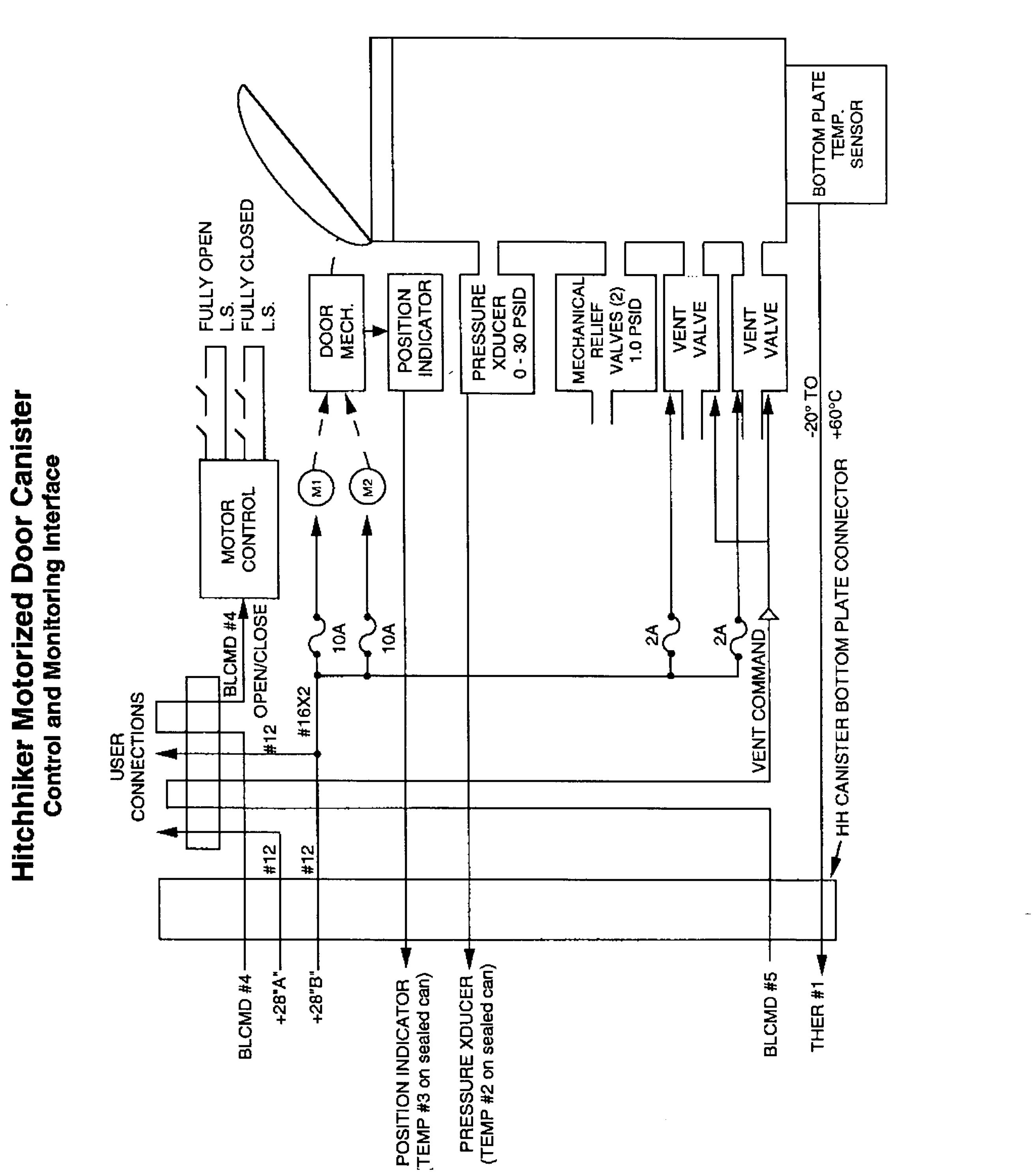


FIGURE 2.36 HITCHHIKER MOTORIZED DOOR CANISTER

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 (Note 11)
PCMENA	32	A	Serial Digital Enable A (Note 11)
PCMENB	33	A	Serial Digital Enable B (Note 11)
PCMDATA	3	A	Serial Digital Data A (Note 11)
PCMDATB	8	A	Serial Digital Data B (Note 11)
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	Bi-level/Pulse Command 1
BLCMD2	18	A	Bi-level/Pulse Command 2
BLCMD3	19	A	Bi-Level/Pulse Command 3
BLCMD4	20	A	Bi-level Cmd 4/Open Close MDALID
SCMDCLK	10	A	Serial Command Clock (Note 11)
SCMDENV	11	A	Serial Command Envelope (Note 11)
SCMDDAT	12	A	Serial Command Data (Note 11)
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 + (Optional Video +)
UNDTSP1-	66	D	Undedicated TSP 1 - (Optional Video -)
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

TABLE 2.5 CONTINUED

ID	Pin(Note 3)	Type(Note 2)	Function
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	26	E	MDA Door Open Switch S6, Normally Open (Note 9)
SW-6 C	27	E	MDA Door Open Switch S6, Center Contact
SW-6 NC	28	E	MDA Door Open Switch S6, Normally Closed
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	---

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

TABLE 2.5 CONTINUED

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.
Note 11:	These services are no longer offered.

TABLE 2.6 CIRCUIT PROTECTION REQUIREMENTS

Min. Wire Gauge	Max. Fuse Size (A)	Max. Load (A)
26	3	1.5
24	5	2.5
22	6	3.0
20	7.5	3.75
18	10	5.0
16	12.5	6.25
14	15	7.5
12	25	12.5
10	30	15

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 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 2.38). Each power interface will have independent current measurement capability.

2.3.3 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 (Note 2)
Low-Rate Downlink	6000 B/S	960 B/S (Note 1)
Medium-Rate Downlink	1.4 Mb/S	1.4 Mb/S (Note 3)
Serial Command Channels	6	1 (Note 4)
Bi-Level Commands	24	4

Note 1: Nominal Information Rate Of One Standard Asynchronous Channel. Any Combination Of Five 1.2k Baud Channels May Be Downlinked Simultaneously.

Note 2: Nominal 1/6 Allocation.

Note 3: By Mission Requirements.

Note 4: These Services Are No Longer Offered.

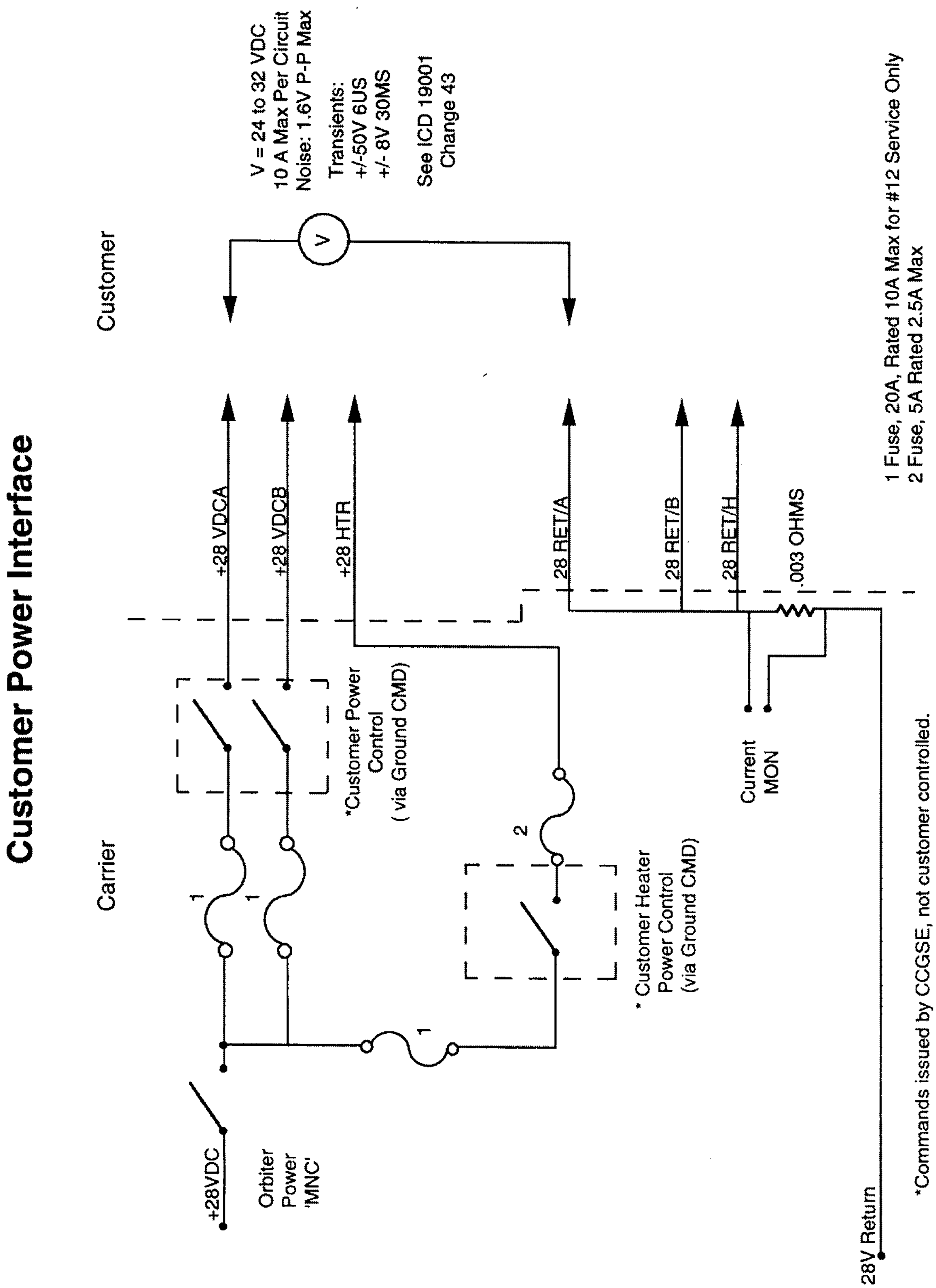


FIGURE 2.37 CUSTOMER POWER INTERFACE

In addition to the two 10-amp power lines, one 2.5-amp heater line is available at each power port. Heater service is controlled via a single relay for multiple customer ports. Therefore, power to this line shall be assumed ON for the duration of the flight. It is recommended that customers included internal (e.g., thermostatic) switching for this service.

Hitchhiker Avionics Unit - Power Distribution

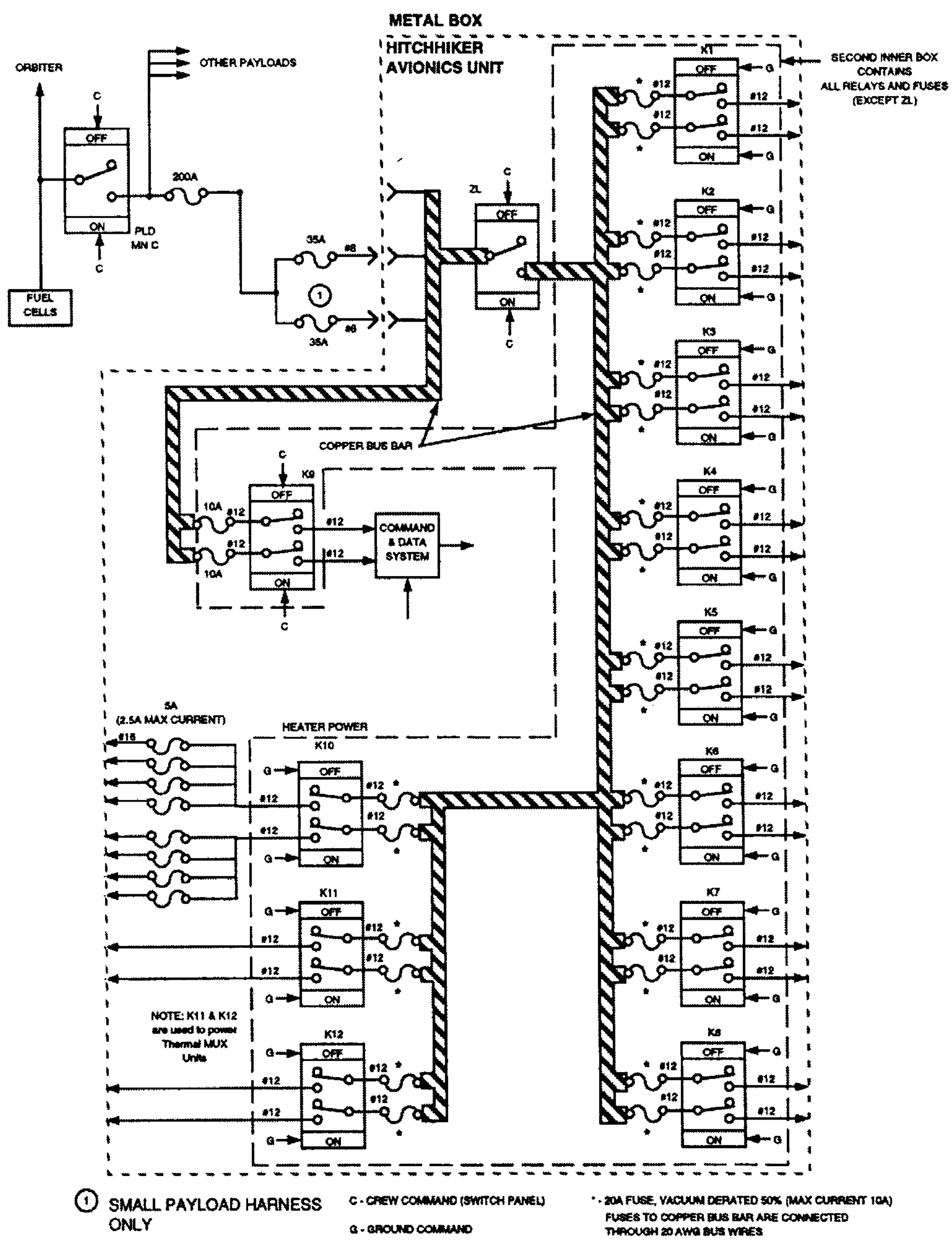


FIGURE 2.38 HITCHHIKER AVIONICS UNIT – POWER DISTRIBUTION

2.3.4 Thermal Power Characteristics

The thermistor characteristics that accomplish thermal control are specified in section 2.2.6.

2.3.5 Signal Characteristics

This data is available to the customer either in real-time or post-fight when specified as a requirement. Figure 2.40 provides a schematic drawing of the HH-S customer power interface. Customer signal ground must be connected to chassis (case). As shown in Figure 2.48, 28v return must be used for the bi-level return. The customer 28v return must be isolated from both signal ground and chassis (case) by a minimum resistance of 1M ohm. 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.

2.3.6 Standard Connectors for Customers

In choosing connectors for experiment internal wiring harnesses, it is highly recommended that the selection be limited to the MIL-C-38999 series I, II, or III or other space flight approved connectors. In the cases where GSFC is to supply the cables and harnesses as a service to the customer or where the connectors are otherwise specified within this document, the selection of connectors must be made from MIL-C-38999 to minimize cost and schedule impacts. GSFC will not be responsible for supplying connectors outside this specification. Sources of supply are as follows:

ITT Cannon
666 E. Dyer Road
P.O. Box 929
Santa Ana, CA 92702-0929

Amphenol Corporation
Bendix Connector Operations
40-60 Delaware Avenue
Sidney, NY 13838-1395

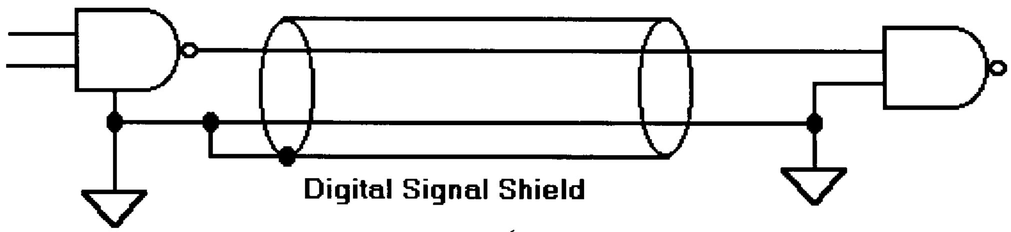
Matrix Sciences
365 Maple Avenue
Torrence, CA 90503

A detailed specification for this series of connectors may be obtained through the GSFC library or through the GSFC Code 300 library. Specific information regarding the manufacturer part numbering, cost, availability, etc. may be obtained from the above sources or through the GSFC electrical engineer assigned to the project.

2.3.7 Shield Grounding

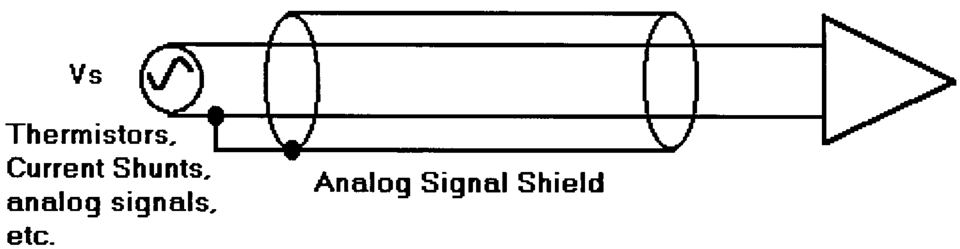
In order to maintain the EMC of the Hitchhiker and its customer, the following shielding practices will be used.

Refer to Figure 2.40. All logic level signals and analog signals excluding video and RF shall have their shields grounded to the signal ground at the sending end only. Signal returns will be routed in the same bundle as the associated signal lines in order to minimize electromagnetic emission and susceptibility.



a. Logic Level signal shield practice

FIGURE 2.39 DIGITAL SIGNAL SHIELD



b. Analog shielding practice

FIGURE 2.40 SHIELD GROUNDING OF LOGIC LEVEL AND ANALOG SIGNALS

All lines which carry significant current transitions while displaying "clean" constant voltages will be electromagnetically shielded (both ends grounded). Typically this will occur on power lines and the shields shall be grounded to chassis in these cases. Power distribution shall be through twisted pairs of wires in bundles separate from other signals. Refer to Figure 2.41.

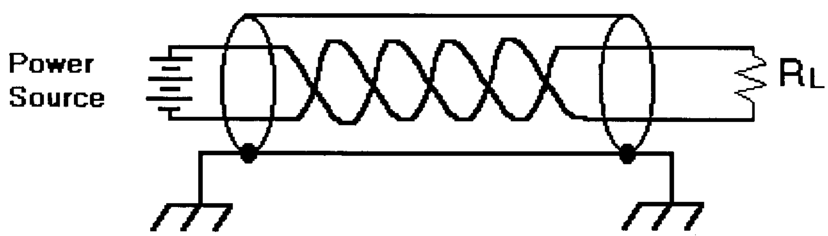


FIGURE 2.41 SHIELD GROUNDING OF POWER LINE

All lines which carry significant current and voltage transitions will be double shielded with an electrostatic shield (sending end grounded) and an electromagnetic shield (both ends grounded to chassis). Refer to Figure 2.42. This will occur on relay drive signals typically.

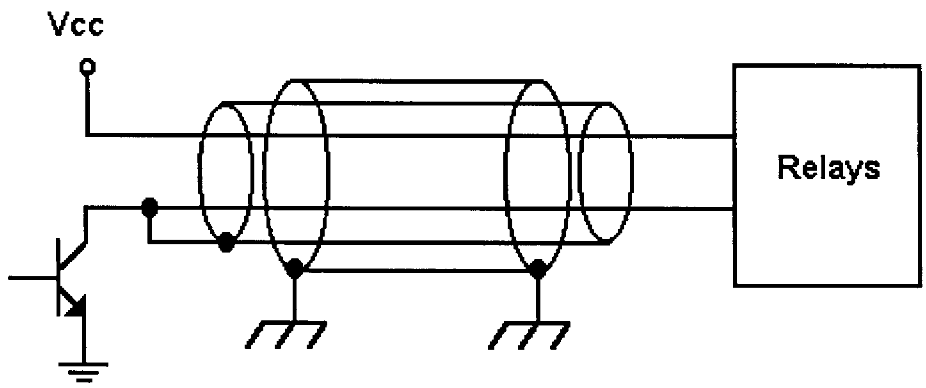


FIGURE 2.42 DOUBLE SHIELDING SIGNIFICANTLY VARYING CURRENT AND VOLTAGE LINES

2.4 Command And Communication Support System

2.4.1 Transparent Data System

Figures 2.43 through 2.47 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. Some ground data processing functions may have optional service charges for reimbursable customers. Contact the Project Office for details.

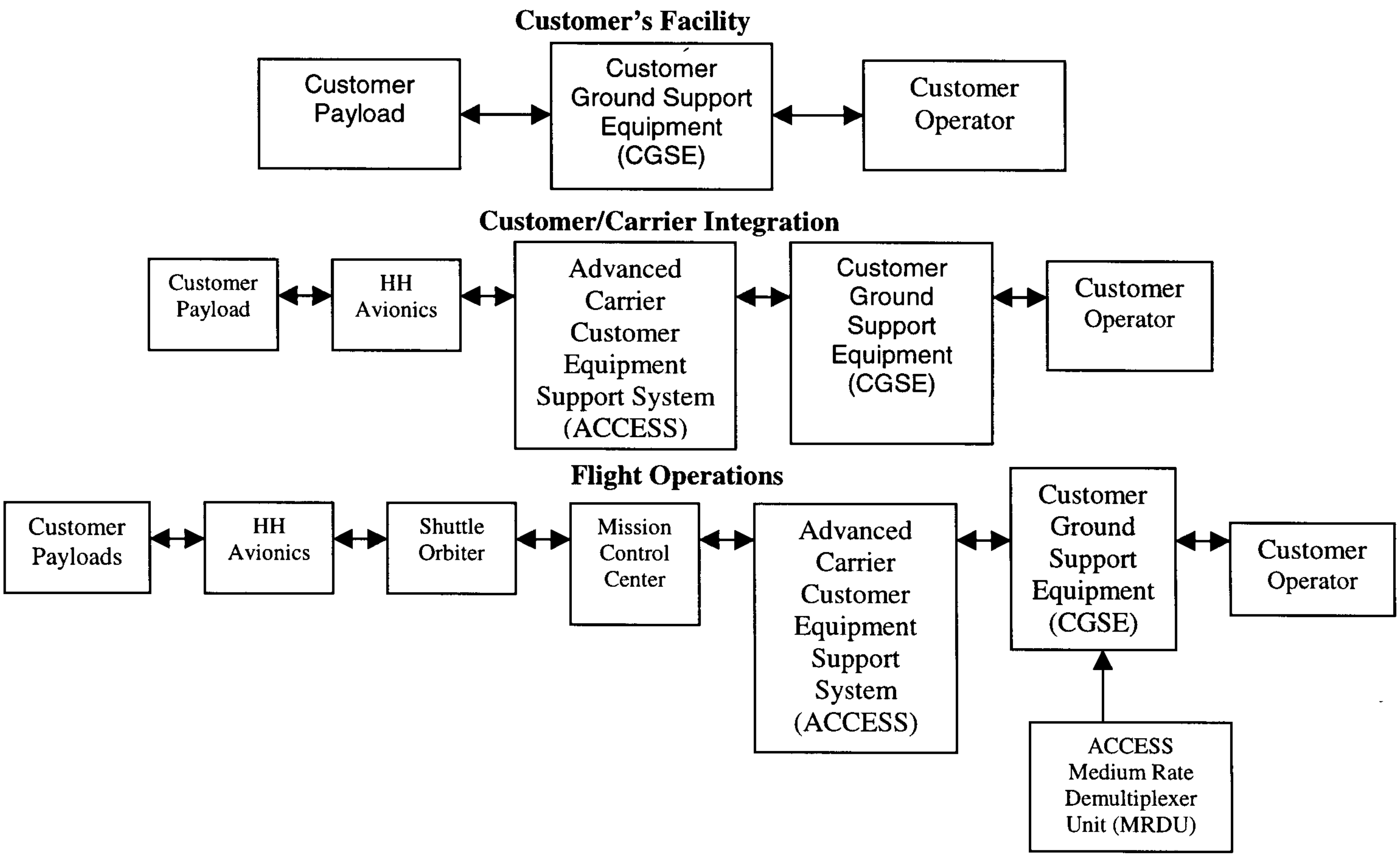


FIGURE 2.43 HITCHHIKER TRANSPARENT DATA SYSTEM

Hitchhiker Command Flow

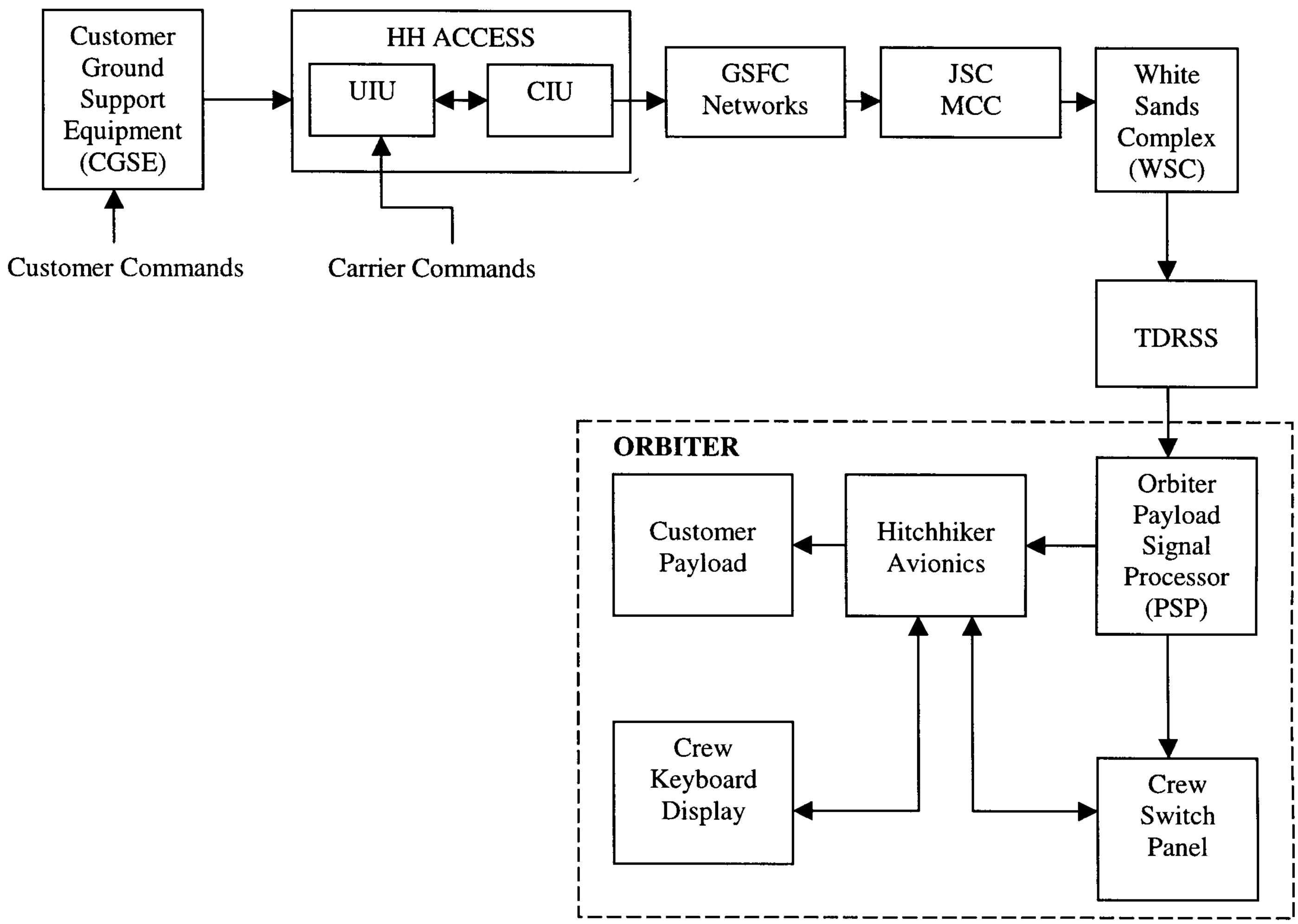


FIGURE 2.44 HITCHHIKER COMMAND FLOW

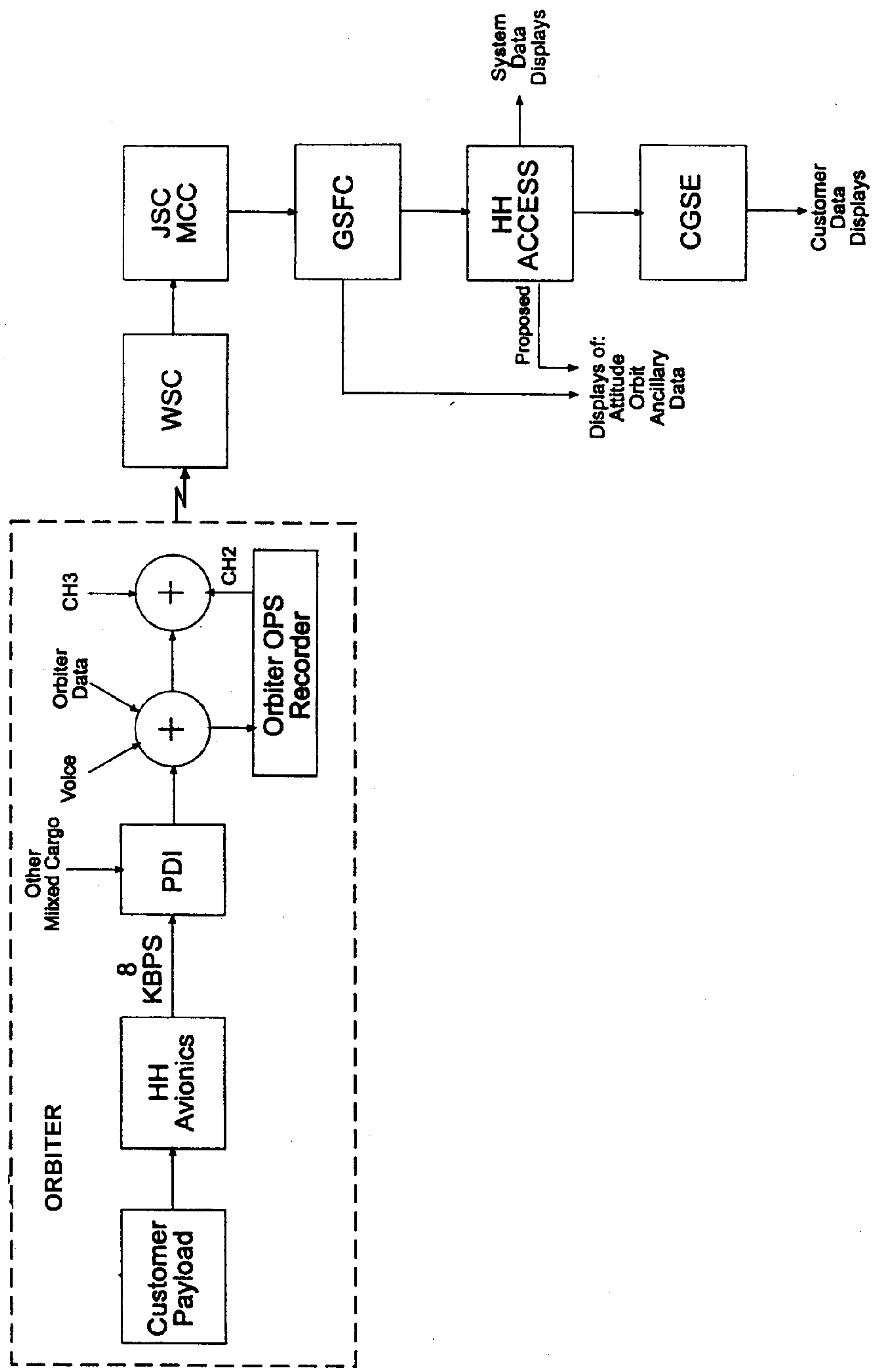


FIGURE 2.45 HITCHHIKER LOW RATE DATA FLOW

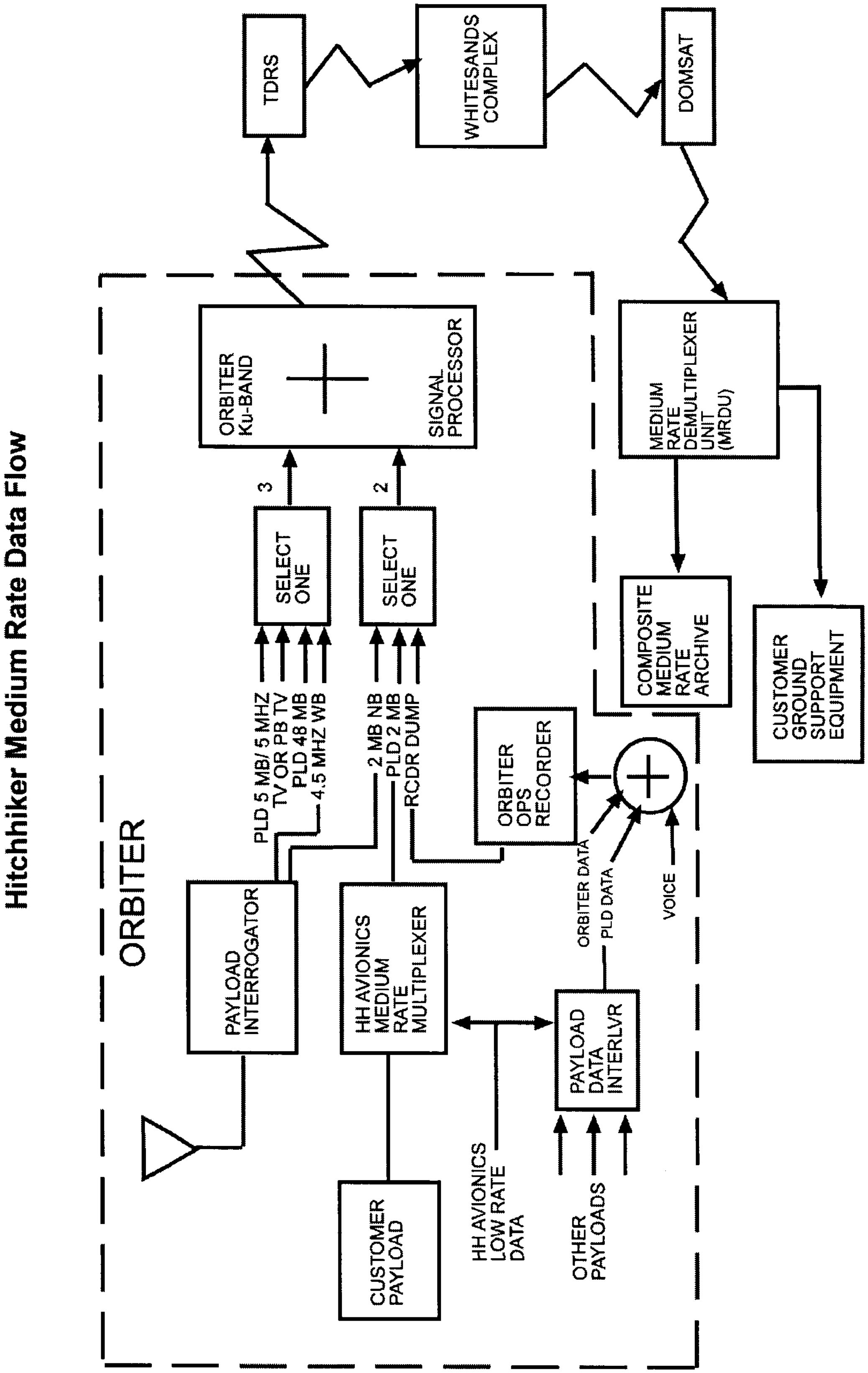


FIGURE 2.46 HITCHHIKER MEDIUM RATE DATA FLOW

Hitchhiker Signal Port to Customer Interface

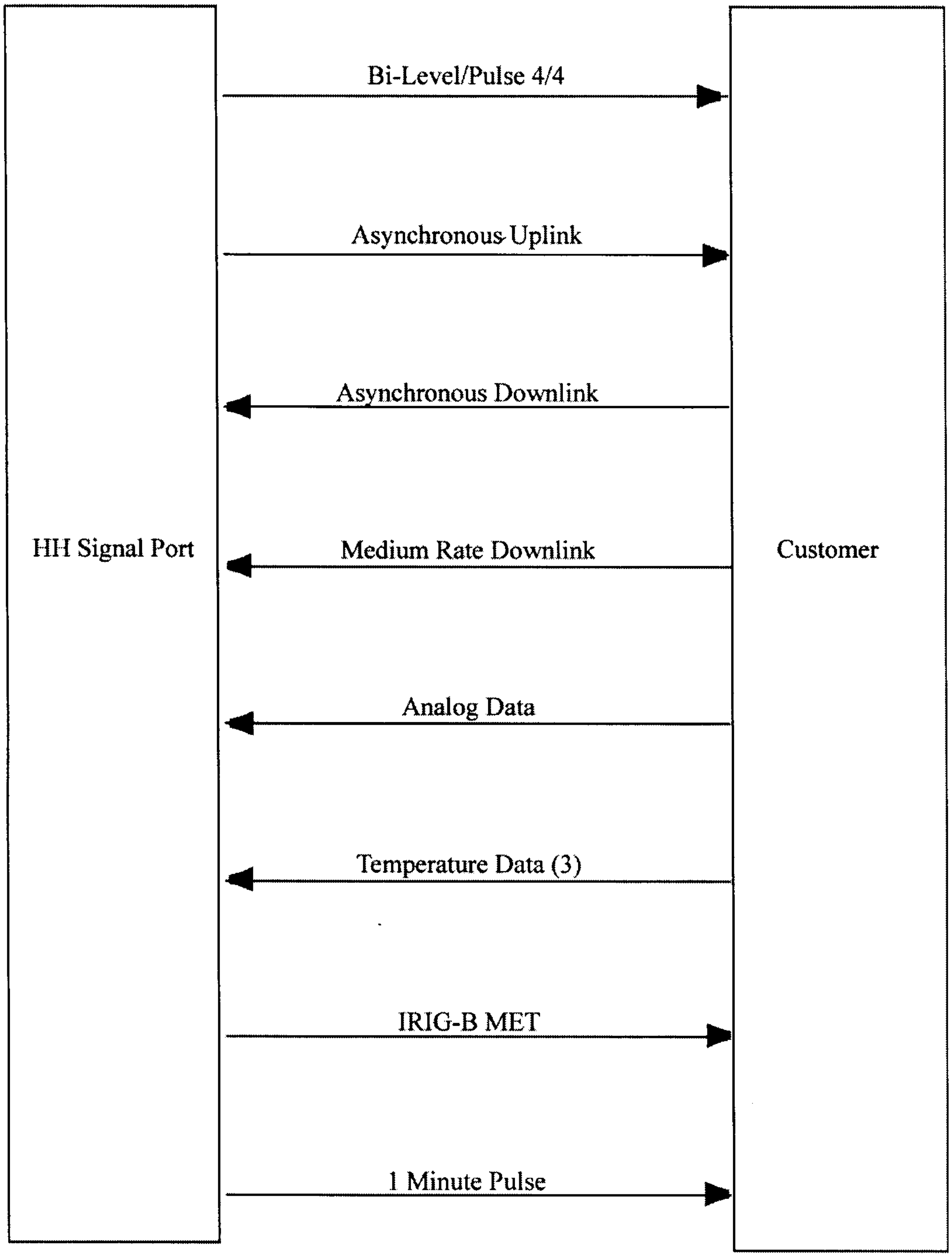
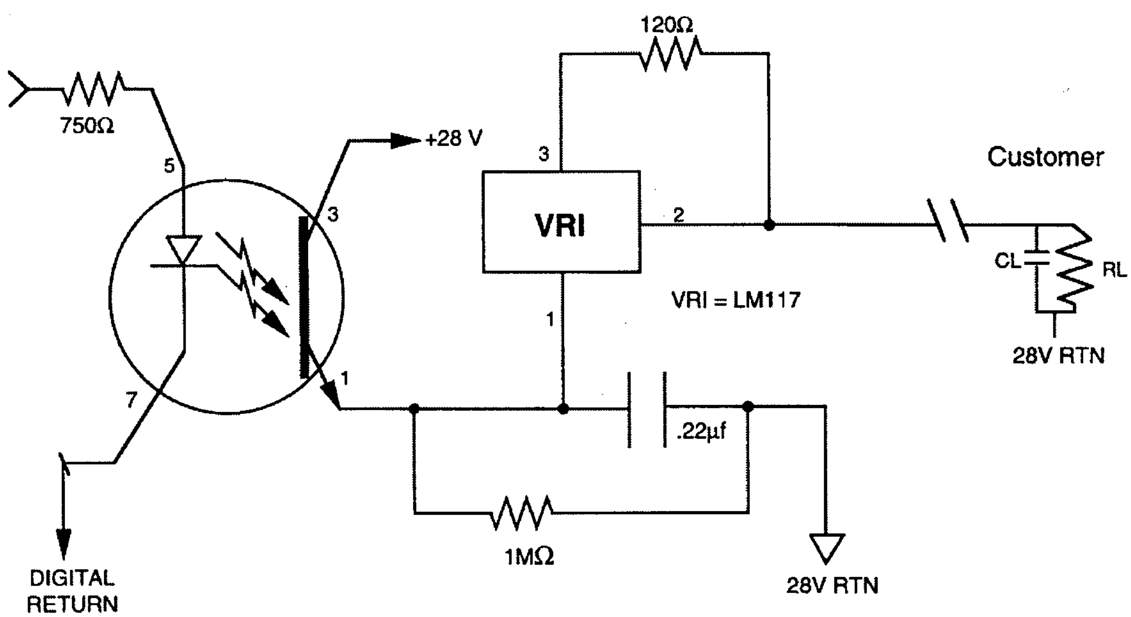


FIGURE 2.47 HITCHHIKER SIGNAL PORT TO CUSTOMER INTERFACE

2.4.2 Bi-Level Command System

Signals that traverse the bi-level command interface may be set to ØV (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 2.48 illustrates the customer bi-level command interface while Figures 2.49 and 2.50 show the command formats. Only one of the four signals may be affected by any one command. Bi-level commands can be sent either via ACCESS or CGSE.

CUSTOMER BI-LEVEL COMMAND INTERFACE



RL = 3.2K OHMS Min. (Customer Power On or Off)
RL = 10K Ohms Max, (Source 10ma Max; Sink 0)
CL = 1500 PF Max,
VT = 26 +/- 7V
VF = 1.5 +/- 1.5V
VNOISE = 1.6 V P-P (Max.)
TR = TF= 10 Microsec(Min)
TR = TF= 100 Microsec (Max)
T1 = 50 +/- 30 MS (Pulse Mode)

FIGURE 2.48 CUSTOMER BI-LEVEL COMMAND INTERFACE

Customer Message Format for 28 Volt Bi-Level Commands

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	0	0	1
CID				0	0	1	1
S4	S3	S2	S1	R4	R3	R2	R1
CHECK							

S1-S4 Set Bi-Level 1-4 True = 28V
R1-R4 Reset Bi-Level 1-4 to False = 0V
RN and SN Simultaneously True = Error, No Action
Type = 3, Byte Count = 1. Any Bi-Level Command Lines Not Selected by Ones in SN, RN Will Not Be Affected

Customer Line Numbers

Only One Bi-Level Line May be Set/Reset by a Single Command.

Note: 28 volt bi-level and 28 volt pulse commands use the same 4 wires per customer interface (17,18,19,20).

FIGURE 2.49 CUSTOMER MESSAGE FORMAT FOR 28 VOLT BI-LEVEL COMMANDS

Customer Message Format For 28 Volt Pulse Commands

1	2	3	4	5	6	7	8	
1	1	1	0	0	1	0	1	P1 -P4+ 1 PULSE BI-LEVEL LINE 1-4 SETS SELECTED BI-LEVEL LINES(S) ON CUSTOMER PORT CID TO TRUE (+28V) FOR 20- 80 MILLISECONDS THEN RETURNS LINE TO FALSE (OV). STATES OF ANY BI-LEVEL COMMAND LINES NOT SELECTED BY ONES ARE NOT AFFECTED. CUSTOMERS DESIGN MUST BE CAPABLE OF WITHSTANDING CONTINUOUS +28V ON ANY BI-LEVEL LINE WITH NO DAMAGE IN EVENT OF SOFTWARE FAILURE. TYPE =5, BYTE COUNT =1
0	0	0	0	0	0	0	1	
CID				0	1	0	1	CUSTOMER LINE NUMBERS
0	0	0	0	P4	P3	P2	P1	← ONLY ONE LINE MAY BE PULSED BY A SINGLE COMMAND.
CHECK								

NOTE: 28 VOLT PULSE AND 28 VOLT BI-LEVEL COMMAND USE THE SAME 4 WIRES PER CUSTOMER INTERFACE (17,18, 19, 20)

FIGURE 2.50 CUSTOMER MESSAGE FORMAT FOR 28 VOLT PULSE COMMANDS

2.4.3 Asynchronous Uplink

The asynchronous uplink is used to transmit customer asynchronous command messages and Mission Elapsed Time (MET) messages to the payload. All commands issued by the CGSE have the general format shown in Figure 2.51

The customer message format for asynchronous commands is shown in Figure 2.52. The format of the asynchronous MET message is shown in Figure 2.53. The format of the synchronize to MET command is shown on Figure 2.54 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 2.55 where each signal contains one start bit, eight data bits (no parity), and one stop bit. The uplink messages may originate from the ACCESS 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.

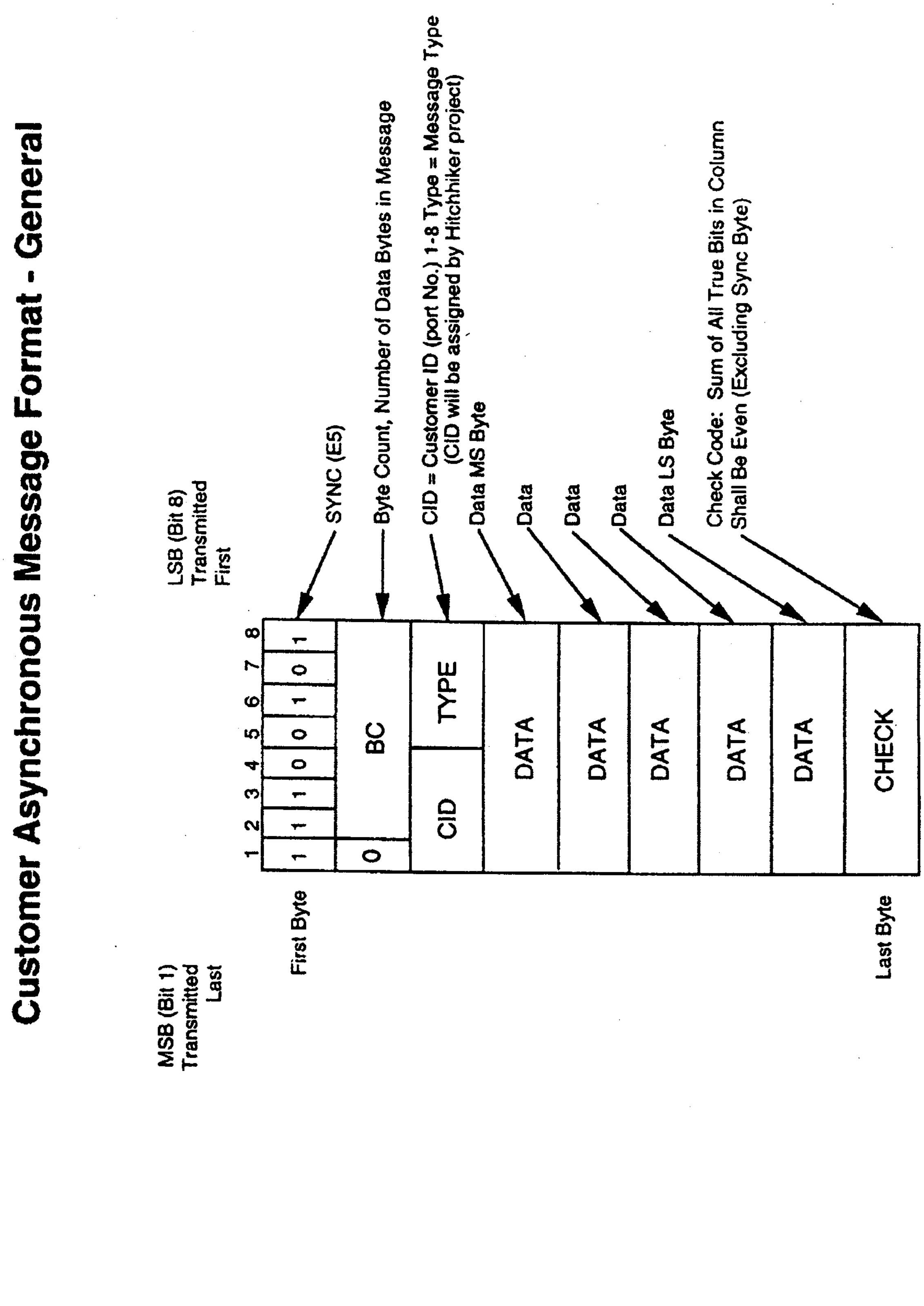
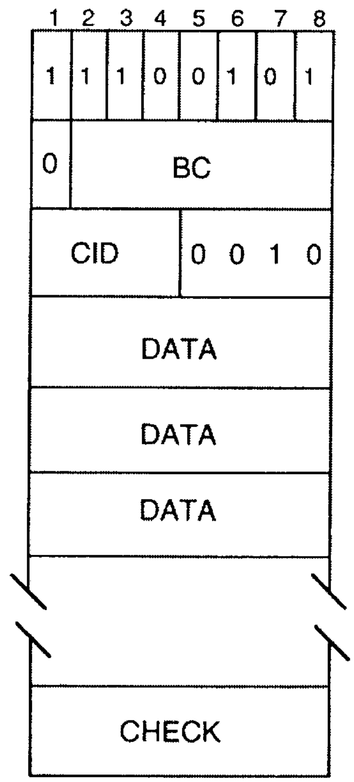


FIGURE 2.51 CUSTOMER ASYNCHRONOUS MESSAGE FORMAT – GENERAL

Customer Message Format for Asynchronous Commands



Entire Message Including Sync and Check Bytes to be Transmitted to Customer Port CID
RD Asynchronous on Pins 21 & 22.
Type = 2

Format of CGSE Message Identical

FIGURE 2.52 CUSTOMER FORMAT FOR ASYNCHRONOUS COMMANDS

Customer Message Format For MET

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	1	0	0
CID				0	1	0	0
D1	D2	D3	D4	D5	D6	D7	D8
D9	D10	H1	H2	H3	H4	H5	H6
0	M1	M2	M3	M4	M5	M6	M7
0	S1	S2	S3	S4	S5	S6	S7
CHECK							

D1-200 DAYS	H1-20 HOURS	M1-40 MIN	S1-40 SEC
D2 -100	H2-10	M2-20	S2-20
D3-80	H3-8	M3-10	S3-10
D4-40	H4-4	M4-8	S4-8
D5-20	H5-2	M5-4	S5-4
D6-10	H6-1	M6-2	S6-2
D7-8		M7-1	S7-1
D8-4			
D9-2			
D10-1			

4 BYTES

Command to be transmitted to customer payload asynchronous port at a time other than MET second 1 or 59. The 4 bytes of time data will be filled in by the SPOC avionics using Orbiter supplied time. When sent by the customer, the 4 bytes are "don't care" and may contain anything. CGSE command with dummy data initiates transmission of MET command, type=4.

FIGURE 2.53 CUSTOMER MESSAGE FOR MET

Customer Message Format for Synchronized MET

1	2	3	4	5	6	7	8	
1	1	1	0	0	1	0	1	
0	0	0	0	0	1	0	0	Byte Count
CID				0	1	1	0	Subcommand Type 6
D1	D2	D3	D4	D5	D6	D7	D8	
D9	D10	H1	H2	H3	H4	H5	H6	
0	M1	M2	M3	M4	M5	M6	M7	
0	S0	S0	S0	S0	S0	S0	S0	
CHECK								Checksum

Notes:

1. Unless MET is within ±5 seconds of the new minute, the next minute represented by the minute pulse is sent via the RS-422 Asynchronous Interface.
   If MET is within 5 seconds of the new minute, then the time sent to the customer is the NEXT minute, not the upcoming minute.

2. This command is not implemented in some HH avionics. Check with HH project for availability.

FIGURE 2.54 CUSTOMER MESSAGE FORMAT FOR SYNCHRONIZED MET

Customer Asynchronous RD Interface

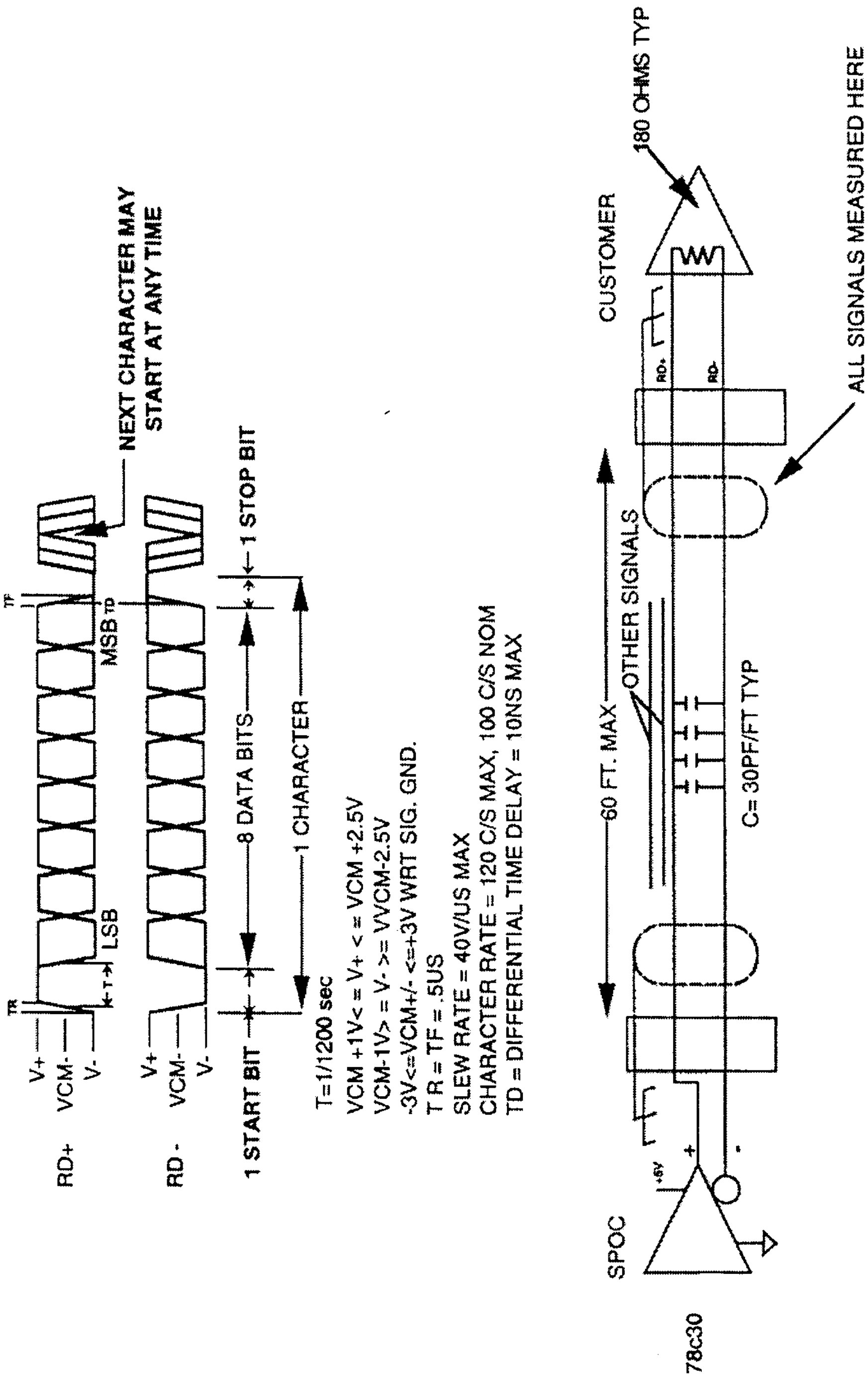


FIGURE 2.55 CUSTOMER ASYNCHRONOUS RD INTERFACE

2.4.4 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 2.56).

The downlink can support continuous 1200-baud transmission which will be routed to the customer's GSE via the ACCESS 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 avionics arrangement can simultaneously downlink any 5 of the 8 available asynchronous downlink channels. These channels are selectable via ground system commands from the ACCESS.

Customer Asynchronous SD Interface

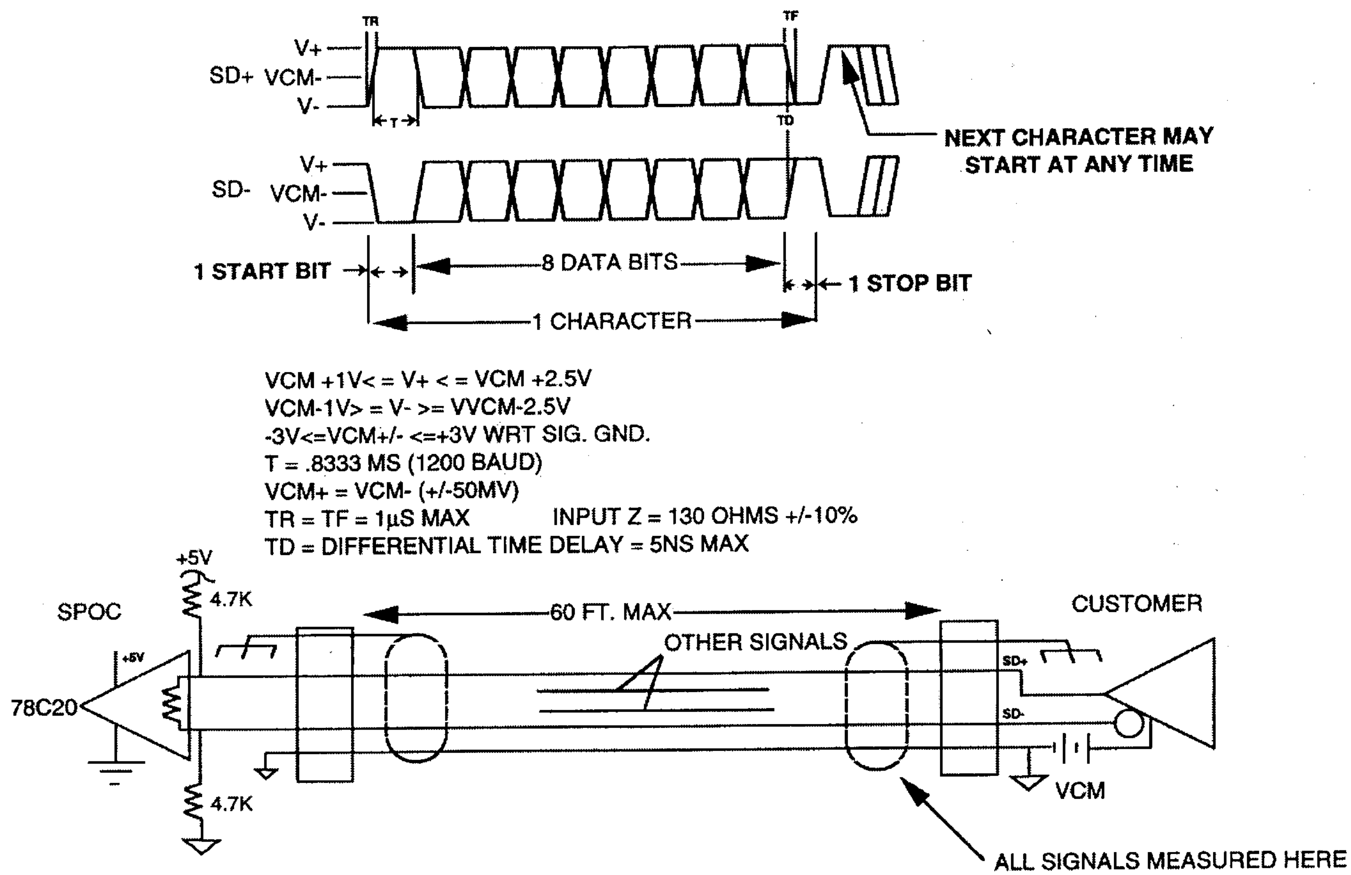


FIGURE 2.56 CUSTOMER ASYNCHRONOUS SD INTERFACE

2.4.5 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 simultaneous 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 2.45, 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.

Medium-rate data accommodations will be allocated by the SSPP on a case-by-case basis. This allocation will depend on several factors, including experiment data rate, mission timeline, and the requirements of other co-manifested experiments. The maximum data rate per user channel is 880 kbps. If conflicts exist between several medium-rate users, then medium-rate data output must be controllable via CGSE ground command.

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 data is discontinuous or event-oriented, the customer may elect to have the clock stop between periods of valid data, or may elect to transmit continuous clock but discontinue transmitting valid data.

It is recommended that each valid period be preceded by at least 4 data frames of leader telemetry prior to the first frame of required data. This is needed in order to ensure that the ACCESS ground data system has sufficient time to sync on the composite downlink signal during mission. Each data period must be followed by at least 66 bytes of clock to flush the customer data buffer in the MRM.

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 but may be customer selected. 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' goals.

During testing and flight operations, the Medium Rate Demultiplexer Unit (MRDU), referenced in Figure 2.46, will decommutate the multiplexed signal and regenerate the customer's clock and data for use by the CGSE. This data interface is shown in Table 2.12. 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 2.57, 2.58 and 2.59. Data return on the ground can be either by NRZ-L serial data and clock interface identical to Figures 2.58 and 2.59 or post mission by Compact Disc (CD). The CD 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 in Table 2.12.

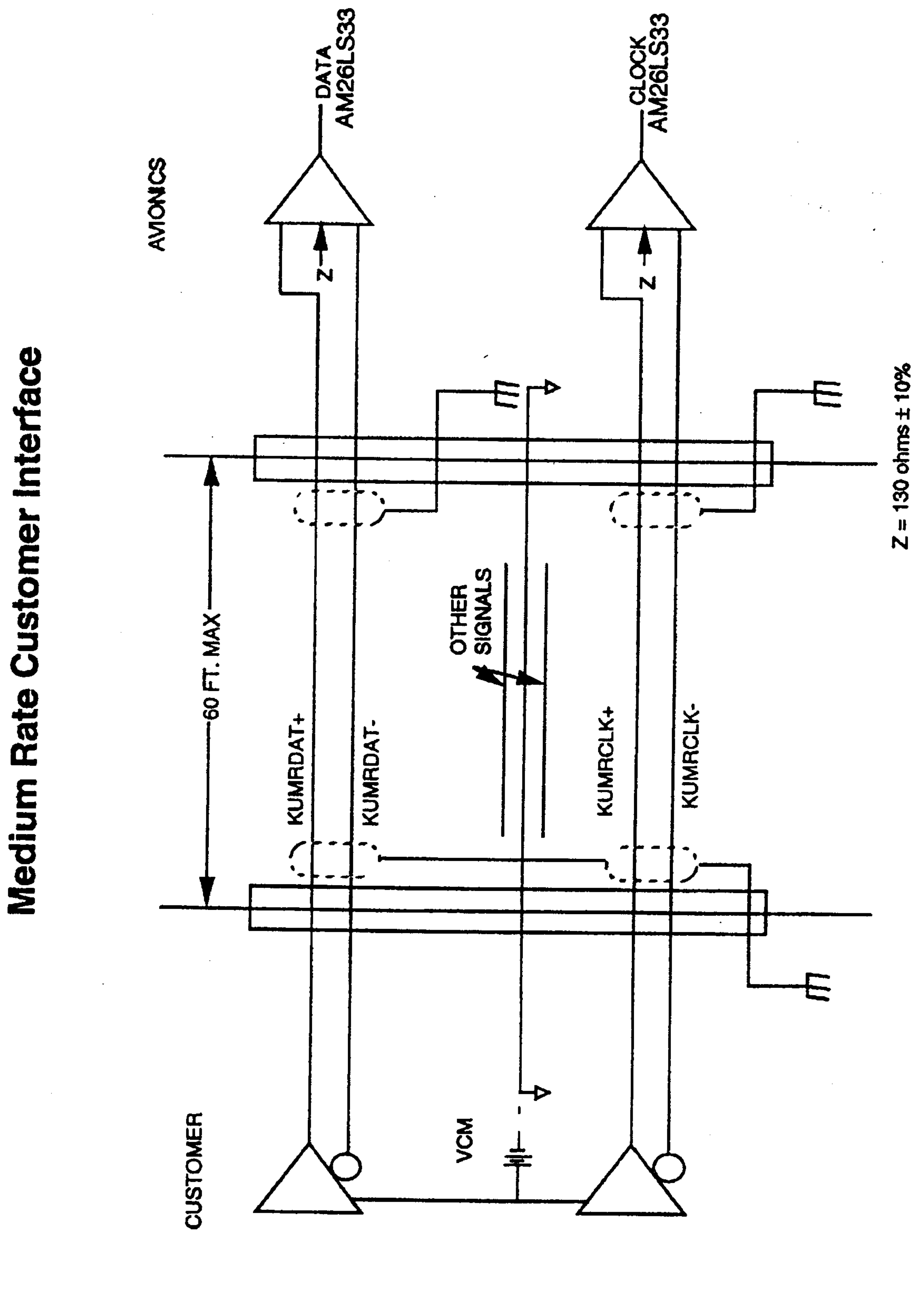
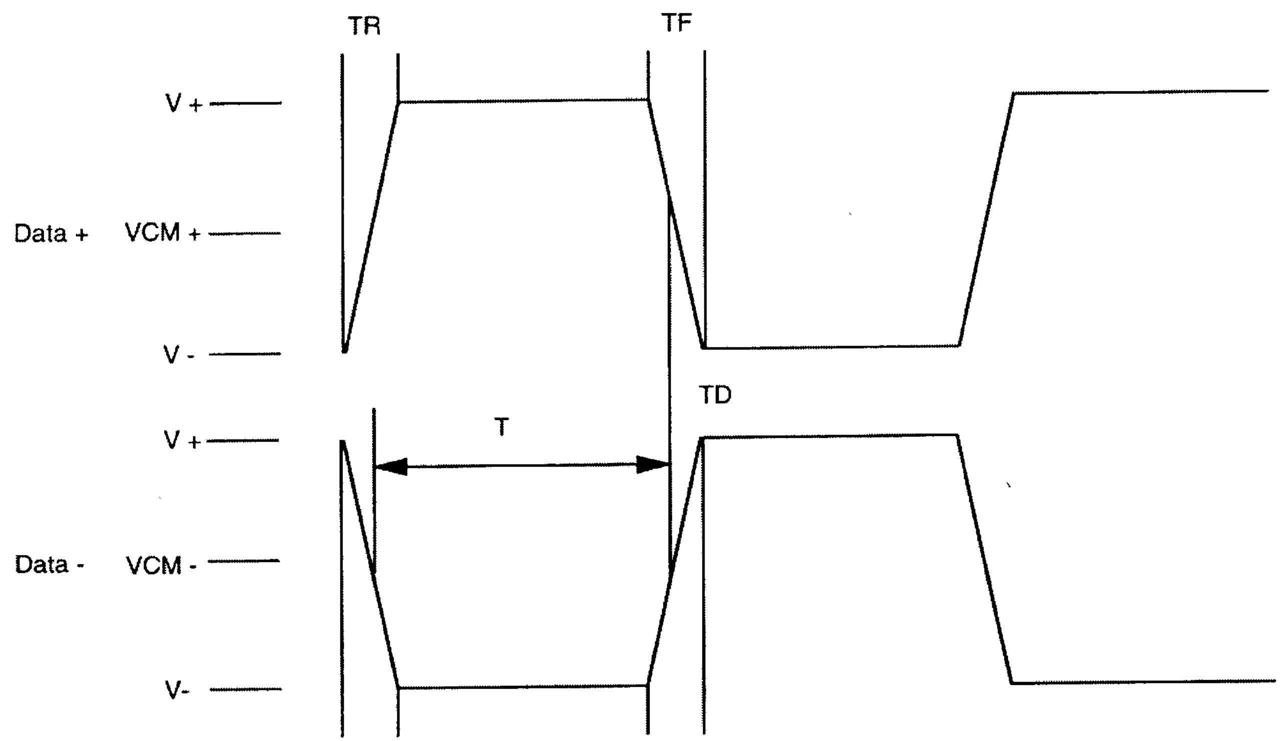


FIGURE 2.57 MEDIUM RATE CUSTOMER INTERFACE

Medium Rate Customer Data



Required: VCM+ = VCM- +/-50MV, Then VCM+ = VCM- = VCM
Required: VCM + 1 volt ≤ V + ≤ VCM + 2.5V
Required: VCM - 1 volt ≥ V - ≥ VCM - 2.5V
Required: -3 volts ≤ VCM ≤ + 3 volts with respect to signal ground
TR ≤ TF ≤ 1US

} For Data + and Data- Lines

T = Baud Period = 1/Baud Rate Baud Rate = TBD
T = Differential Time Delay = 10 MS Max
Baud Rate Stability ≤ 0.1%

FIGURE 2.58 MEDIUM RATE CUSTOMER DATA

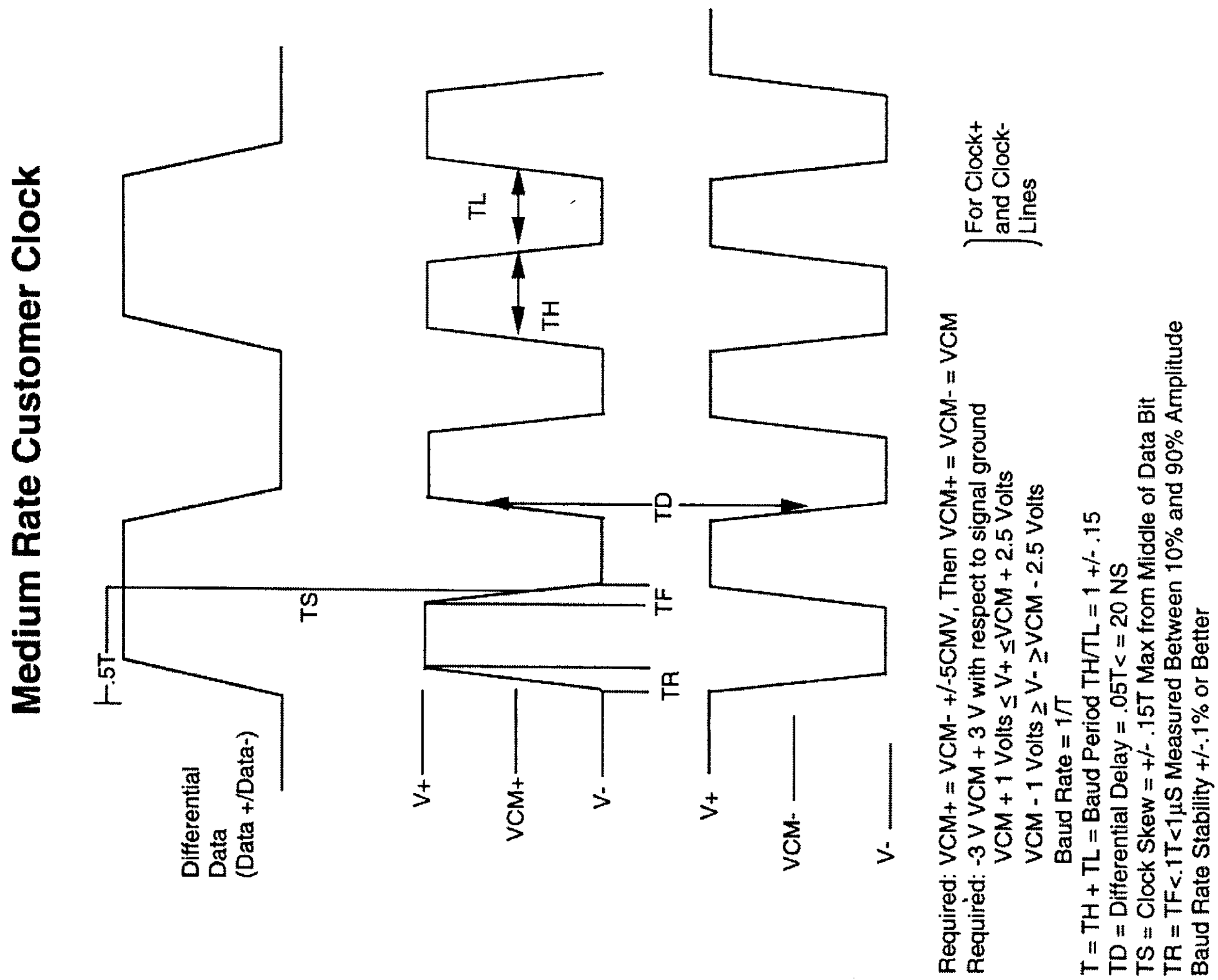


FIGURE 2.59 MEDIUM RATE CUSTOMER CLOCK

2.4.6 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 2.60.

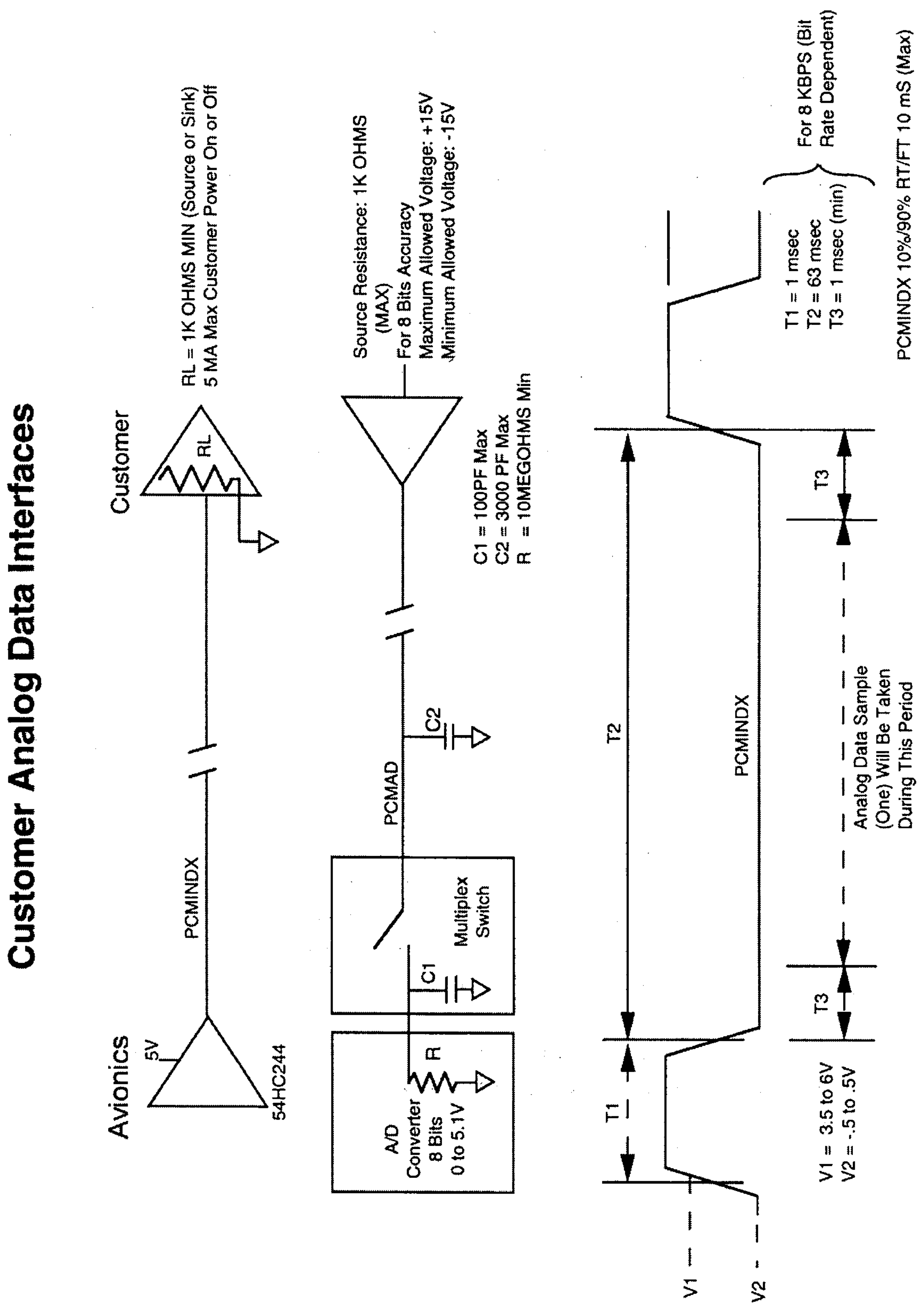


FIGURE 2.60 CUSTOMER ANALOG DATA INTERFACES

2.4.7 Temperature Data

As provided in each interface, three additional analog data lines (Figure 2.33) 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 2.60. Greenwich Mean Time (GMT) may be used in place of MET on some HH missions.

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.

The signal characteristics of this interface are described in paragraph 8.2.10 of JSC 07700 Vol. XIV Attachment 1 OICD 2-19001) SHUTTLE ORBITER/CARGO STANDARD INTERFACES. 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 groundstation 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 ring 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 is modified IRIG-B as shown in Figure 2.62. The electrical interface characteristics are shown in Figure 2.61.

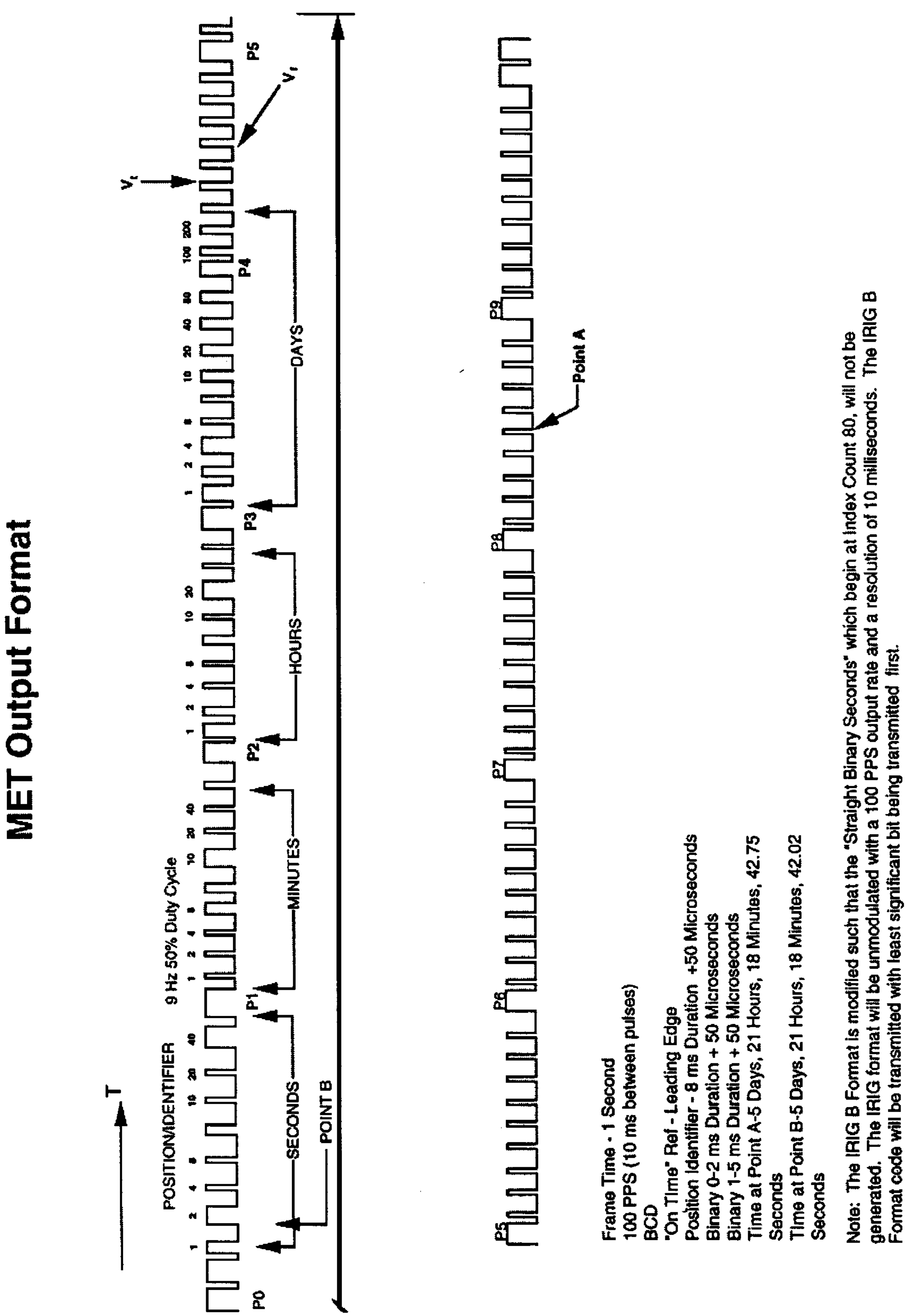


FIGURE 2.62 MET OUTPUT FORMAT

2.4.9 ACCESS/CGSE Interface

Overall communication between the customer's payload and their ground support equipment are shown in Figure 2.63. The ACCESS 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 ACCESS provides two asynchronous data lines for these purposes.

The Advanced Carrier Customer Equipment Support System (ACCESS) is a Pentium PC-based, networked system that allows customers to receive telemetry from and send commands to their experiment during Integration and Test (I&T) and mission operations. The ACCESS system consists of the User Interface Unit (UIU) and the Carrier Interface Unit (CIU) and the Medium Rate Demultiplexer Unit (MRDU). Figures 2.63 and 2.64 illustrate the Hitchhiker ACCESS system. ACCESS can also provide data displays for each customer and thermal plotting capabilities.

The UIU is the main console for the system operator. Its overall function is to ingest low rate telemetry packets via the network from the CIU and distribute user packets via the ARNET RS232/RS422 ports. It allows the operator to send various directives and commands to control the different UIU and CIU processes as well as control of the HH Carrier. The UIU also allows the operator to view numerous pages that monitor the health and safety for the customer payload, such as the current and temperatures. The UIU also performs hazardous command checks and telemetry limit checking. The UIU is also responsible for ingesting users commands via RS232/RS422 serial ports and sending the command packets to the CIU for output to the carrier.

The CIU is responsible for ingesting low rate telemetry from the HH carrier in the form of minor frames (I&T) or NASCOM blocks (mission), decommutating the data into subcom frames, and creating user data packets for distribution through the UIU to the customer. The CIU is also responsible for transmitting the commands to the avionics in I&T format (ground testing) or NASCOM format (mission operations). The CIU acts as a front end for the UIU.

The MRDU is a stand-alone medium rate processing system that ingests the 2MB composite data stream from the NASA Communications network (NASCOM), demultiplexes the customer medium rate data, and distributes that customer data via an RS422 interface to the CGSE. The MRDU is also responsible for archiving the 2MB composite data stream for use in creating the post-mission customer data products.

The ACCESS also has the capability of providing a real-time Data Display Unit (DDU) for each customer's use during a HH mission. The DDU's are stand-alone Windows-based PC's that display HH avionics health and safety data, as well as thermistor temperatures, customer data streams, and other telemetry and command status information. The pages displayed on the DDU contain the same information used by the ACCESS operators to monitor the HH avionics.

The thermal plotting capability is contained in a stand-alone workstation monitored by a thermal engineer during all HH missions. The system provides real time monitoring and near real time plots of the HH avionics and customer temperatures.

The following sections define the electrical interfaces supported by the ACCESS and the data transferred between the ACCESS and the CGSE.

Hitchhiker/Customer Communications

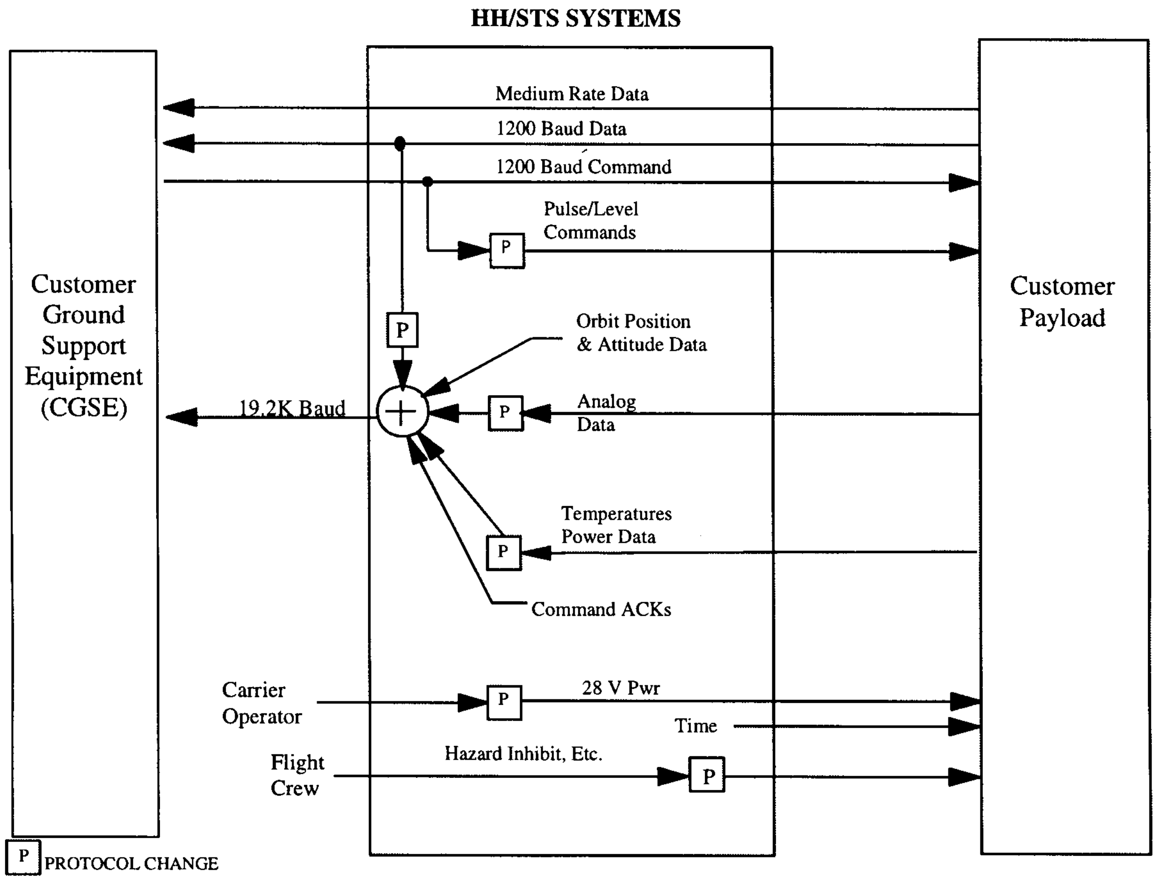


FIGURE 2.63 HITCHHIKER/CUSTOMER COMMUNICATIONS

Advanced Carrier Customer Equipment Support System (ACCESS)

Low Rate Data Processing

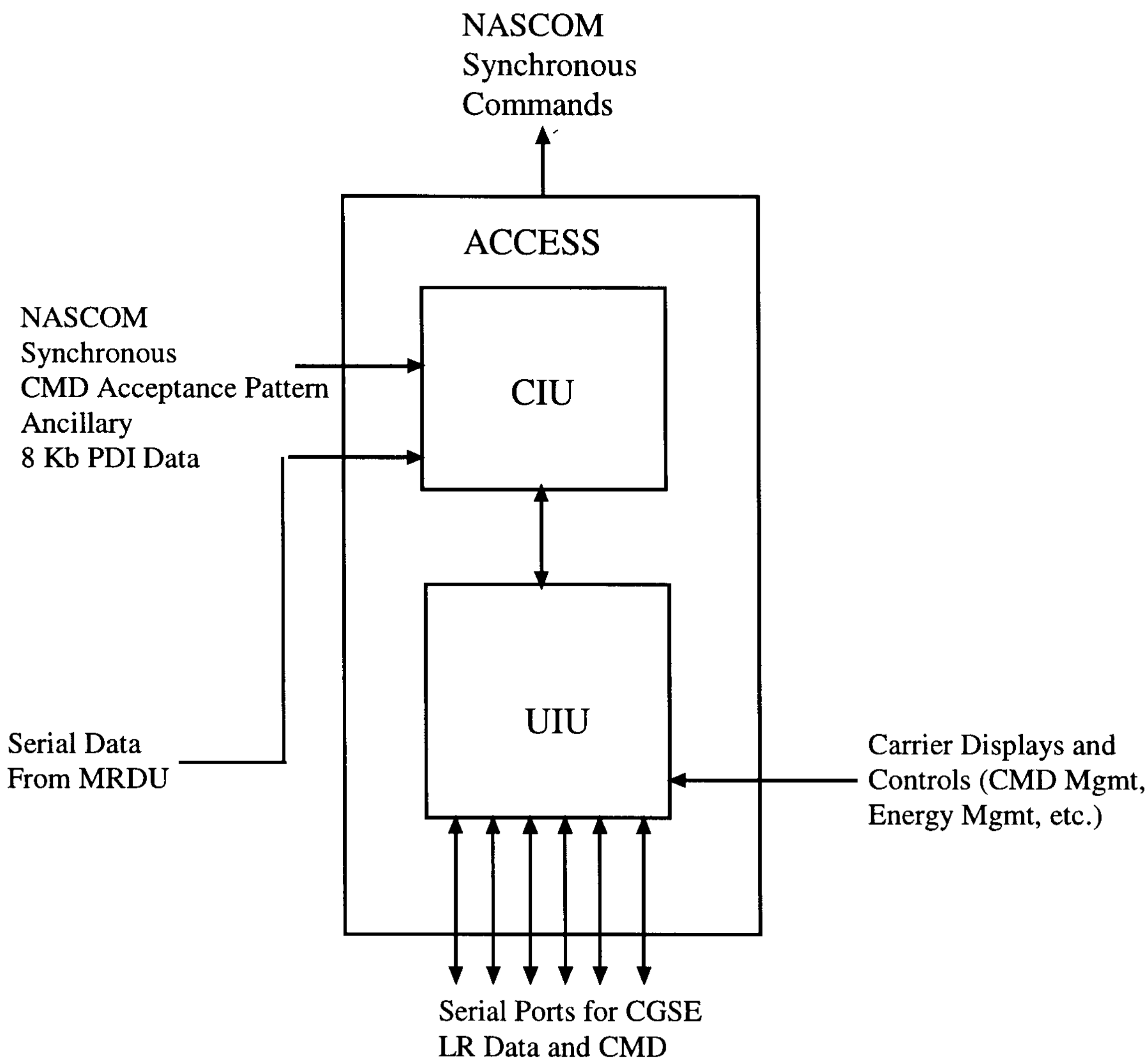


FIGURE 2.64 ACCESS LOW RATE DATA PROCESSING

Advanced Carrier Customer Equipment Support System (ACCESS)
Medium Rate Data Processing Unit (MRDU)

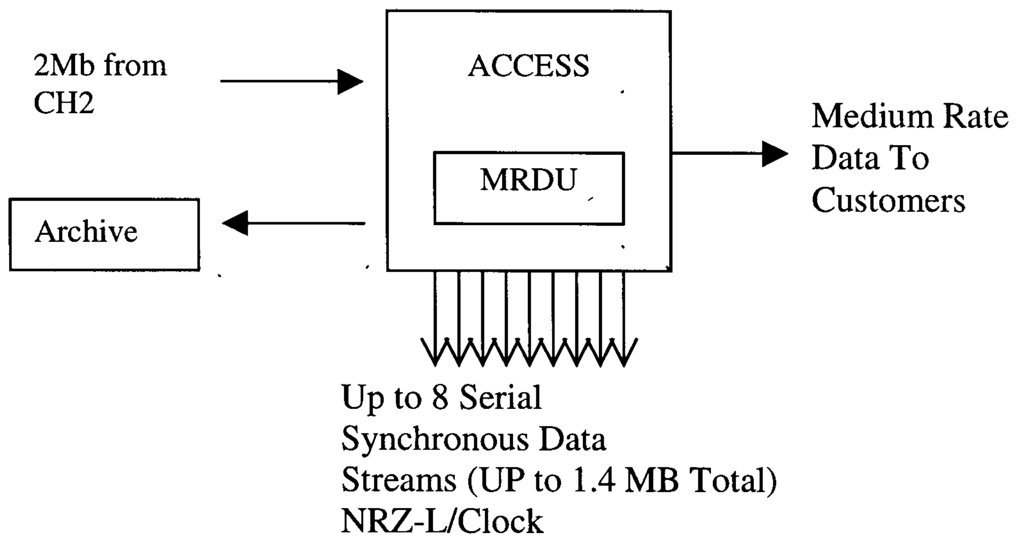


FIGURE 2.65 ACCESS MEDIUM RATE DATA PROCESSING UNIT

2.4.9.1 ACCESS-CGSE Physical Interface Requirements.

The asynchronous interfaces for customer unformatted payload telemetry (type 2) data and command generation are RS-232 or RS-422 compatible. These interfaces are full duplex with an ACCESS receive side for CGSE command messages and an ACCESS send side for transmitting customer data to the customer CGSE. One line (either RS-232 or RS-422) is assigned per customer ID (CID). The default data rate is 1200 baud (see Table 2.9 for additional line rates and information).

The asynchronous interfaces provided for HH ancillary data (type 4), formatted payload data (type 2), Shuttle orbit and attitude data (CAS – type 10), Analog data (type 3), Command Completion status messages (type 5), and Command Link status messages (type 6) are RS-232 compatible. These interfaces are half duplex and are not nominally used for command messages. The default rate is 19200 baud (see Table 2.9 for additional information).

A summary of the RS-232-C and RS-422 lines and their characteristics are presented in Table 2.9. The RS-232-C and RS-422 connector types and pin assignments are shown in Tables 2.10 and 2.11 respectively.

The interface for customer medium rate payload telemetry is RS-422 compatible. One line is assigned per customer ID (CID). The data rate is dependent on the number of customers using the HH avionics medium rate capability up to a combined rate of 1.2 Mb.

The medium rate connectors and pin assignments are shown in Table 2.12. A more detailed explanation of the telemetry and command interfaces are provided in the following sections.

TABLE 2.9 ACCESS - CGSE COMMUNICATIONS LINE

Line #	Line Characteristics	Function	Comments
1	Full Duplex, 1200 Baud, No Echo, 1 Start, 1 Stop, No Parity, RS422 Or RS232	Access Receive Side: CGSE Command Messages Access Send Side: Raw Payload Data From Avionics 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:	1 Line Per CID
		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 (Orbit/Attitude) 14 - Customer PCM-B Data 15 - Customer PCM-A Data	If Utilization Rate Exceeds 75% Of Baud Rate, A Second Line Will Be Required

TABLE 2.10 PIN DESIGNATION FOR RS-232 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Unformatted Data
Avionics Ancillary Data
STS Orbit/Ancillary Data
Serial Command Messages (CGSE to ACCESS)

PIN Number	Function (Access)
1	Frame Ground (FG)
2	Transmit Data (TD)
3	Received Data (RD)
4-6	N/C
7	Signal Ground (SG)
8-25	N/C

The Serial Interface Circuit will use the "Null Modem" configuration, shown in Figure below.

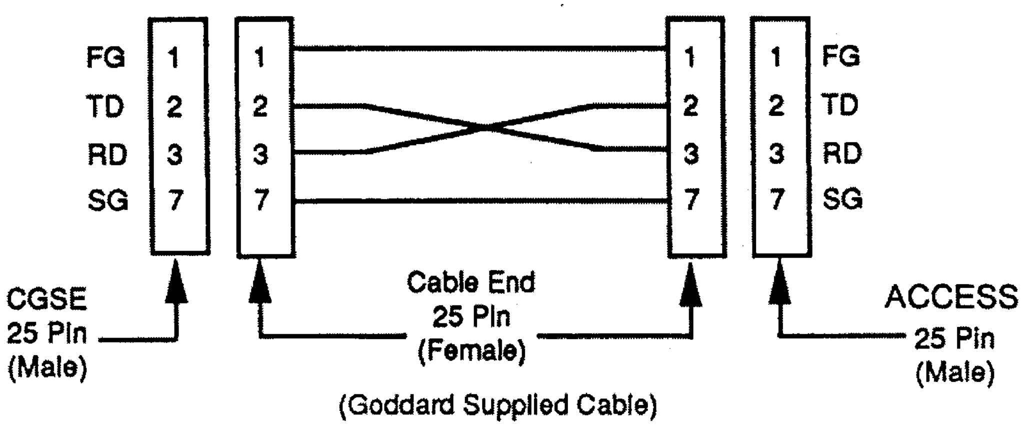


TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

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 Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

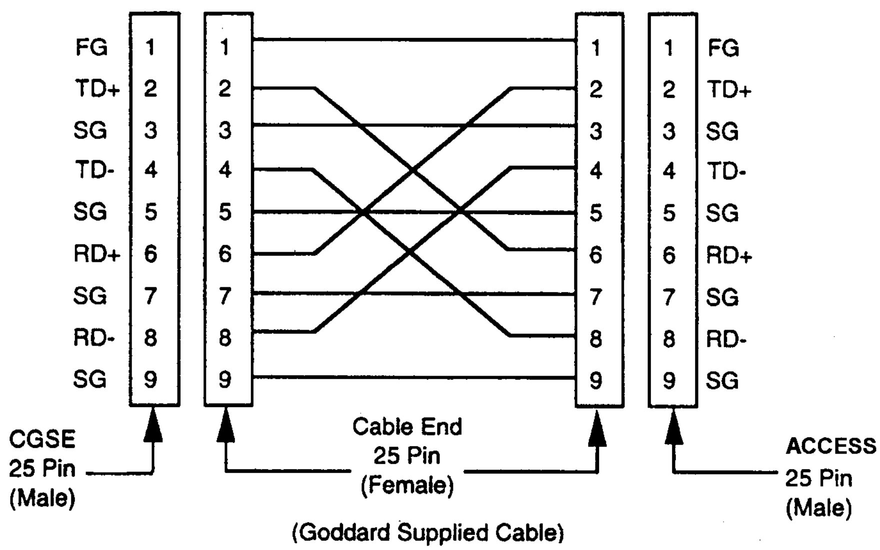


TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

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 Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

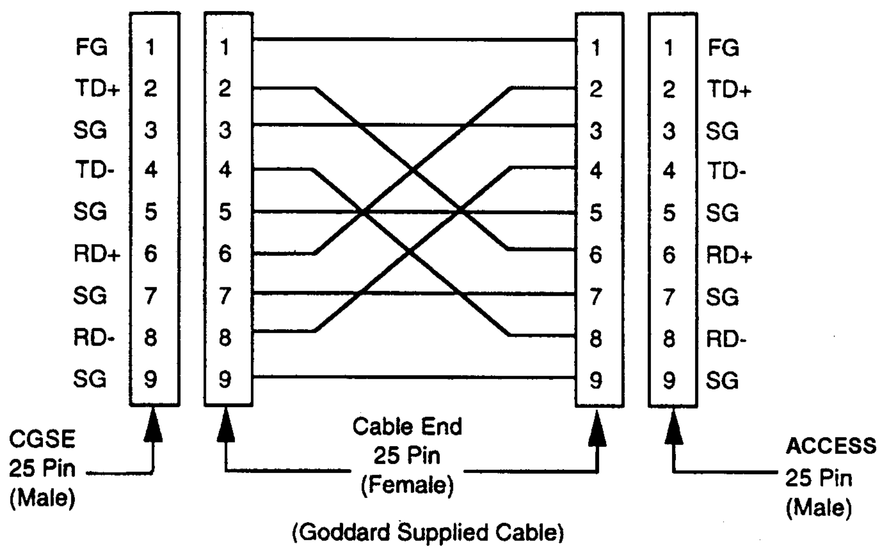
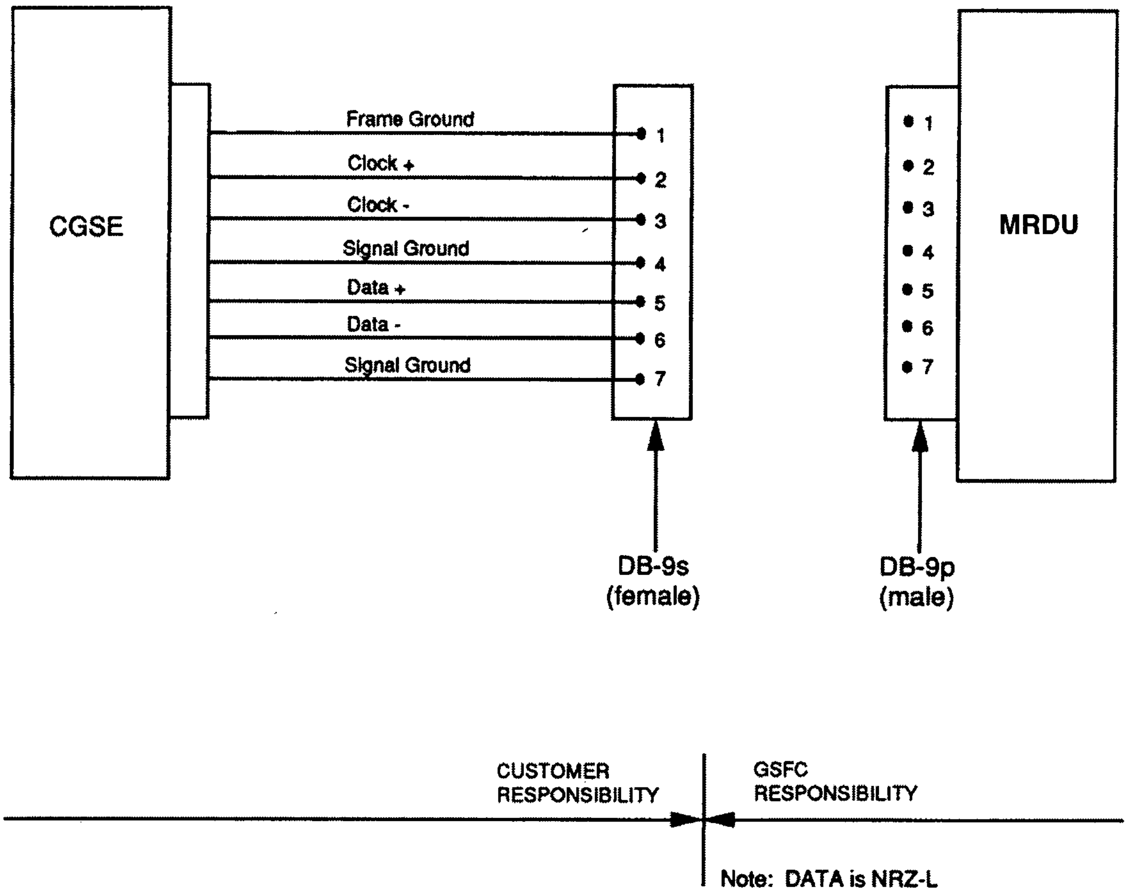


TABLE 2.12 PIN DESIGNATION FOR CUSTOMER RS-422 MEDIUM RATE DATA
Ground Data Interface
(ACCESS to CGSE)



NOTE: Suggested Cable length is 30 feet.

2.4.9.2 ACCESS-CGSE Telemetry Interface

The ACCESS can provide HH avionics telemetry and asynchronous payload telemetry to the CGSE. No data interpretation or conversions are performed by the ACCESS. All data of a given type are transferred in a time-sequential order. The following sub-sections describe the format of the data transferred.

1. Unformatted Customer Payload Asynchronous Downlink Data (Type 2)

The customer will receive the asynchronous payload telemetry in near real-time in a "transparent" manner. The data are bursted to the CGSE over a dedicated 1200-baud asynchronous telemetry/command line (RS-232-C or RS422) without any framing, as they are received by the ACCESS. No attempt is made to synchronize this stream with any other data stream or to maintain the data sampling timing relationship within a stream.

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

The ACCESS 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 ACCESS 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.

The customer will receive the formatted asynchronous payload data in near real time over an ACCESS/CGSE line. The electrical interface is nominally a 19.2 baud RS-232-C data line. The ACCESS will place the payload data into individual messages. No attempt is made to synchronize the data within the messages.

The ACCESS can also send the HH avionics ancillary data, customer energy data, analog data, command acknowledgments, and a subset of the Shuttle orbit and attitude data multiplexed with the formatted asynchronous payload data.

The aggregate data rate of all the multiplexed data (including overhead) must not exceed 75 percent of the data line baud rate. Whenever the data rates are predicted to exceed the 75 percent threshold, another RS-232-C line will be provided. In this case, the assignment of data types transferred over each line will be negotiated with the Project. The user may reconstruct each data stream by grouping data of similar types.

TABLE 2.13 ACCESS 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)	$1 \leq CID \leq 8$
3	5-8	Message type	2
4-5	1-8/1-8	Binary day of MET from Avionics PCM frame containing last payload data byte (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8	Milliseconds of day from Avionics PCM frame containing last payload data byte. Treated as a 32-bit integer (M)	$0 \leq M \leq 86399999$
10	1	Avionics 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 ACCESS formats 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.

TABLE 2.14 ACCESS 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)	$1 \leq CID \leq 8$
3	5-8	Message type	3
4-5	1-8/1-8	Binary day of year from Avionics PCM frame containing last byte of multiplexer data transferred (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day from Avionics PCM frame containing last byte of analog data transferred (M)	$0 \leq M \leq 86399999$
10	1	Avionics 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 2-42	0-255

4. HH Ancillary Data Message (Type 4)

The ACCESS will provide HH avionics ancillary data messages which contain information such as 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-unique HH telemetry format. Currently, the message is transmitted approximately once every 4 seconds assuming a nominal 8kb/sec telemetry rate. 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 2.15 ACCESS 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)	$1 \le CID \le 8$
3	5-8	Message type	4
4-5	1-8/1-8	Binary day of year	$0 \le DD \le 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day	$0 \le M \le 86399999$
10	1	HH minor frame sync loss indicator (1=Loss)	0/1
10	2	MCU sync loss indicator (1=Loss)	0/1
10	3	Avionics 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 ACCESS from the Calibrated Ancillary System (CAS) at the Johnson Space Center (JSC). 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)	$1 \leq CID \leq 8$
3	5-8	Message type	10
4-5	1-8/1-8	Binary day of year computed from Primary Source MET	$0 \leq DD \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day computed from Primary Source MET	$0 \leq M \leq 86399999$
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.	

TABLE 2.16 CONTINUED

47-54	All	Time Tag associated with current state in IBM floating point.
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

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

TABLE 2.16 CONTINUED

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

2.4.9.3 ACCESS-CGSE Command Interfaces

Messages are exchanged between the ACCESS and CGSE for payload commanding and command acknowledgment.

The ACCESS UIU will accept commands from the CGSE over a 1200 baud RS-232-C or RS-422 interface. These commands will be screened by the ACCESS for criticality, then transferred to the ACCESS CIU via the LAN. Once a customer's command is received at the CIU, it is placed in a command block, encoded in the proper format (NASCOM or I&T) and placed into an uplink command buffer, then transmitted. The CIU will verify that the command block was accepted by the HH avionics. A new command block will not be transmitted until a previously transmitted command block is verified by the HH avionics in telemetry. Commands that are not verified within a timely manner (nominally 5 seconds for I&T, and 15 seconds during mission operations) by the HH avionics will be retransmitted by the ACCESS operators. The command will not be released from the ACCESS buffer until a verification has been received from the avionics. ACCESS, however, does not monitor the telemetry to determine if the customer payload responded to the commands.

Customer CGSE's are connected to the ACCESS via the Serial Port Interfaces referenced in Figure 2.63. This 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 ACCESS 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 ACCESS is:

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

2. The ACCESS UIU uses message queues for transferring user commands to the ACCESS CIU via the LAN. It takes the UIU 400 milliseconds to encode the user input command for transfer it to the CIU. It will take twice as long, on average, to process two user input buffers. If a user does not enforce a delay of DT milliseconds between long command strings, an overflow can occur causing customer commands to be lost.

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

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

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

2.4.9.4 ACCESS Command Acknowledgment (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. These messages are transmitted from the ACCESS to the CGSE on the 19.2k baud link. The time in these two messages is the ACCESS computer GMT time when the message was generated.

1. Command Completion Status (Type 5)

After transmission by the ACCESS, the ACCESS issues an optional command acknowledgment message to the CGSE 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. The format of this message is shown in Table 2.17.

TABLE 2.17 ACCESS 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)	$1 \leq CID \leq 8$
3	5-8	Message type	5
4-5	1-8/1-8	Binary day of year	$1 \leq DD \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day	$0 \leq M \leq 86399999$
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 ACCESS computer GMT time.

2. Data Link Status (Type 6)

The ACCESS will originate messages if errors are detected in the command data link between the ACCESS and the CGSE. The messages indicate the error and the number of commands rejected by the ACCESS because of the error. The format of this message is shown in Table 2.18.

TABLE 2.18 ACCESS 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)	$1 \leq CID \leq 8$
3	5-8	Message Type	6
4-5	1-8/1-8	Binary day of year	$1 \leq DD \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day (M)	$0 \leq M \leq 8639999$
10	1-8	Spare	0
11	1-8	Number of command bytes accepted or rejected	$1 \leq M \leq 120$
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-ACCESS	
	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 ACCESS computer GMT time.

2.4.10 Crew Control

The Crew Control 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.

Crew Control of the carrier power system (see Figure 2.34) 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 2.68). 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 2.69. The SSP cargo switching and fusing interface schematic is shown in Figure 2.70 (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:

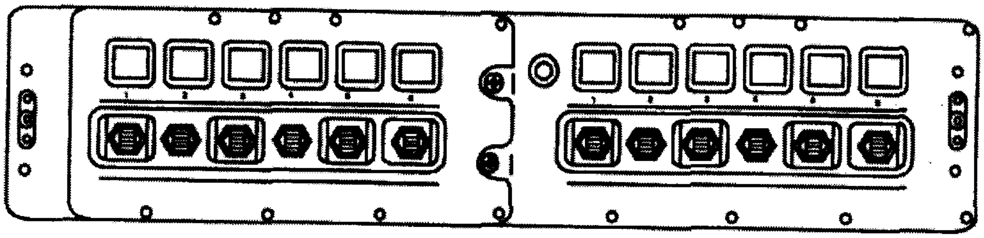
1. Crew Control (Switch Panel)

2. Undedicated wires in a second standard interface port assigned to the same customer.

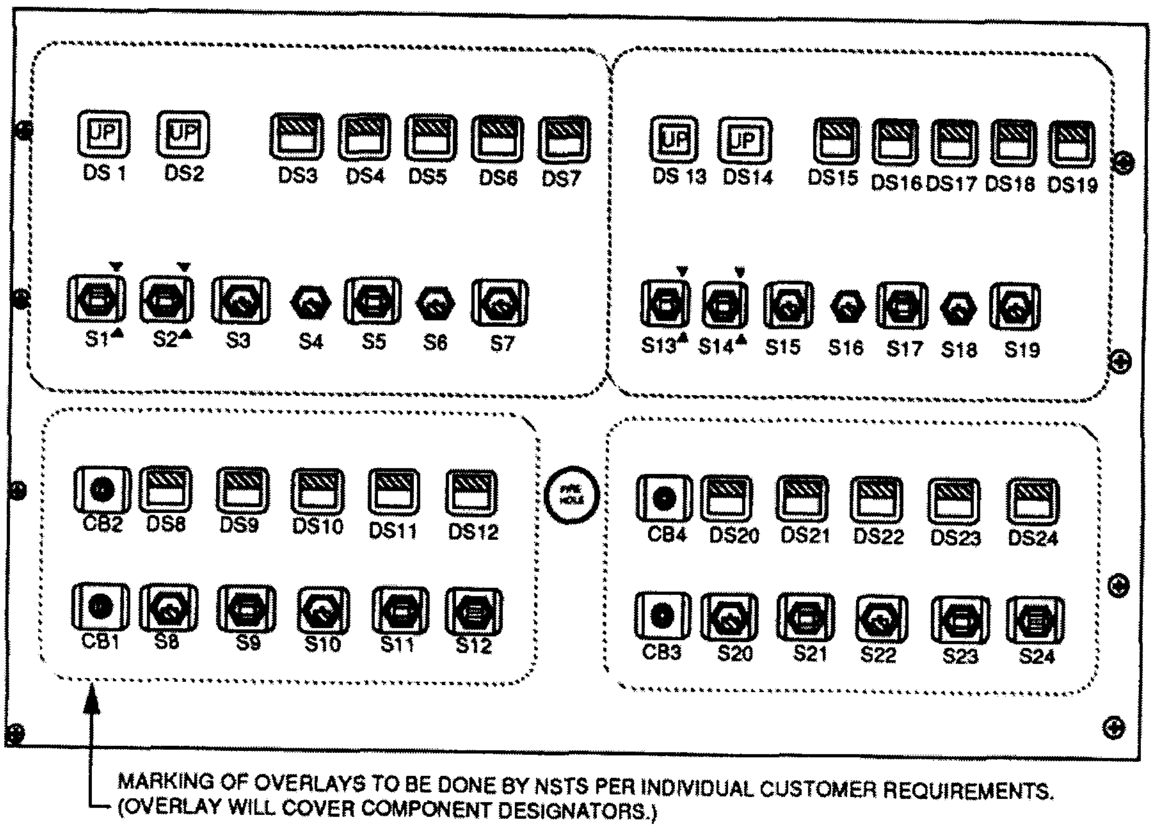
3. Other function as negotiated.

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.

Switch Panels



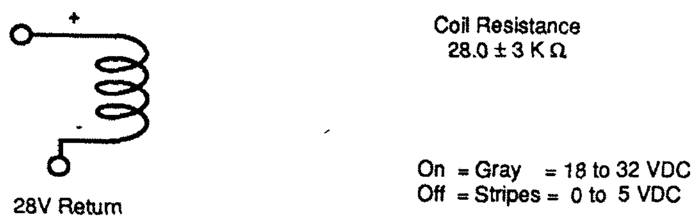
SMALL PAYLOAD ACCOMMODATION SWITCH PANEL (SPASP)
S1, S2, DS1, DS2- RESERVED FOR CARRIER USE



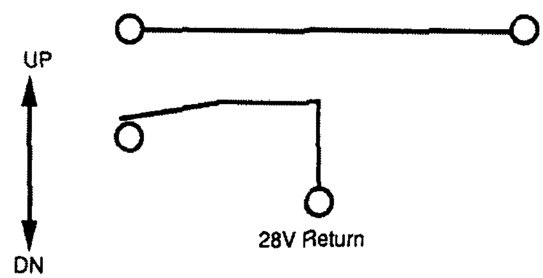
STANDARD SWITCH PANEL (SSP)
S1, S2, DS1, DS2 OR S13, S14, DS13, DS14 RESERVED FOR CARRIER USE

FIGURE 2.65 SWITCH PANELS

SPASP or SSP Switch and Indicator Characteristics



SPASP or SSP Mechanical Indicator



SPASP Switch (TYP 6 Places)

Resistance: 5 Ω MAX
Maximum Current: 1 AMP (dc only)
Minimum Current required to drive indicator:30 ma
Maximum Voltage: 32 VDC
Total available for customers: 4 (SPA), 10 (SMC)

FIGURE 2.66 SPASP OR SSP SWITCH AND INDICATOR CHARACTERISTICS

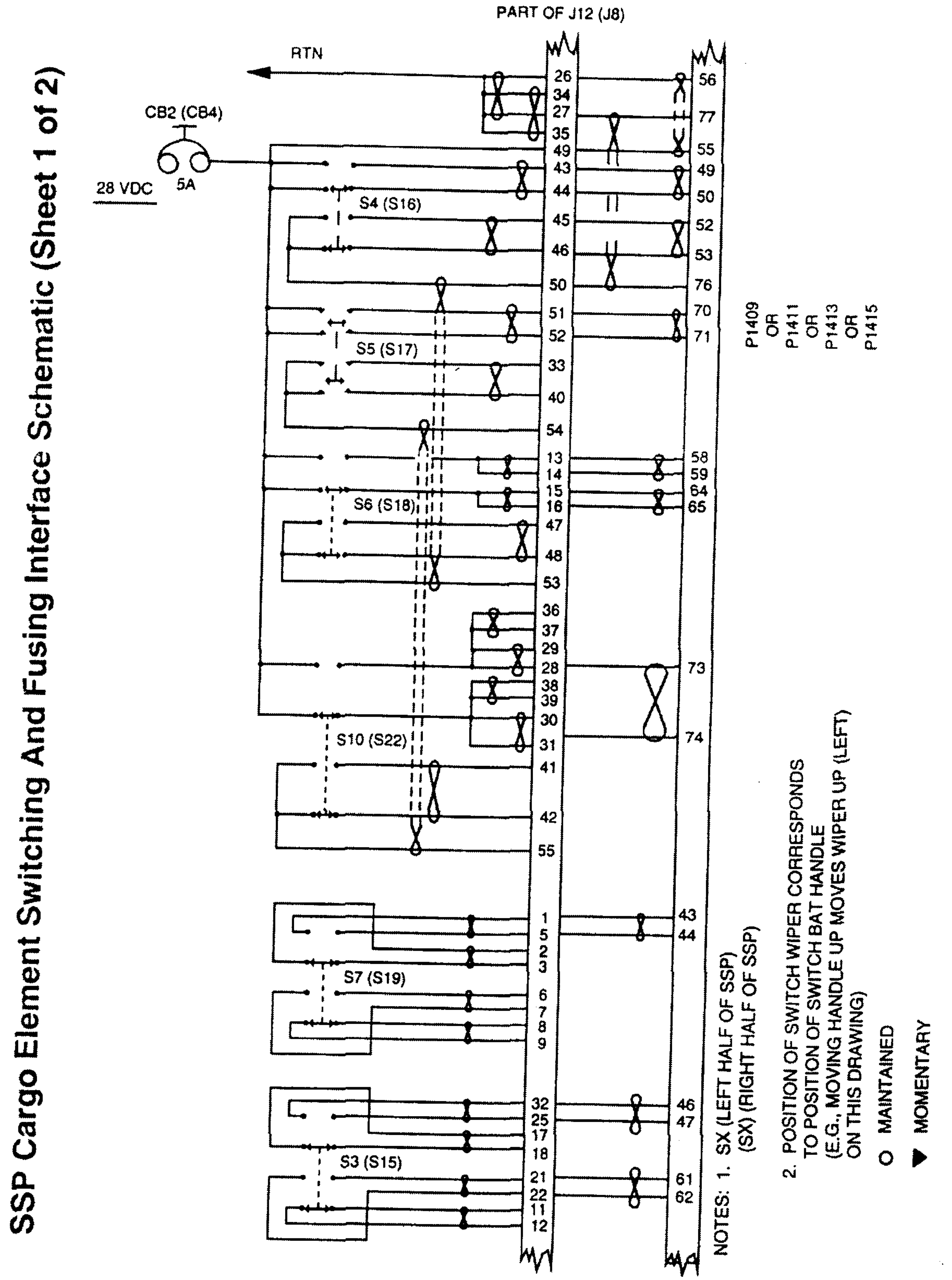


FIGURE 2.67 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (1OF 2)

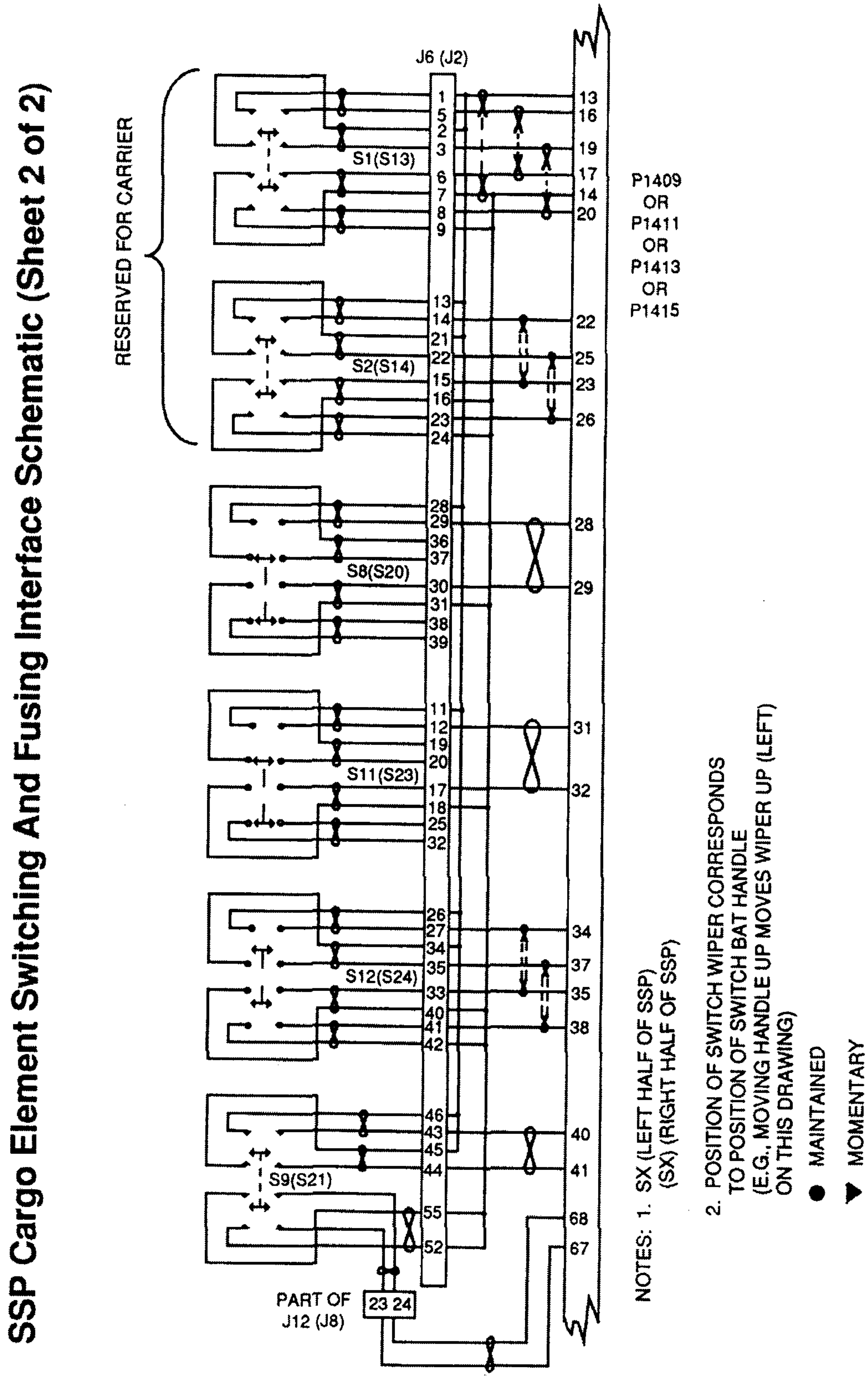


FIGURE 2.68 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (2 OF 2)

2.4.12 Orbiter CCTV Interface

A special interface can be provided 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 RS-170/RS-330) 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.

2.4.13 Hitchhiker Video Interface Unit

The Hitchhiker Video Interface Unit (HVIU) is Hitchhiker-provided. Video can be accommodated from eight separate customer signal ports, one at a time. Switching of HVIU channels is commanded via ACCESS. The HVIU produces a differential signal output to the orbiter CCTV interface.

Customer video input to the HVIU shall be an unbalanced, 75-ohm interface and shall conform to RS-170 and RS-330 specifications. Shield shall be tied to frame ground at the customer side; the video signal lines shall be isolated from frame ground by at least 1 Mohm. Therefore, use of commercially available devices which tie signal ground to chassis should be avoided.

During the mission, availability of real-time video telemetry depends on orbiter support of payload CCTV and cannot be guaranteed. However, payload video can be recorded via the orbiter recorders and replayed at a later time during the mission or provided post-mission. Therefore, customers whose video is critical to their experiment are advised to consider incorporating recording capability in their hardware design.

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 2.72 - 2.74) 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 a control 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.

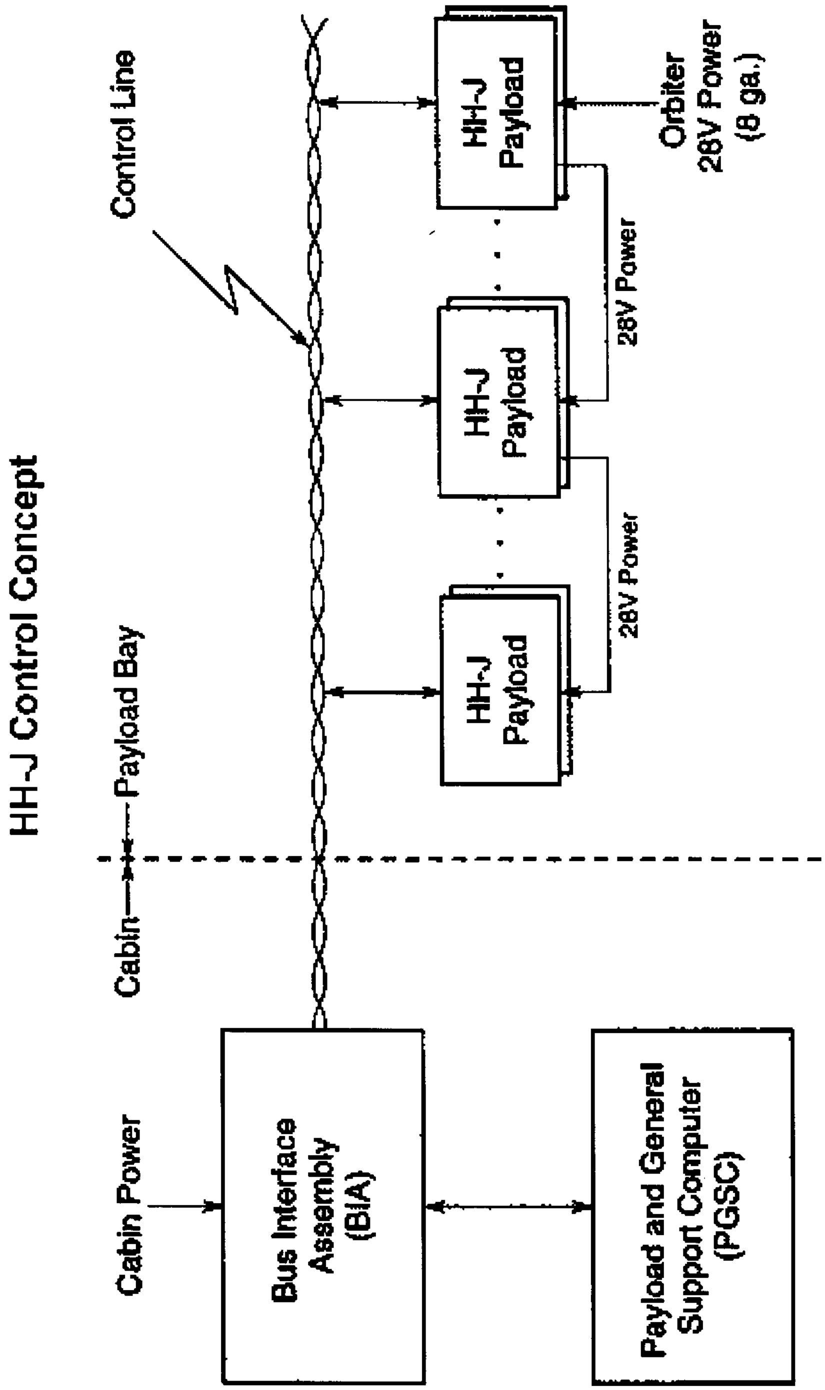


FIGURE 2.69 HH-J CONTROL CONCEPT

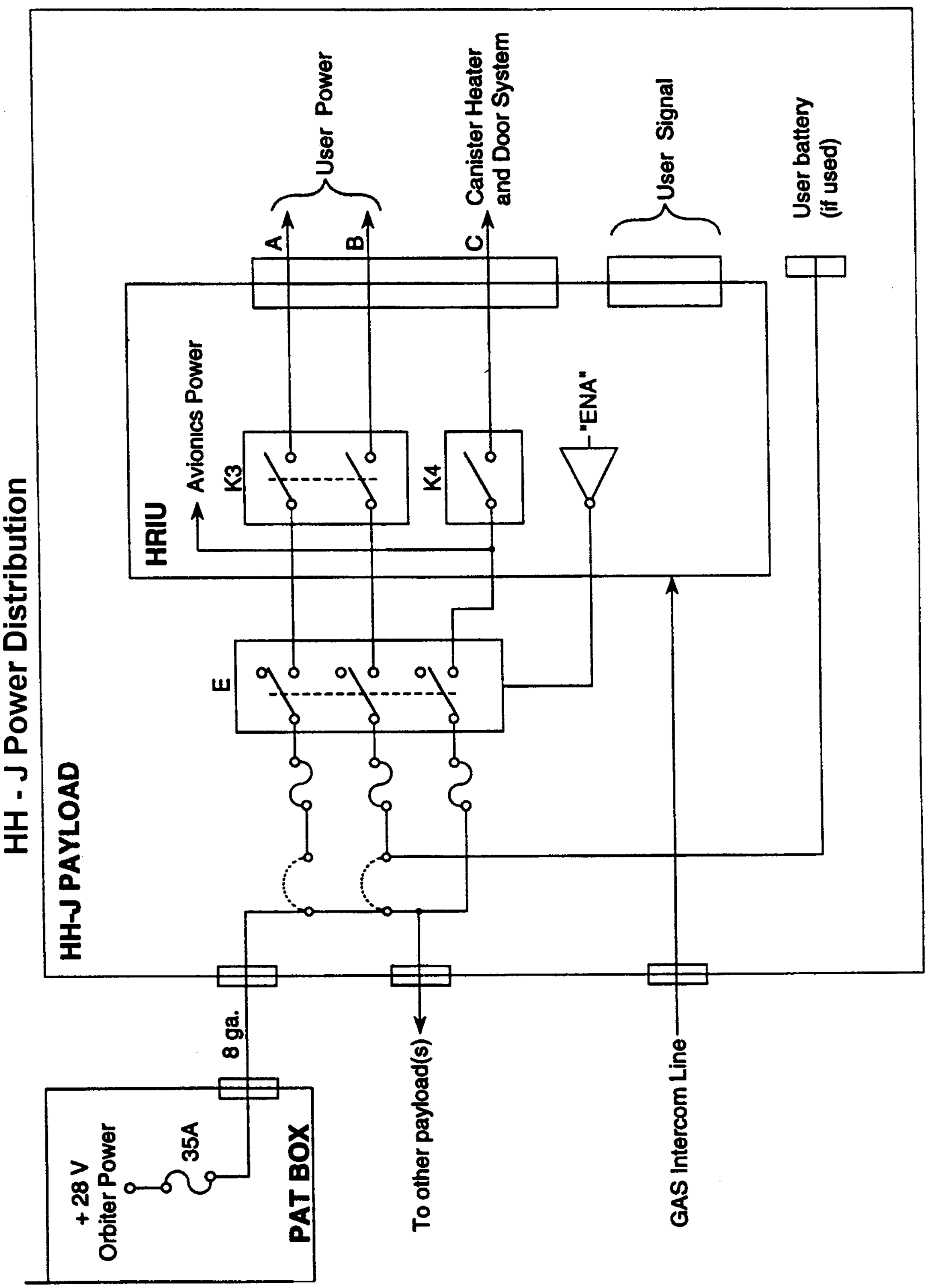


FIGURE 2.70 HH-J POWER DISTRIBUTION

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 2.70. 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

Bi-level commands may be set to OV (false), or to +28V (true), or pulsed from false to true and back to false. (It is preferred to have the bi-level transverse from false to true, default state is OV for HRIU) All commanding of bi-level functions is performed by the mission specific Flight Software (FSW), which is developed at GSFC, and executed on the Payload & General Support Computer (PGSC). Four bi-levels are available to each customer. Only one bi-level signal may be commanded by the FSW at a time. A minimum of 100msec is required between each bi-level command. Figure 2.71 illustrates the HH-J bi-level command electrical interface.

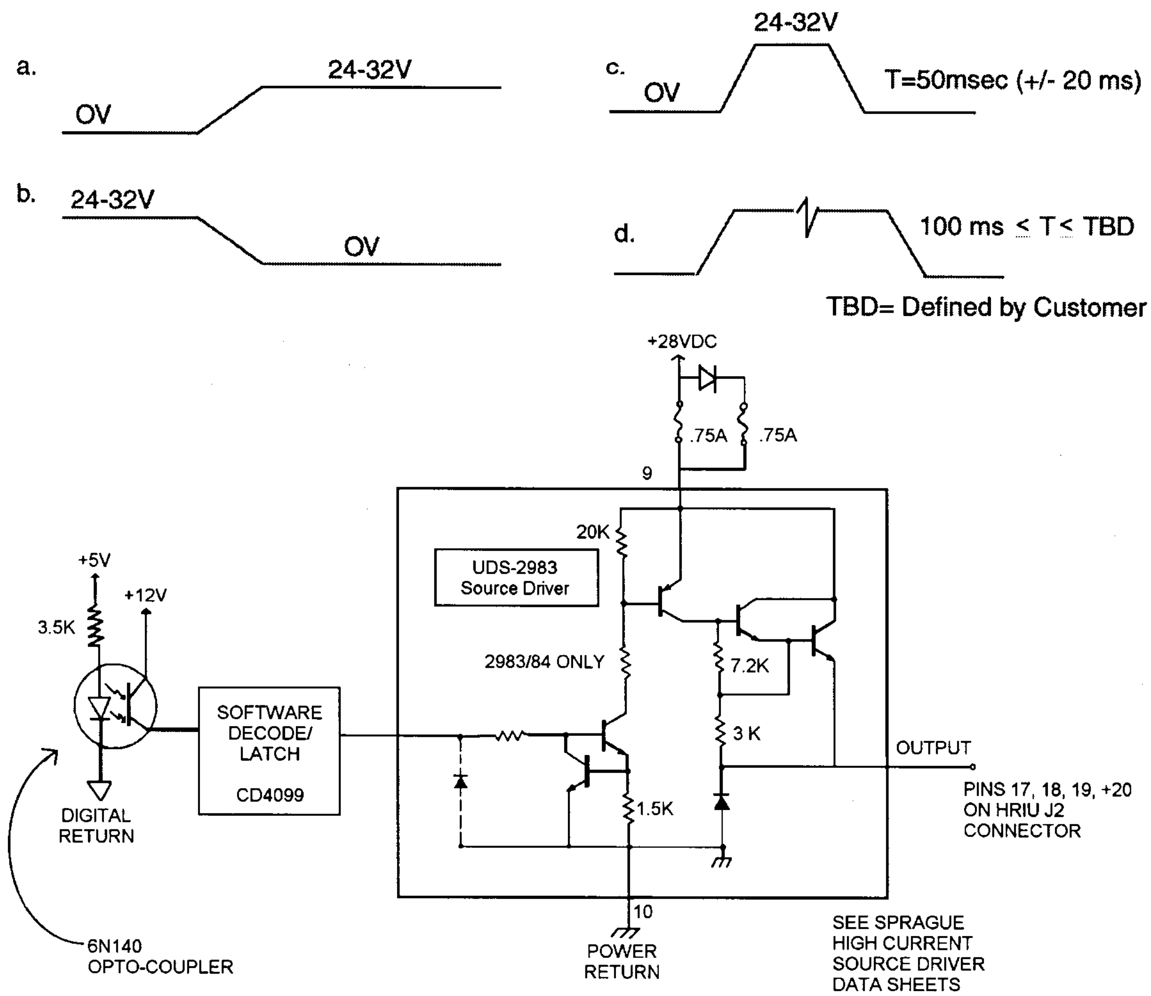


FIGURE 2.71 HH-J BI-LEVEL COMMAND ELECTRICAL INTERFACE

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 equivalent circuit for the malfunction input in the carrier is the same as for the thermistor input shown in Figure 2.69.

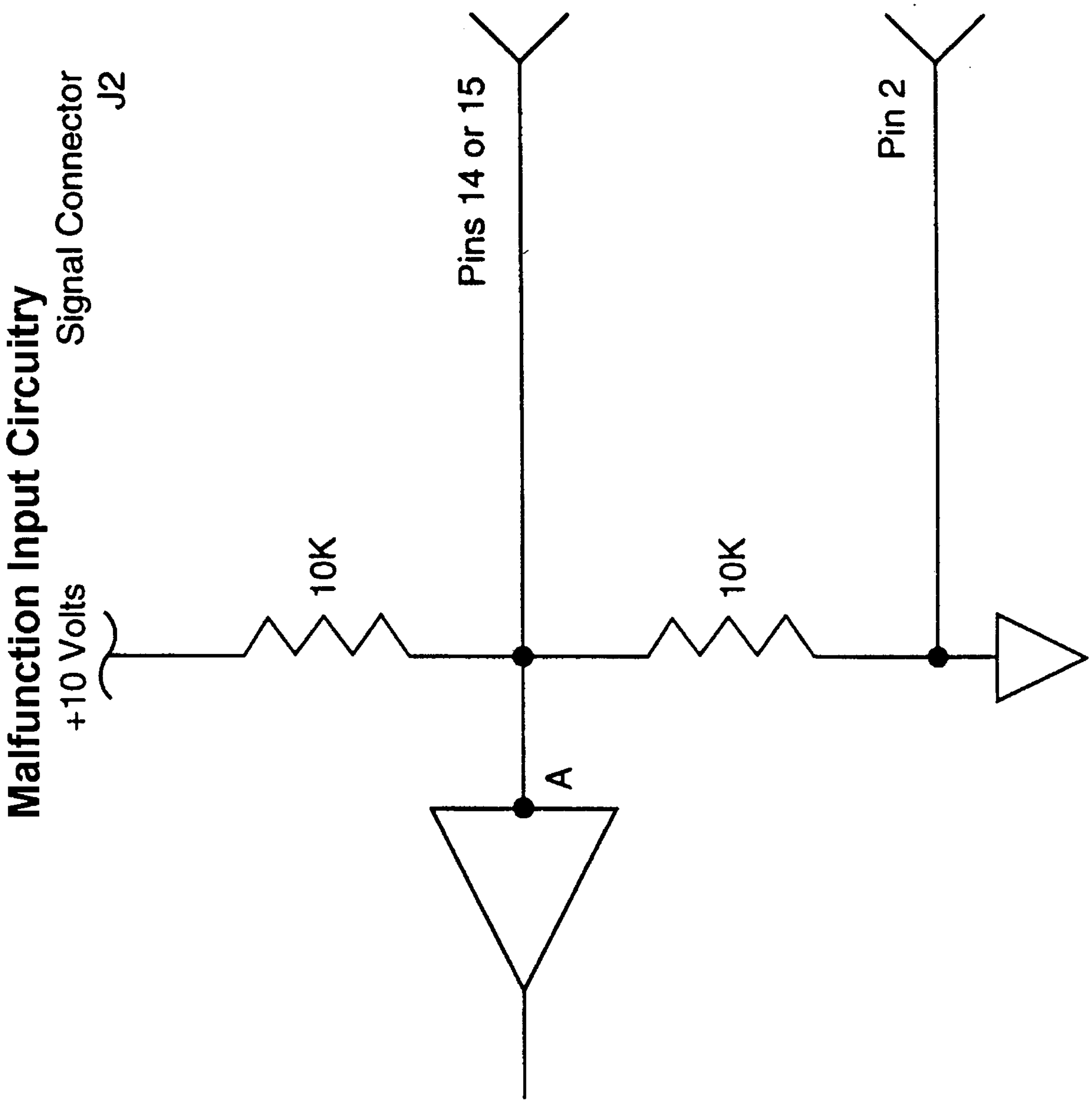


FIGURE 2.72 MALFUNCTION INPUT CIRCUITRY

TABLE 2.20 HITCHHIKER-JR ELECTRICAL INTERFACE CONNECTIONS

Power Connector P13 (Orbiter Power)

Customer Connector Type: CVA6R20-15PN-16

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: KJG6E18-35PN-16

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	Bi-level/Pulse Command 1
BLCMD2	18	A	Bi-level/Pulse Command 2
BLCMD3	19	A	Bi-level/Pulse Command 3
BLCMD4	20	A	Bi-level/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	56	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
	M	A	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 Hitchhiker Ejection Capabilities Specification

The Hitchhiker carrier system provides several options for launching a small spacecraft from the Shuttle payload bay. Figure 2.75 shows a typical payload configuration. Each option requires the same maximum payload weight and CG offset and same user-supplied 9.37 inch interface plate, which attaches to the carrier with a clamp mechanism. Figure 2.76 describes this interface plate with some reference dimensions. Detailed requirements for this plate are contained in the most current revision of GD 1507205, Ejection System User Interface Control Drawing. None of the launch configurations provides any electrical power or signal connection to the spacecraft, but each provides a different satellite envelope and payload environment. The five different payload configurations listed below are shown in Figures 2.77 to 2.81.

PAYLOAD CONFIGURATIONS

Hitchhiker Ejection System (HES): always mounted in a canister.
1. with an opening door
2. with no door (open-top canister)

Pallet Ejection System (PES): canister-mounted configuration.
3. with an opening door
4. with no door (open-top canister)

Pallet Ejection System (PES): pallet-mounted configuration.
5. on top of cross-bay structure

Payload and ejection system are mounted either in a canister or on a pallet prior to orbiter installation and launch. The user must provide means for lifting the spacecraft during installation on to the ejection system. For a canister-mounted satellite, only the top of the payload will be accessible for servicing after it is installed into the canister.

Once in orbit with the Shuttle in the requested attitude, the clamp is released by the crew and the payload is ejected. The system does not provide for controlled rotation (spin) of the payload prior to ejection, but a worst case ejection torque applied about the ejection vector will be calculated for every mission. This torque is dependent on several factors. Orbital lifetime of ejected objects in typical Shuttle orbits is usually less than one year.

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

The ejection system and door mechanism are zero fault tolerant against a failure that 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 with hazardous functions that occur after ejection (such as deploying appendages) must provide adequate safety inhibits to prevent premature activation. Payloads with such functions are strongly advised to set up a Technical Interchange Meeting (TIM) with the SSPP system safety organization.

Users must select an ejection attitude and velocity that preclude any possibility of collision with the Shuttle during the portion of the mission following satellite deployment. JSC will perform a re-contact analysis to insure that no re-contact occurs.

Table 2.23 lists some characteristics and requirements of HH launcher systems. Deviations from these or other ejection system requirements are negotiable on a case-by-case basis. For example, a larger CG offset may be acceptable for a physically smaller satellite.

TABLE 2.21 CHARACTERISTICS OF HITCHHIKER LAUNCHER SYSTEMS

Maximum spacecraft weight	150 lb (68 kg)
Maximum spacecraft CG offset from separation plane	10.25 in (26 cm)
Maximum spacecraft CG offset from launcher centerline	0.25 in (0.64 cm)
Ejection velocity range	1 to 4 ft/sec (0.3 to 1.2 m/sec)

EJECTION SYSTEM OVERVIEW

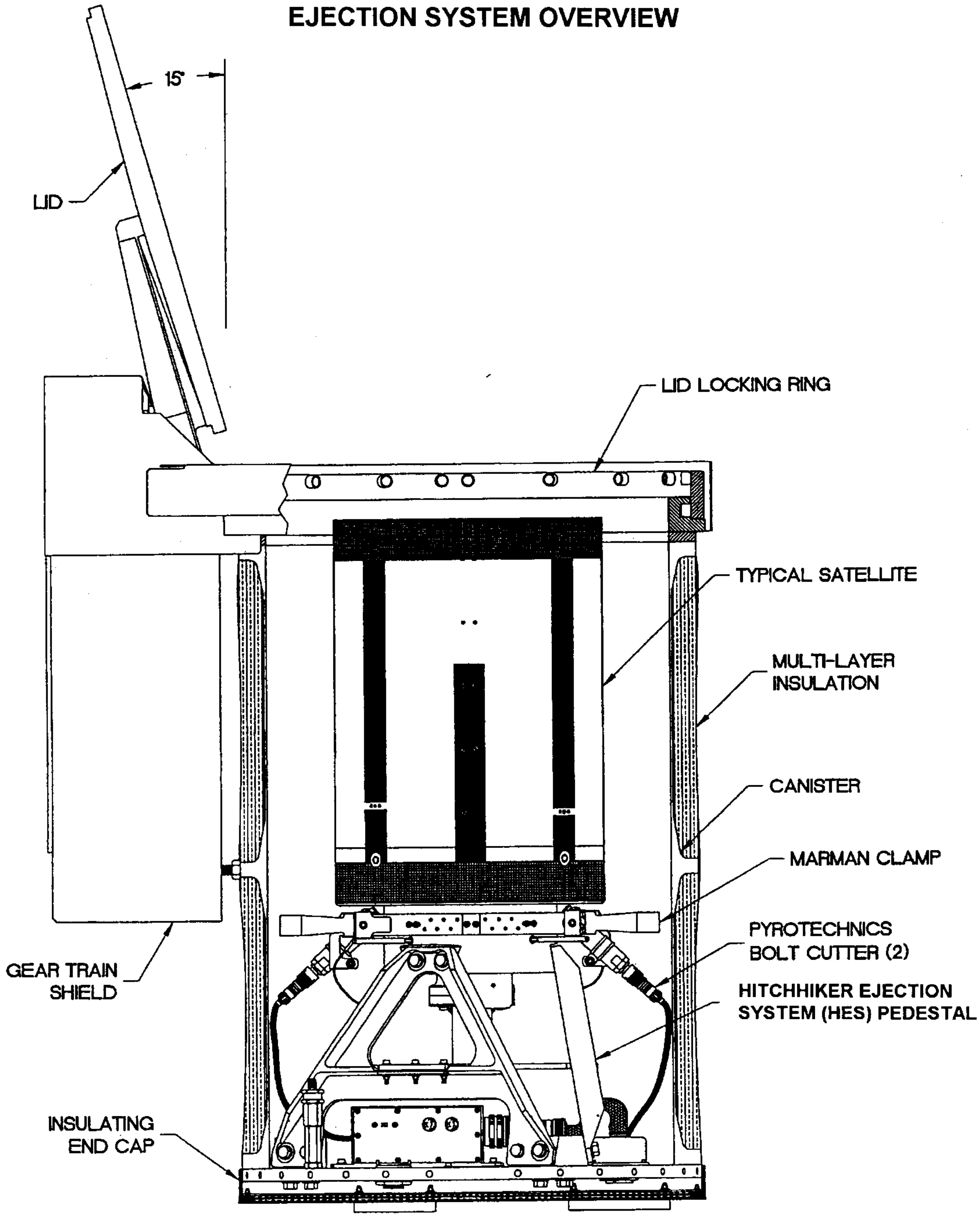


FIGURE 2.73 EJECTION SYSTEM OVERVIEW

PAYLOAD INTERFACE PLATE

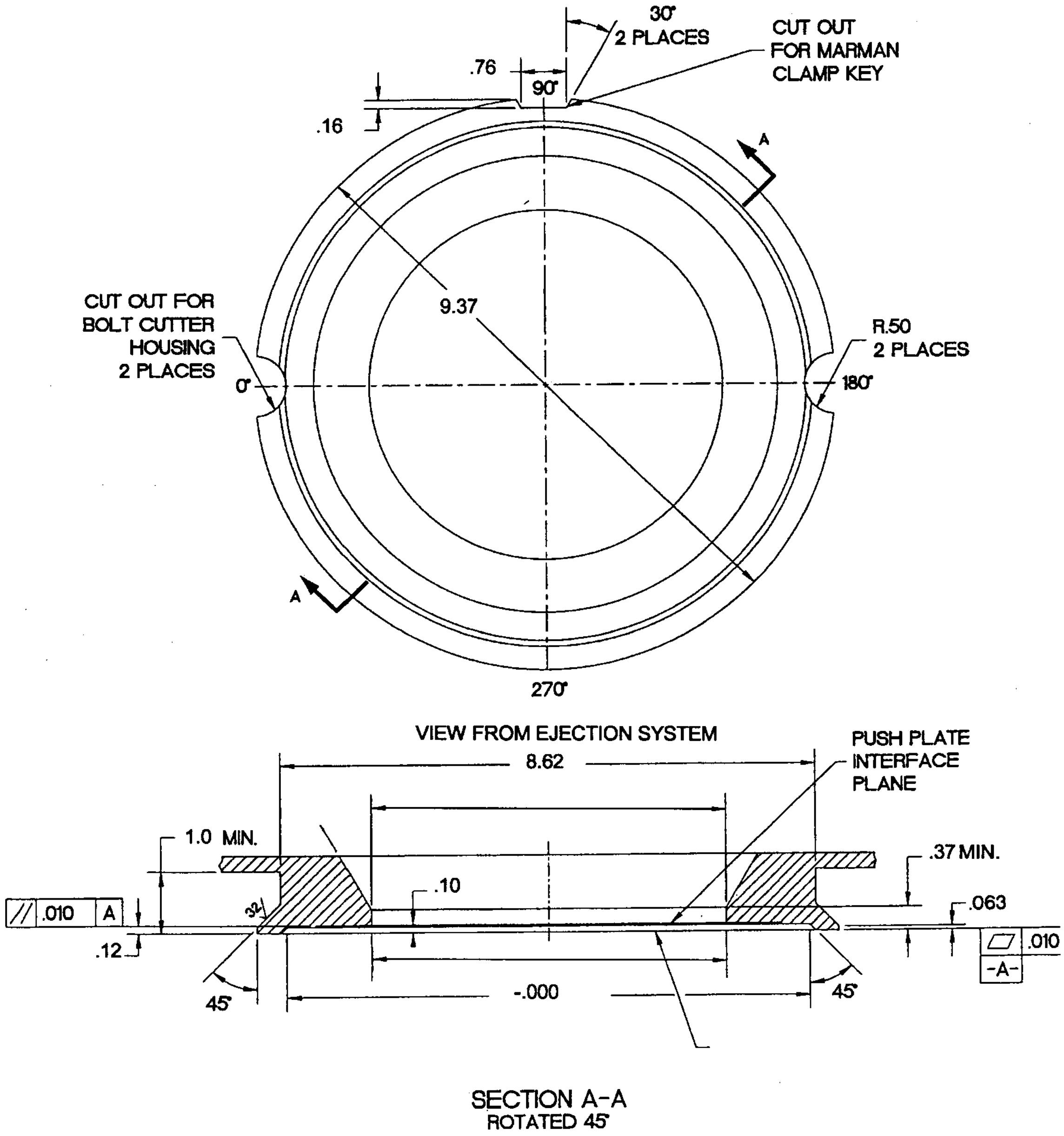


FIGURE 2.74 PAYLOAD INTERFACE PLATE

HITCHHIKER EJECTION SYSTEM WITH DOOR

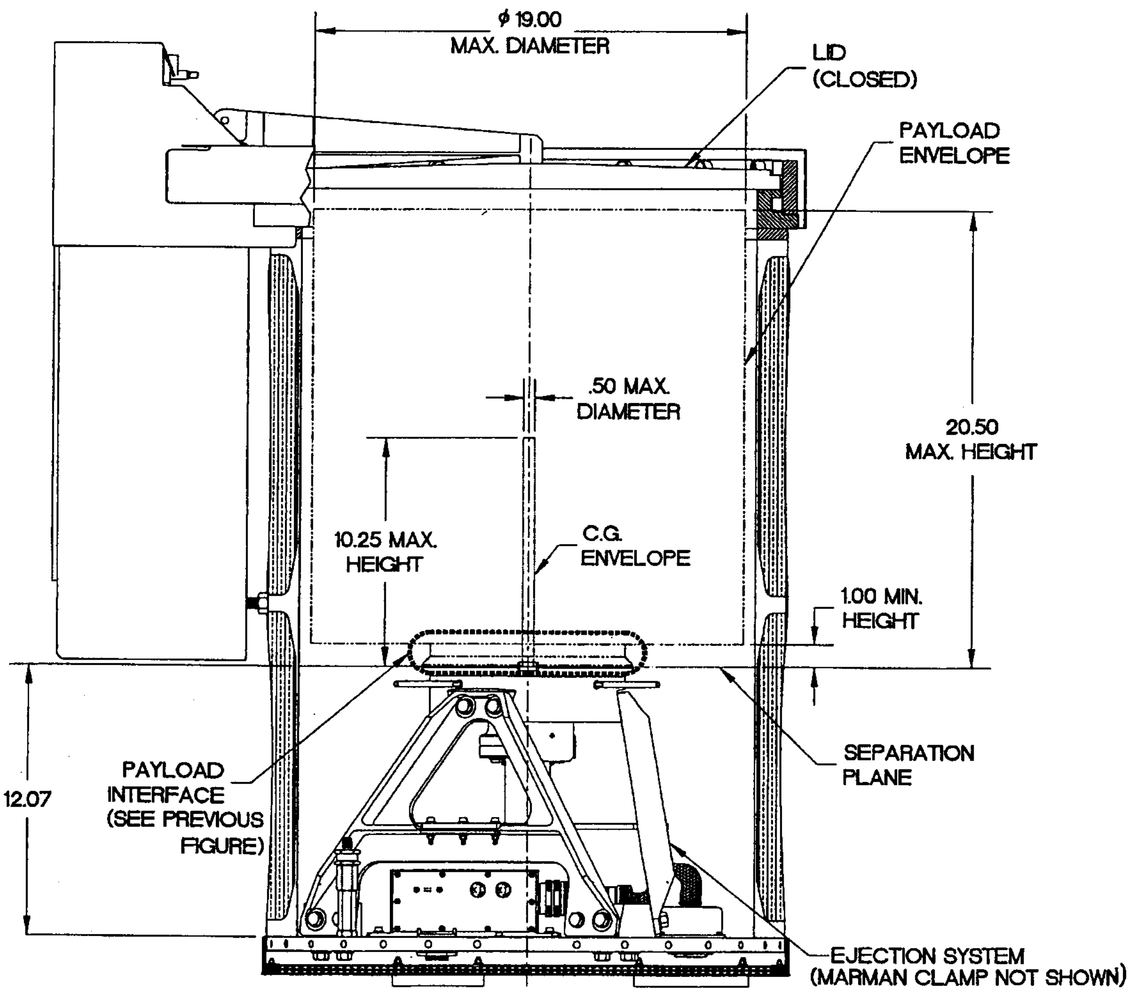


FIGURE 2.75 HITCHHIKER EJECTION SYSTEM WITH DOOR

HITCHHIKER CARRIER EJECTION SYSTEM WITH OPEN CANISTER

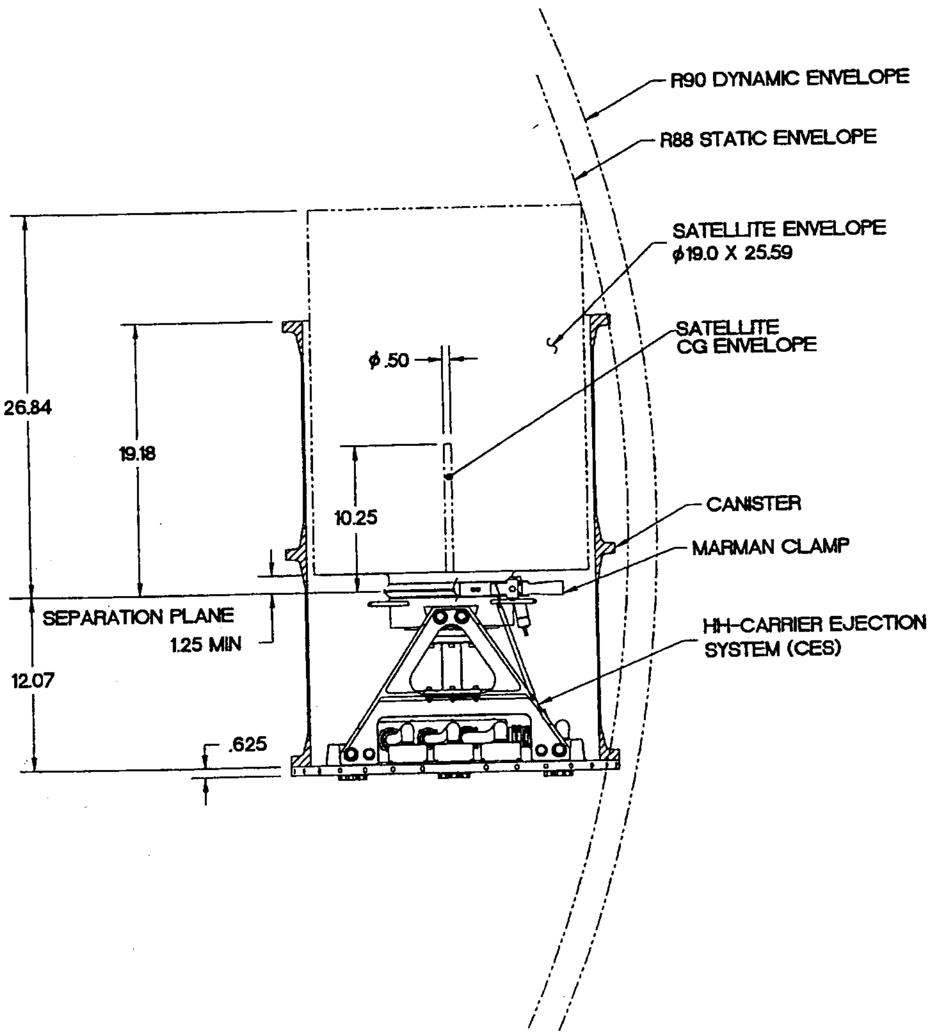


FIGURE 2.76 HITCHHIKER CARRIER EJECTION SYSTEM WITH OPEN CANISTER

PALLET EJECTION SYSTEM WITH DOOR

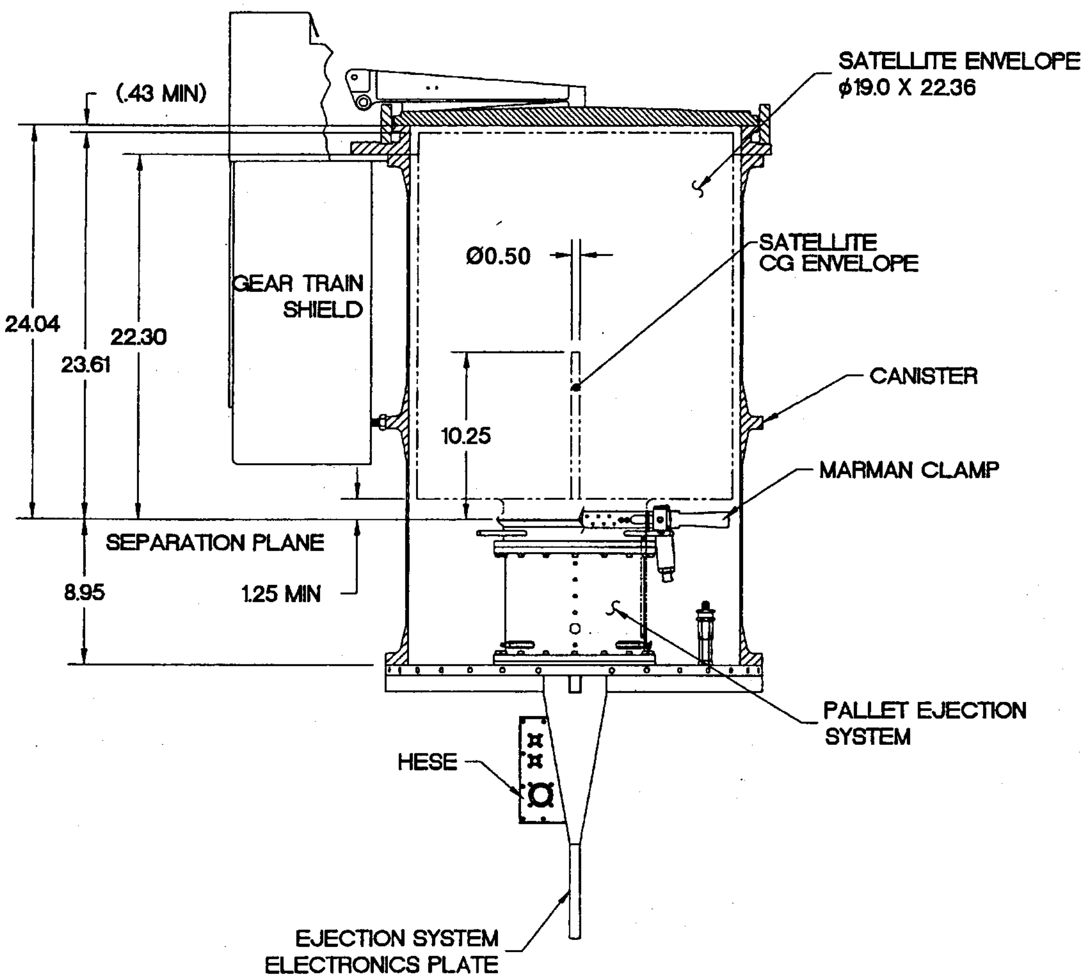


FIGURE 2.77 PALLET EJECTION SYSTEM WITH DOOR

PALLET EJECTION SYSTEM WITH OPEN CANISTER

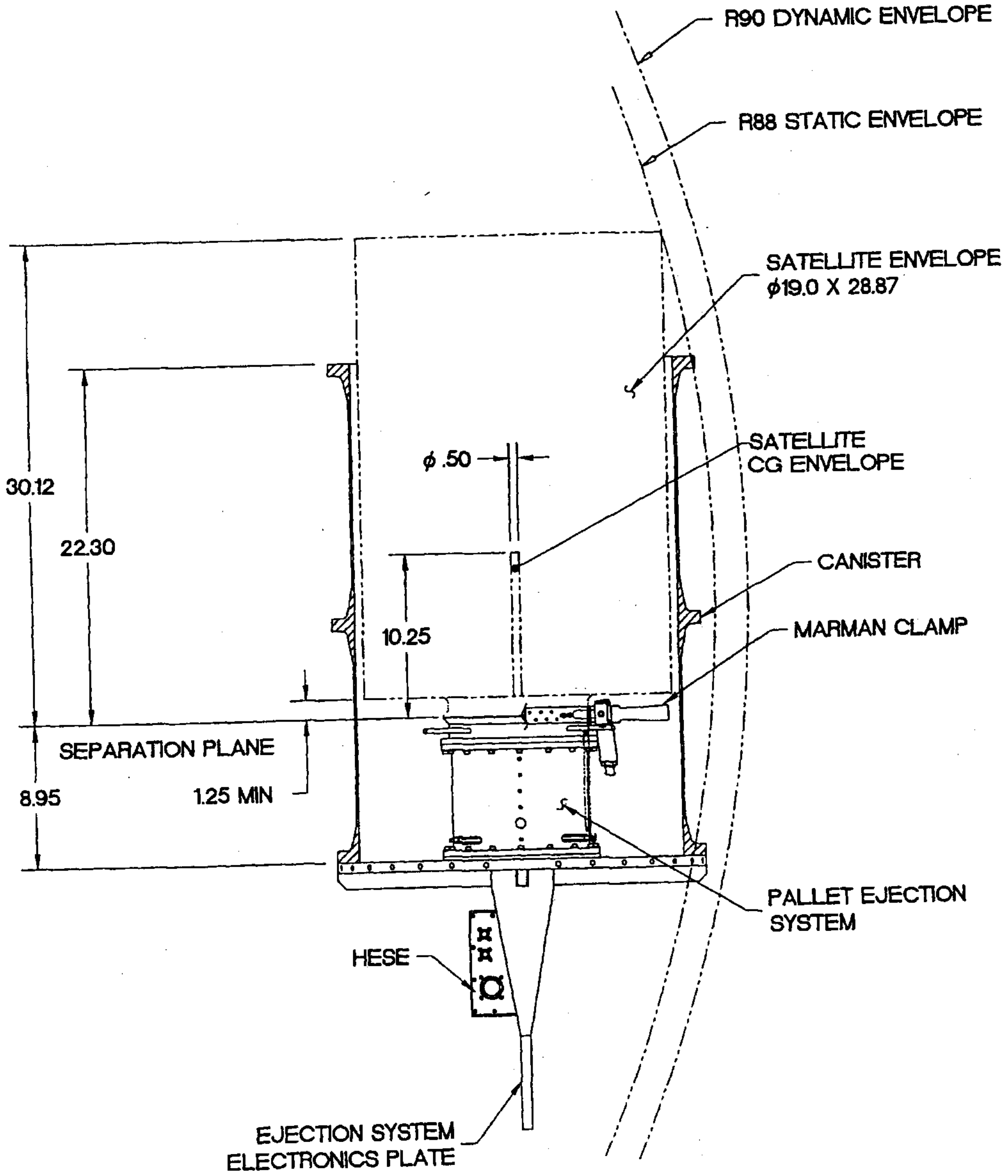


FIGURE 2.78 PALLET EJECTION SYSTEM WITH OPEN CANISTER

PALLET EJECTION SYSTEM ON SINGLE BAY PALLET

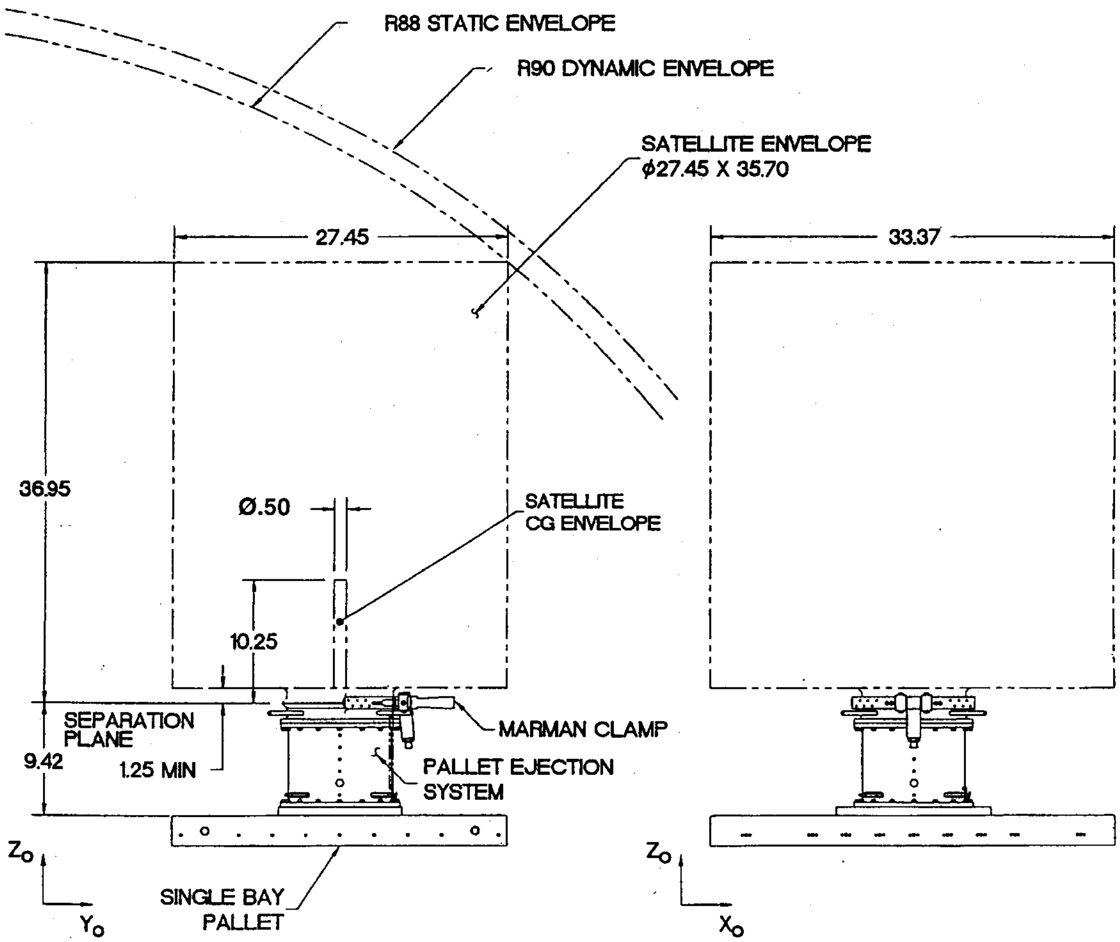


FIGURE 2.79 PALLET EJECTION SYSTEM ON SINGLE BAY PALLET

APPENDIX A

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APPENDIX A
PAYLOAD SAFETY REQUIREMENTS

A1. OVERVIEW

All payloads using the STS must meet certain design and operational requirements prior to being considered "safe". Payloads and GSE must not be capable of generating or sustaining any failure mode that will result in a hazard to the flight and ground personnel, the STS, GSE, and other payloads. A hazard is defined as the presence of a potential risk situation caused by an unsafe act or condition that could disable or cause damage to the Orbiter, its crew, ground processing facilities or personnel during pre- and post- launch activities. Basic requirements for payload safe design and operation are provided for in the following NASA documents:

NSTS 1700.7 (current issue*) - Safety Policy Requirements for Payloads Using the Space Transportation System (STS), January 1989.

SAMTO HB S-100, KHB 1700.7 (current issue*) - Space Transportation System Payload Ground Safety Handbook.

All payloads must comply with the guidelines and requirements set in these documents.

This section summarizes information from NSTS 1700.7 latest version to aide the customer in understanding the requirements and guidelines that must be followed in order to obtain safety certification for their payload. This section is not a substitute for NSTS 1700.7 latest version which takes precedence and must be adhered to by the customer for their payload. KHB 1700.7 latest version is the governing document for the GSE and ground operations.

* Current issue includes all future changes and revisions.

A2. RESPONSIBILITIES

A customer representative should be designated as the technical point of contact between the HH Project and the customer. This representative is called the Payload Manager. The Payload Manager is responsible for assuring the safety of his payload and to implement the requirements of NSTS 1700.7 and KHB 1700.7. Each customer payload shall have a system safety support person to advise the payload manager and designers, and to act as a point of contact for safety matters. The HH Project, acting as the responsible "payload organization," interfaces with the NSTS on behalf of the group of individual payload elements or experiments and carrier systems which comprise a Shuttle payload. GSFC will assign a Mission Manager who will be the single technical point of contact for GSFC and interface with the payload Manager. The HH Project Safety Manager will support the NASA Mission Manager in the safety review process. Payload shall have a system safety support person as a member of the payload team to advise. All payload safety data will be reviewed and approved by GSFC prior to submittal to JSC/KSC.

A3. SAFETY REVIEW PROCESS

The safety review process between the customer, GSFC, and the STS begins 18-24 months prior to launch with the development of safety-related information as part of the Payload Accommodations Conference. The review process culminates just prior to launch with the Final Safety Inspection. Aspects of safety-related issues extend into flight operations as well. Figure A.1 represents an overview of the safety review process.

The system safety requirements associated with use of the Shuttle are extensive, and are intended to insure the safety of ground processing and flight personnel, as well as the Shuttle Orbiter and flight hardware. The phased safety reviews and safety data packages, through which the project demonstrates compliance with these requirements, are major mission milestones.

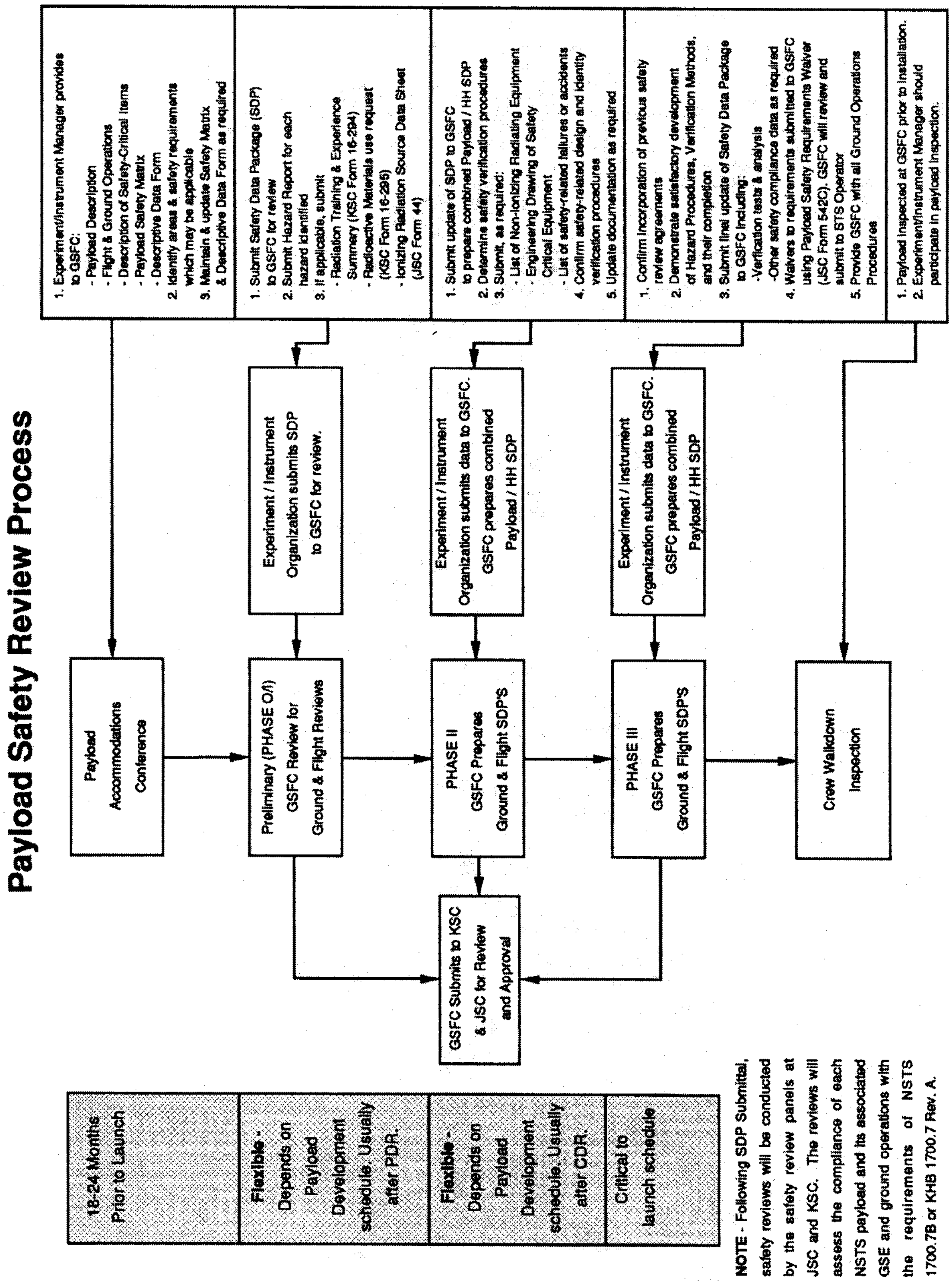

FIGURE A.1 PAYLOAD SAFETY REVIEW PROCESS

A4. PAYLOAD HAZARD ANALYSIS

A hazard analysis is the technique used to systematically identify, evaluate and resolve hazards. Typically, such analyses assess the entire system and its interfaces. Results of the hazard analysis leads to one or more of the following:

- Improved payload safety design,

- Development of controls to mitigate hazards,

- Establishment of acceptable risk levels.

There may be many factors contributing to a hazard, however, there are basic hazard groups that are applicable to HH payloads. Those hazard groups and representative examples of their causes and effects are summarized in Table A.1. Figure A.2 provides an overview of the hazard analysis process.

TABLE A.1 BASIC HAZARD GROUPS, CAUSES, AND EFFECTS

Hazard Type	Definition	Possible Cause	Possible Effect
Collision	Payloads and/or Elements Break Loose and Impact Structures, Other Payloads, or Ground Personnel	Structural Failure Procedural Error, Inadequate Ground Handling Equipment	Penetration of Payload, Personnel Injury
Contamination	Release or Accumulation of Particular Matter or The Placement of the Wrong Material in a Container	Leakage, Spillage, Outgassing, Abrasion, Improper Cleanliness Procedures, Inappropriate Materials Usage	Degraded Atmosphere or Equipment Operation, Personnel Injury
Corrosion	Structural Degradation of Metallic and Non-Metallic Equipment	Leakage, Material Incompatibility, Environmental Extremes, Short Circuits	Mechanical Failures, Premature Wear, Seizure
Electrical shock	Electrical current passing through any portion of the body	Human error, procedural error, equipment failure, static discharge, short circuit	Personnel Injury
Explosion	Violent Release of Energy Due to Over-pressurization	Susceptible Equipment, Batteries, Pumps, Motors, Blowers, Generators, Lasers, Etc.	Payload Damage, Personnel Injury
Fire	Rapid Oxidation of Payload Element Combustibles Flammability of Materials	Fuel and Oxidizer Exposed to Ignition Source	Payload Damage, Personnel Injury
Radiation	Exposure (Human or Equipment) To: Ionizing Radiation, UV or IR Light, Lasers, Electromagnetic or RF-Generating Equipment	Leaky or Inadequate Shielding	Degraded or Damaged Payload or Equipment Personnel Injury
Temperature extremes	Exposure to abnormal temperature extremes (hot or cold)	Insulation breakdown, short circuits, seal leaks plumbing failures procedural error, human error	Degraded or damaged payload or equipment, personnel injury
Injury and Illness	Payloads Break Loose and Impact Ground Personnel and Release of Toxic Materials	Procedural Error, Inadequate Ground Handling Equipment Leakage or Spillage of Toxic Materials	Personnel Injury, Payload Penetration Degraded a Atmosphere or Equipment Operation

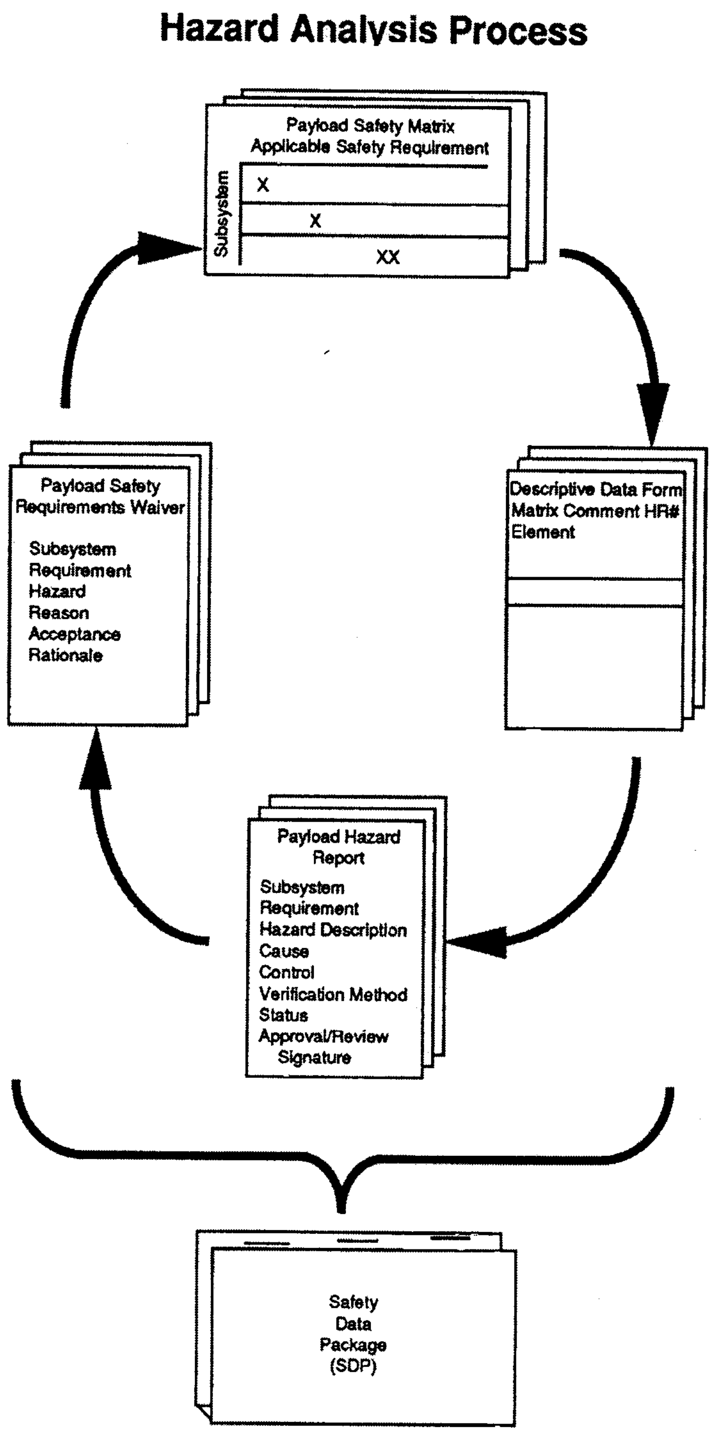

FIGURE A.2 HAZARD ANALYSIS PROCESS

A4.1 Payload Safety Matrix

The initial version of the Payload Safety Requirements Applicability Matrix is required early in the safety review cycle and should be kept up to date throughout the development process. This form and the Payload Ground Safety Requirements Applicability Matrix documents are used to foresee and assess interrelationships between the basic hazard groups and subsystems contained in the payload. Examples of these forms are presented in Figures A.3 and A.5.

NSTS PAYLOAD SAFETY REQUIREMENTS APPLICABILITY MATRIX

PAYLOAD:	DATE:	PHASE:	PAGE___ OF___

GENERAL REQUIREMENTS (NHB 1700.7B REQUIREMENTS)

	200 GENERAL	201 HAZARDOUS FUNCTIONS	203 RETRIEVAL OF PAYLOAD	204 HAZARD DETECTION/SAFING	205 CONT. RETURN/RAPID SAFING	206 FAILURE PROPAGATION	207 REDUNDANCY SEPARATION	211 DESTRUCT SYSTEMS	213.3 LIGHTING	214 VERIFICATION	215 HAZARDOUS OPERATIONS	216 SERIES PAYLOAD	216 R' LOWN HARDWARE	217 PLANNED EVA	218 PAYLOAD COMMANDING	220 CREW HABITABLE
PAYLOAD APPLICABILITY	X	X			X	X	X			X						

SPECIFIC PAYLOAD HAZARDS — HAZARD REPORT REFERENCE NUMBER

PAYLOAD ELEMENT OR SYSTEM	202.1 SOLID PROPELLANT	202.2 LIQUID PROPELLANT	202.3 DEPLOYMENT/JETTISON	202.4 PLANNED EXTENSION	202.5 RF RADIATION	208.1, 2, & 3 STRUCTURES	208.4 PRESSURE SYSTEMS	208.5 SEALED COMPARTMENTS	209.1 HAZARDOUS MATERIALS	209.2 FLAMMABLE MATERIALS	209.3 OFFGASSING MATERIALS	210 PYROTECHNICS	212.1 IONIZING RADIATION	212.2 NONIONIZING RADIATION	212.3 LASERS	213 ELECTRICAL SYSTEMS	213.2 BATTERIES	219 FLAMMABLE ATMOSPHERES

	IMPLEMENTATION PERSONNEL	DATE	PAYLOAD ORGANIZATION PERSONNEL	DATE
PREPARED BY:				
REVIEWED BY:				
APPROVED BY:				

JSC Form 1090 (Rev Jul 89) Previous Editions Are Obsolete

FIGURE A.3 PAYLOAD SAFETY MATRIX

NSTS PAYLOAD SAFETY REQUIREMENTS APPLICABILITY DESCRIPTIVE DATA		Page ____Of_____
		Date:
PAYLOAD:		Phase:
MATRIX ELEMENT REFERENCE NO.	HAZARD REPORT NUMBER	HAZARD TITLE

JSC Form 1090A (Rev Oct 88) Previous Editions Are Obsolete

FIGURE A.4 NSTS PAYLOAD SAFETY REQUIREMENTS APPLICABILITY DESCRIPTIVE DATA FORM

A4.2 Description Data Form

Similar to the Payload Safety Matrix, the Payload Safety Requirements Applicability Descriptive Data Forms are required early in the safety cycle and must be continually updated. These forms (Figure A.4 and A.6) are completed for each subsystem having a "X" in any corresponding hazard group box on the Payload Safety Matrix. The Descriptive Data Forms provide a listing of the hazard groups applicable to each subsystem and cross-references each hazard to the applicable technical requirement from NSTS 1700.7B and KHB 1700.7, Revision A. Upon completion of the Payload Safety Matrix and the Descriptive Data Form, the customer has a comprehensive list of all the payload safety hazard issues that must be addressed in order for the payload to be granted safety certification.

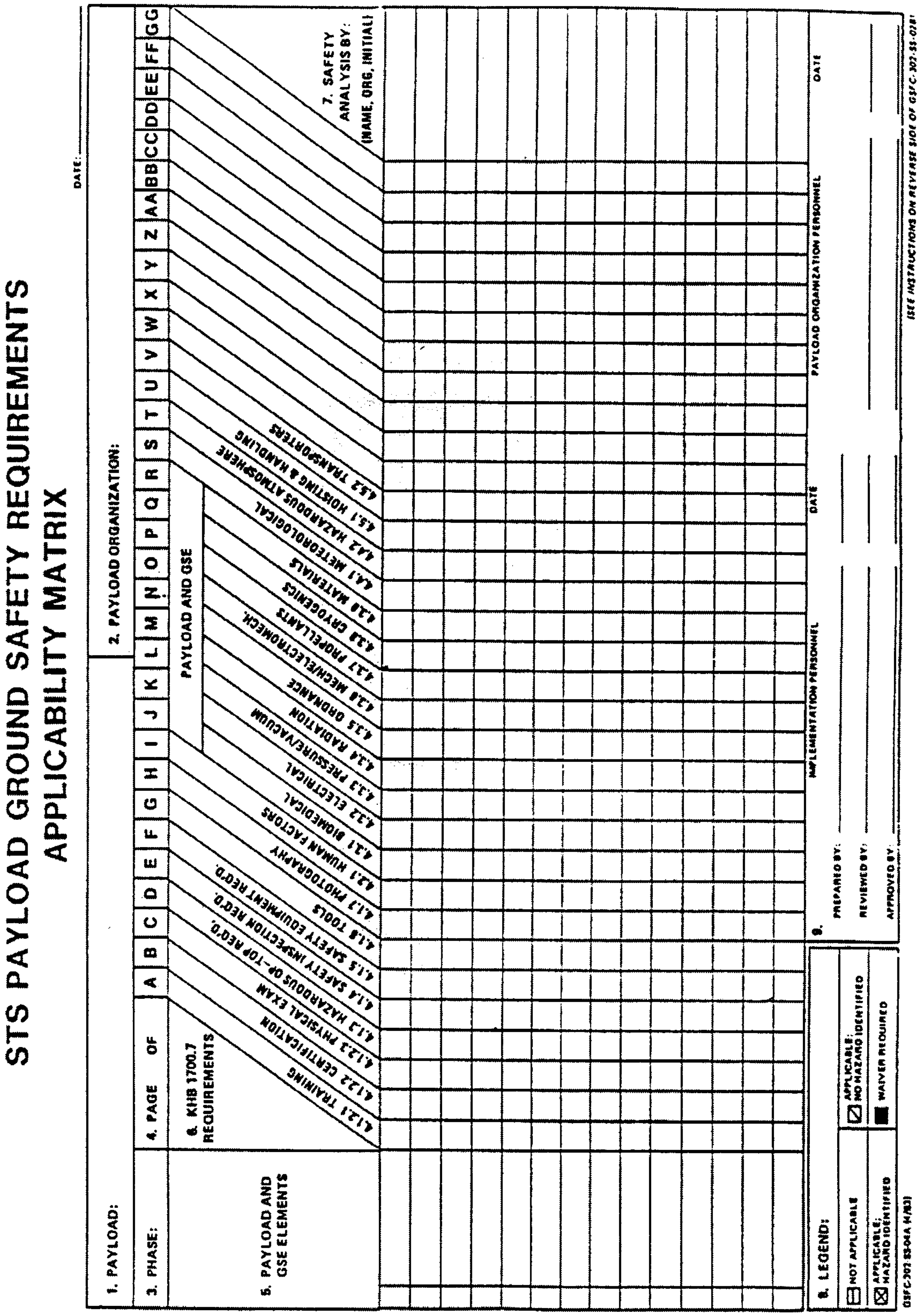

FIGURE A.5 STS PAYLOAD GROUND SAFETY REQUIREMENTS APPLICABILITY MATRIX

10. STS PAYLOAD SAFETY REQUIREMENTS APPLICABILITY DESCRIPTIVE DATA		
MATRIX ELEMENT	COMMENTS	H/R #

GSFC-302-SS-02B (2/83)

FIGURE A.6 STS PAYLOAD SAFETY REQUIREMENTS APPLICABILITY DESCRIPTIVE DATA

A4.3 Payload Hazard Report

Following the completion of the safety analysis and identification of potential hazards, a Payload Hazard Report must be completed. This report is to be completed for each hazard identified on the Descriptive Data Form. Each hazard report should stand alone. Data required to understand the hazard, the hazard controls, and safety verification methods including the organization responsible for each verification, should be attached to the report. When functional diagrams are supplied, the pertinent information shall be clearly identified, (e.g., controls, inhibits, monitors, etc.).

Information for Hazard Reports, is to be submitted to the HH Safety Manager. This data is included in a Payload/HH combined SDP.

The hazard report is used to track hazards identified throughout the lifecycle of the payload. It contains NASA review and approval signatures, acknowledging the possibility of hazard occurring, and the result rationale that has been reviewed in accordance with NASA standards. Figure A.7 represents the Payload Hazard Report.

<table>
<tr><td colspan="3">PAYLOAD HAZARD REPORT</td><td colspan="2">No.</td></tr>
<tr><td colspan="3">PAYLOAD</td><td colspan="2">PHASE</td></tr>
<tr><td>SUBSYSTEM</td><td colspan="2">HAZARD GROUP</td><td colspan="2">DATE</td></tr>
<tr><td colspan="5">HAZARD TITLE</td></tr>
<tr><td colspan="3">APPLICABLE SAFETY REQUIREMENTS</td><td colspan="2">HAZARD CATEGORY</td></tr>
<tr><td colspan="3" rowspan="2"></td><td></td><td>CATASTROPHIC</td></tr>
<tr><td></td><td>CRITICAL</td></tr>
<tr><td colspan="5">DESCRIPTION OF HAZARD</td></tr>
<tr><td colspan="5">HAZARD CAUSES</td></tr>
<tr><td colspan="5">HAZARD CONTROLS</td></tr>
<tr><td colspan="5">SAFETY VERIFICATION METHODS</td></tr>
<tr><td colspan="5">STATUS OF VERIFICATION</td></tr>
<tr><td>APPROVAL</td><td colspan="2">PAYLOAD ORGANIZATION</td><td colspan="2">STS</td></tr>
<tr><td>PHASE I</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>PHASE II</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>PHASE III</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

JSC Form 542B (Rev Nov 82)

FIGURE A.7 PAYLOAD HAZARD REPORT

A4.4 Payload Safety Noncompliance Report (Waiver)

A waiver request form (as shown in Figure A.8) must be submitted for noncompliance. This request will be returned to GSFC for review in such cases when safety requirements cannot be met. The Mission Manager will negotiate with the STS on behalf of the customer concerning the acceptability of the waiver request. Should the waiver be denied, the customer must meet the requirement through design changes to the payload or run the risk of having the payload denied the opportunity for flight on the STS.

PAYLOAD SAFETY NONCOMPLIANCE REPORT	NO.	DATE

TITLE (Brief reference to noncompliance)

PAYLOAD IDENTIFICATION (Include reference to applicable payload element, subsystem, and/or component)

APPLICABLE REQUIREMENT

DESCRIPTION OF NONCOMPLIANCE (Specify how the design or operation does not meet the safety requirements)

HAZARD OR HAZARD CAUSE (Include reference to Payload Hazard Report)

REASON REQUIREMENT CANNOT BE FULFILLED

RATIONALE FOR ACCEPTANCE (Define the design feature or procedure used to conclude that the noncompliance Condition is safe. Attach applicable support data, I.e. drawings, test reports, analyses, etc.)

APPROVAL SIGNATURES			
PAYLOAD ORGANIZATION			DATE
WAIVER APPROVAL		DEVIATION APPROVAL	
EFFECTIVITY		EFFECTIVITY	
STS OPERATOR	DATE	STS OPERATOR	DATE

JSC Form 542C (Rev Mar 83)

FIGURE A.8 PAYLOAD SAFETY NONCOMPLIANCE REPORT

A4.5 Additional Safety Requirements

Depending on the design of the payload and its operating characteristics, beginning at Phase O/I Safety Data Package (SDP) submission timeframe, the customer may be required to submit the last version of additional forms such as:

a. Radiation Training and Experience Summary
(Figure A.9)
b. Radioactive Materials Use Request
(Figure A.10)
c. Ionizing Radiation Source Data Sheet
(Figure A.11A and A.11B)
d. Training and Experience Summary Non-Ionizing Radiation Users
(KSC Form 16-450) (Figure A.12)
e. Non-Ionizing Radiation Protection Source Questionnaire
(KSC Form 16-453) (Figure A.13)

It is important to address and identify special safety requirements and document them, beginning at Phase O/I SDP as soon as possible. These requirements may include:

a. Special handling or testing during installation or removal of the payload
b. Special environments during certain mission phases
c. Special flight operations.

RADIATION TRAINING AND EXPERIENCE SUMMARY (IONIZING RADIATION)

Note: (Complete unshaded sections of Form only) (Please type/print legibly, prepare original and one copy)(Instructions for completion on reverse)

I. GENERAL INFORMATION

NAME/TELEPHONE NUMBER	DATE OF BIRTH	ORGANIZATION/MAILCODE OR ADDRESS	AUTHORIZATION NUMBER

SOCIAL SECURITY NO.	TYPE OF USER	SYSTEM/DEVICE TO BE USED
	AREA RADIATION OFFICER MAINTENANCE USER OTHER USE SPVR/ CUSTODIAN	

II. TRAINING *(Use supplemental sheets as needed)*

TYPE OF TRAINING	WHERE TRAINED	DURATION	ON-THE-JOB	FORMAL COURSE
A. Principles And Practices Of Radiation Protection			YES NO	YES NO
B. Radioactivity Measurement Standard- Ization Monitoring Techniques And Instruments			YES NO	YES NO
C. Mathematics And Calculations Basic To The Use And Measurement Of Radioactivity			YES NO	YES NO
D. Biological Effects Of Radiation			YES NO	YES NO

III. EXPERIENCE *(Use supplemental sheets as needed)*

A. RADIOACTIVE MATERIALS   YES   NO   *(Describe below)*

RADIONUCLIDE	MAXIMUM AMOUNT	LOCATION	TYPE OF USE	DURATION

B. ACCELERATOR OR X-RAY EQUIPMENT   YES   NO   *(Describe below)*

TYPE	MAXIMUM ENERGY	LOCATION	TYPE OF USE	DURATION

IV. REFERENCE DOCUMENTS

I HAVE READ AND UNDERSTAND APPLICABLE PORTIONS OF THE FOLLOWING:

KHB 1860.1	YES	NO	
NRC REGULATIONS, 10 CFR 19 AND 20	YES	NO	N/A
KMI 1860.1 *(If applicable)*	YES	NO	N/A
ESMCR 160-1 *(If applicable)*	YES	NO	N/A
FLORIDA REGULATIONS, CHAPTER 10D-56	YES	NO	N/A

SIGNATURE OF APPLICANT   DATE

V. AUTHORIZATIONS

HEALTH PHYSICS	DATE	KSC RADIATION PROTECTION OFFICER	DATE
ESMC RADIATION PROTECTION OFFICER *(If applicable)*	DATE	CHMN, KSC RADIATION PROTECTION COMMITTEE	DATE

FIGURE A.9 RADIATION TRAINING AND EXPERIENCE SUMMARY (IONIZATION RADIATION) FORM

RADIOACTIVE MATERIAL USE REQUEST

(Prepare in original and four copies)

FROM (NAME) *(Please print)*	OFFICE CODE	DATE	REF. NUMBER*

TO: KSC RADIATION PROTECTION OFFICER (RPO)

VIA

HEALTH PHYSICS SECTION (OMEHS)

RADIOACTIVITY REQUIREMENTS

A. ELEMENT AND ISOTOPE	B. PHYSICAL FORM
C. TOTAL QUANTITY REQUIRED (MC OR UNITS)	D. ESTIMATED ACTIVITY PER EXPERIMENT (MC OR UNITS)

E. WASTE CONCENTRATIONS & AMOUNTS	LIQUID	SOLID

2. TITLE OR BRIEF DESCRIPTION OF PROPOSED PROJECT

3. PROPOSED PROCEDURE (INCLUDING SPECIAL PRECAUTIONS)

	3A. LICENSE NO.		3B. NRC ☐ STATE OF

4. LOCATION OF USE	BUILDING NUMBER	ROOM NUMBER	AREA ZONE NUMBER

5. USERS	6. PERIOD COVERED BY REQUEST FROM ____________ TO ____________

7. HEALTH PHYSICS EQUIPMENT REQUIREMENTS

ORIGINATOR	SUPERVISOR'S SIGNATURE

APPROVALS

SIGNATURE (OMEHS HEALTH PHYSICS)	DATE
SIGNATURE (KSC RADIATION PROTECTION OFFICER)	DATE
SIGNATURE (CHAIRMAN RSC)	DATE

KSC Form 16-295NS (Rev. 5/77)

FIGURE A.10 RADIOACTIVE MATERIAL USE REQUEST

IONIZING RADIATION SOURCE DATA SHEET
SPACE FLIGHT HARDWARE AND APPLICATIONS
Lyndon B. Johnson Space Center

Complete Items 1 through 10 and Part A for radioisotope sources and Part B for ionizing radiation - producing equipment.

IDENTIFICATION

1. PAYLOAD DESIGNATION/EXPERIMENT	2. STS NO. AND/OR LAUNCH DATE
3. SOURCE USING ORGANIZATION	4. ADDRESS
5. CONTACT	6. TELEPHONE
7. PAYLOAD SPONSOR/MANAGER	8. ADDRESS
9. CONTACT	10. TELEPHONE

PART A. RADIOISOTOPE SOURCES

I. SOURCE DESCRIPTION

1. ISOTOPE	2. TOTAL QUANTITY (MILLICURIE) (Include determination date.)	3. NUMBER OF SOURCES*

4. CHEMICAL FORM	5. PHYSICAL STATE
6. SOURCE SEALED 0 Yes 0 No	7. IDENTIFICATION NOS.
8. MANUFACTURER	9. ADDRESS

II. SOURCE USE DATA

1. PURPOSE:

0 EXTERNAL CALIBRATION 0 INFLIGHT CALIBRATION
0 OTHER *(Describe)*
0 CREW INVOLVEMENT/REQUIREMENTS *(Include nominal and contingent situations.)*

III. SOURCE DIAGRAM

DETAILS ON SEALING, TECHNIQUES AND DIMENSIONS:

JSC FORM 44 (Rev Oct 81)

*List individual source quantity.

FIGURE A.11 IONIZING RADIATION SOURCE DATA SHEET

IV. TEST DATA

1. DATA SOURCE LEAK TESTED	2. RESULTS (MICROCURIE)

3. THERMO-VACUUM QUALIFIED TO:

________MM HG	________DEGREE C.	DATE

V. PRE-FLIGHT TRANSFERS

1. LOCATIONS WHERE SOURCE IS TO BE USED OR STORED AND APPROXIMATE DATES

A. LOCATIONS	B. DATED FROM	TO

2. SOURCE CUSTODIAN/RADIATION SAFETY OFFICER	TELEPHONE

VI. POST-FLIGHT DISPOSITION

OUTLINE REQUIREMENTS:

PART B. IONIZING RADIATION PRODUCING EQUIPMENT

I. EQUIPMENT CHARACTERISTICS

1. TYPE OF RADIATION PRODUCED:

2. MAXIMUM ENERGY LEVEL	3. OPERATING ENERGY LEVEL
4. DURATION OF OPERATION ________HOURS TOTAL, ALL UNITS	5. NO. OF UNITS 6. PULSED UNIT DUTY CYCLE

II. RADIATION CHARACTERISTICS

1. RADIATION INTENSITY OF FLIGHT CONFIGURED UNIT	2. SECONDARY RADIATIONS PRODUCED	
	ENERGY LEVEL	TYPE
________RAD/HR @________METERS	________KEV	

III. EQUIPMENT USE DATA

1. CREW INVOLVEMENT/PROCEDURES:

2. RADIATION PRODUCTION WARNING SYSTEM:	3. SAFETY INTERLOCK SYSTEM:
0 Yes (Describe) 0 No	0 Yes (Describe) 0 No

NASA-JSC

FIGURE A.11A IONIZING RADIATION SOURCE DATA SHEET (CONT'D)

TRAINING & EXPERIENCE SUMMARY
NON-IONIZING RADIATION USERS
(PLEASE TYPE/PRINT LEGIBLY)
(NOTE - COMPLETE UNSHADED SECTIONS OF FORM ONLY)

I. GENERAL INFORMATION

A. NAME	B. DATE OF BIRTH	C. ORGANIZATION/MAIL CODE	D. REFERENCE NO.

E. SOC SEC NO.	E. TYPE OF USER	F. SYSTEM/DEVICE TO BE USED
	0 **AREA RADIATION OFFICER** 0 **MAINTENANCE** 0 **OPERATOR** 0 **OTHER**	

II. TRAINING *(USE SUPPLEMENTAL SHEETS AS NEEDED)*

TYPE OF TRAINING	YES	NO	WHERE TRAINED	DURATION
A. Biological Effects				
B. Radiation Protection				
C. Other				

III. EXPERIENCE *(USE SUPPLEMENTAL SHEETS AS NEEDED)*

TYPE OF EXPERIENCE	LOCATION	DURATION
A.		
B.		
C.		
D.		

IV. REFERENCE DOCUMENTS

I have read and understand the following:

A. KMI 1860.1 0 **Yes** 0 **No**

B. KHB 1860.2 0 **Yes** 0 **No**

C. 29 CFR 1910.97 0 **Yes** 0 **No**

D. ESMC Regulation 160-1 ***(If Applicable)*** 0 **Yes** 0 **No** 0 **N/A**

Signature of Applicant **Date**

V. AUTHORIZATIONS

HEALTH PHYSICS	DATE
KSC RADIATION PROTECTION OFFICER	DATE
ESMC RADIATION PROTECTION OFFICER (IF APPLICABLE)	DATE
CHMN. KSC RADIATION PROTECTION COMMITTEE	DATE

FIGURE A.12 TRAINING AND EXPERIENCE SUMMARY NON-IONIZING RADIATION USERS FORM

NON-IONIZING RADIATION PROTECTION SOURCE QUESTIONNAIRE *(PLEASE TYPE/PRINT LEGIBLY)*			
ORIGINATOR	**ORG/MAIL CODE**	**PHONE**	**DATE**
SUPERVISOR	**ORG/MAIL CODE**	**PHONE**	**DATE**
DEVICE/SYSTEM DESCRIPTION *(USE SUPPLEMENTAL SHEETS AS NEEDED)*			
TYPE **0 RADIOFREQUENCY/MICROWAVE**		**0 LASER/OPTICAL**	
MANUFACTURER AND YEAR			
MODEL AND SERIAL NO.			
FREQUENCY/WAVELENGTH			
MAX. POWER OUTPUT			
PULSE WIDTH			
REPETITION FREQ.			
USE LOCATION(s) **SITE(s)**			
INTENDED USE(s)			
ANTENNA DATA		ASSOCIATED OPTICS	
TYPE AND QUANTITY		**LENSES**	
DIMENSIONS		**FILTERS**	
GAIN		**OTHER**	
RADIATION PROTECTION CONTROLS EMPLOYED/IDENTIFIED			

KSC FORM 16-453 (REV. 4/81)

FIGURE A.13 NON-IONIZING RADIATION PROTECTION SOURCE QUESTIONNAIRE

A5. SAFETY DATA PACKAGE (SDP)

A Flight Safety Data Package (SDP) and a Ground SDP is prepared for each payload. The Flight SDP is limited to payload design and flight operations and the Ground SDP focuses on ground hazards that might exist during pre-launch and post-landing periods. The SDP's are written to the same level of detail as a design review, but the emphasis is directed toward how the hardware complies with applicable safety requirements, as well as control of identified hazards, rather than operational performance requirements. The packages are the result of detailed analysis of the payload systems, GSE, system/component interfaces, procedures and possible hardware failure/human error combinations. This analysis is done to insure not only that nominal or generic safety requirements are met, but that any additional hazards are identified and adequately controlled. The preliminary SDP is prepared after the Payload Accommodations Conference. After final GSFC approval, the HH Mission Manager will submit the Phase O/I Flight SDP to the STS Payload safety review panel at JSC and the Ground SDP to the review panel at KSC for approval. Phase II and III SDPs will be prepared and submitted by GSFC with inputs from the payload organization. The following chart provides an example outline for the SDP.

EXAMPLE FLIGHT SAFETY DATA PACKAGE (SDP) OUTLINE

SECTION

I. Table Of Contents
II. Acronyms Abbreviations
III. Figures And Diagrams

1.0 Introduction
1.1 Objectives
1.2 Applicable Documents
1.3 Concept
1.4 Operational Scenario
2.0 Payload Description
2.1 Overall Payload Description
2.1.1 Structural
2.1.2 Electrical
2.1.3 Cryogenics
2.1.4 Radiation
2.1.5 Pyrotechnics
2.1.6 Pressure System
2.1.7 Materials
2.1.8 Thermal
2.2 Hitchhiker Hardware Description
2.2.1 Mounting Plate
2.2.2 Adapter Beam
2.2.3 Canister
2.2.4 Hh Avionics
2.3 Flight Operations
3.0 Flight Safety Assessment And Verification
3.1 General
3.2 Integrated Payload/Hh Hazard Analysis
3.3 Payload Verification
Appendix A - Hazard Reports

A Similar Outline Should Be Followed For The Ground SDP And Include Ground Operations.

PAYLOAD SYSTEM SAFETY
DATA SUBMITTAL SUMMARY

Data Submittal	Submittal to GSFC	Updated Submittal to JSC
Flight Safety Data Compliance Package		
PHASE 0/I		
SCDP	L-18 Months	L-16 Months
Presentation & Action Item Responses	L-17 Months	L-15 Months
Phase II		
SCDP	L-12 Months	L-10 Months
Presentation & Action Item Responses	L-11 Months	L-9 Months
Phase III		
SCDP	L-8 Months	L-6 Months
Presentation & Action Item Responses	L-7 Months	L-5 Months
Ground Safety Data Compliance Package		
Phase 0/I		
SCDP	L-18 Months	L-16 Months
(Operations Procedures List & MSDSs)		
Presentation & Action Item Responses	L-17 Months	L-15 Months
Phase II		
SCDP	L-12 Months	L-10 Months
(Preliminary Operations & Hazardous Procedures)		
Presentation & Action Item Responses	L-11 Months	L-9 Months
PHASE III		
SCDP	L-8 Months	L-8 Months
Presentation & Action Item Responses	L-7 Months	L-5 Months
Launch Site Safety		
Final Launch Site Safety documentation including: list of names of KSC I&T teams, function and organization, KSC Operations Procedures, and Final Hazardous Operations Procedures	75 days prior to shipping to KSC	
Verification Tracking		
Ground VTL	L-4 Months	Semi-Weekly Updates
Flight VTL	L-12 Months	Following Phase III Review

FIGURE A.14 PAYLOAD SYSTEM SAFETY DATA SUBMITTAL SUMMARY

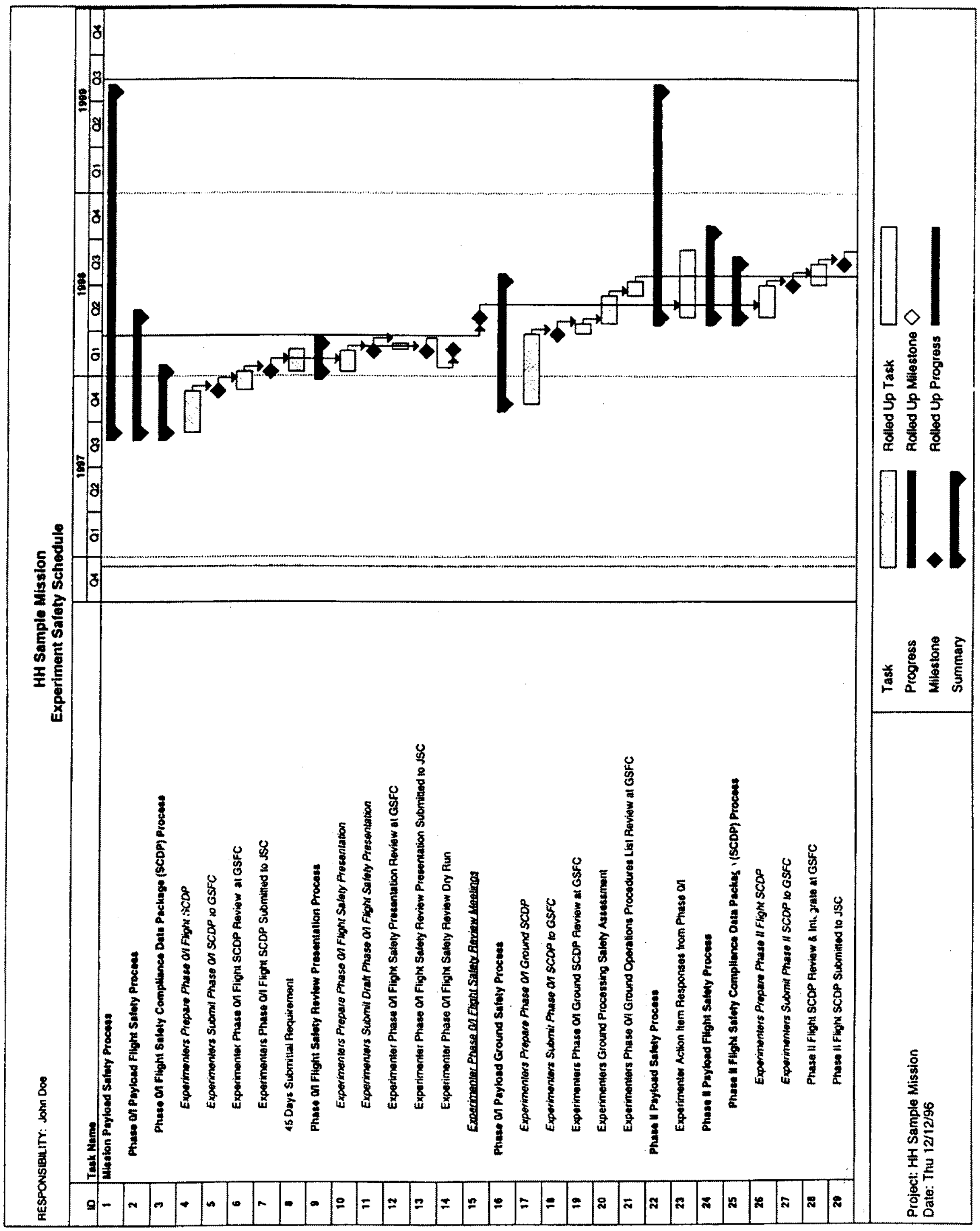

FIGURE A.15 HH SAMPLE MISSION EXPERIMENT SAFETY SCHEDULE

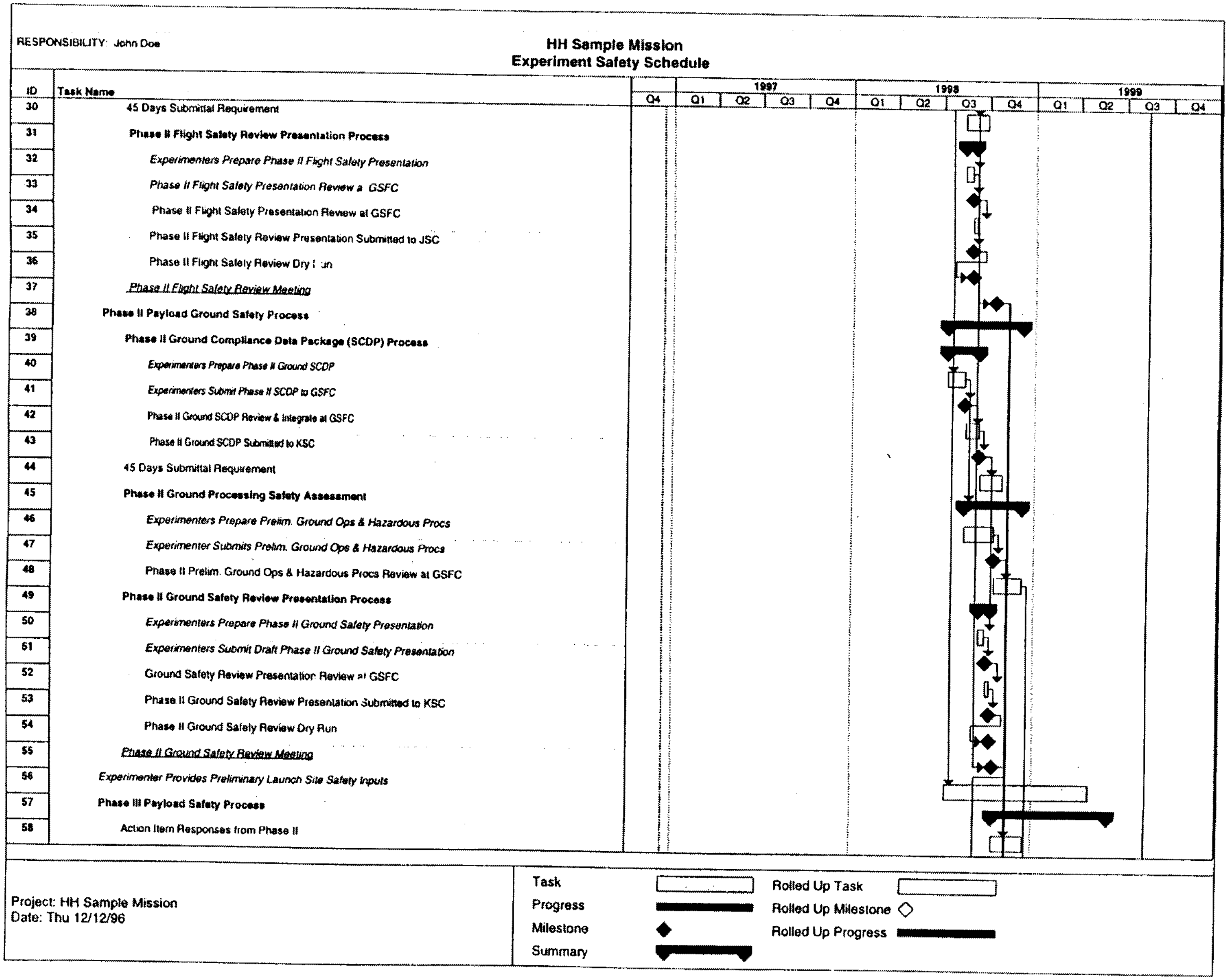

FIGURE A.15 (CONTINUED)

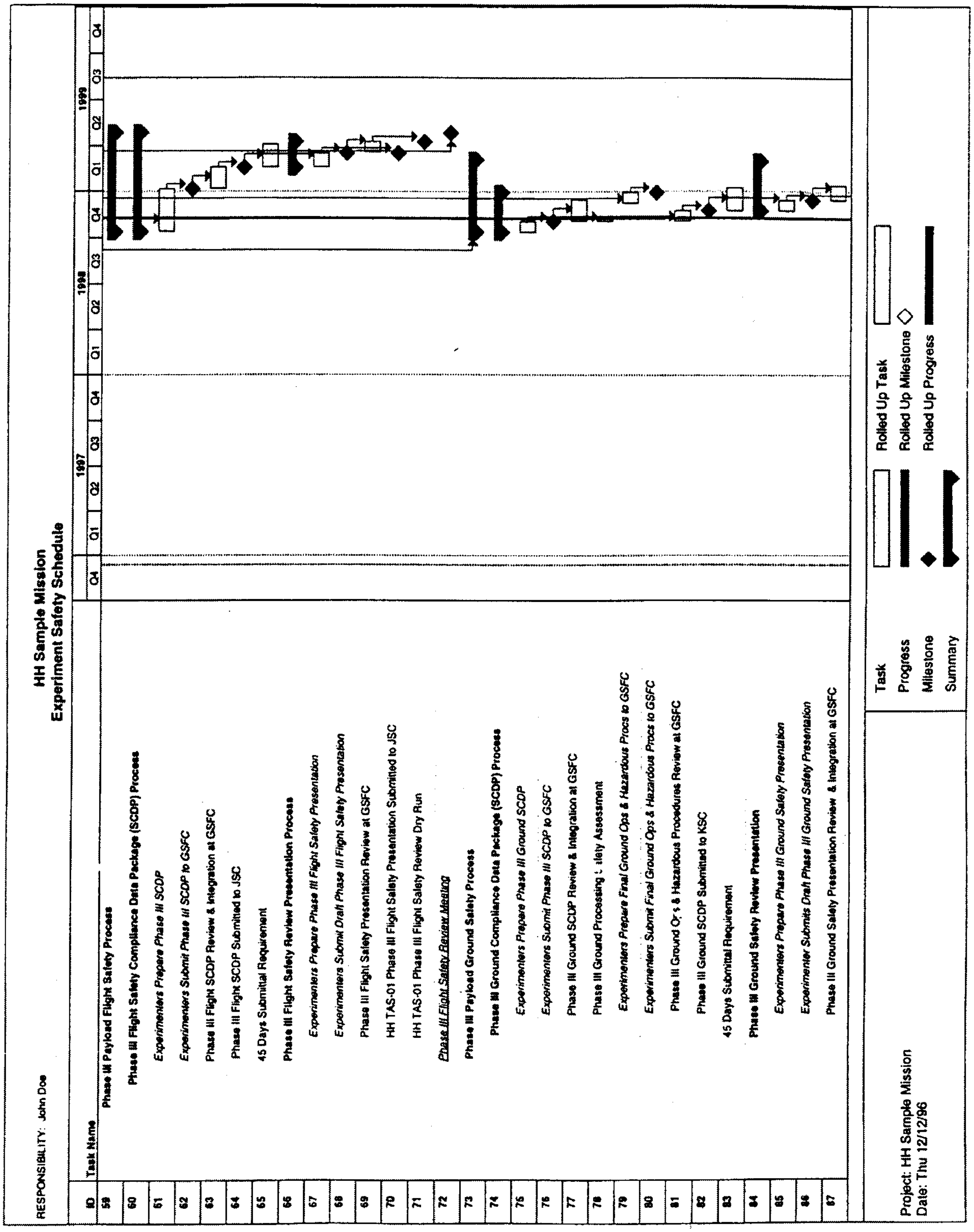

FIGURE A.15 (CONTINUED)

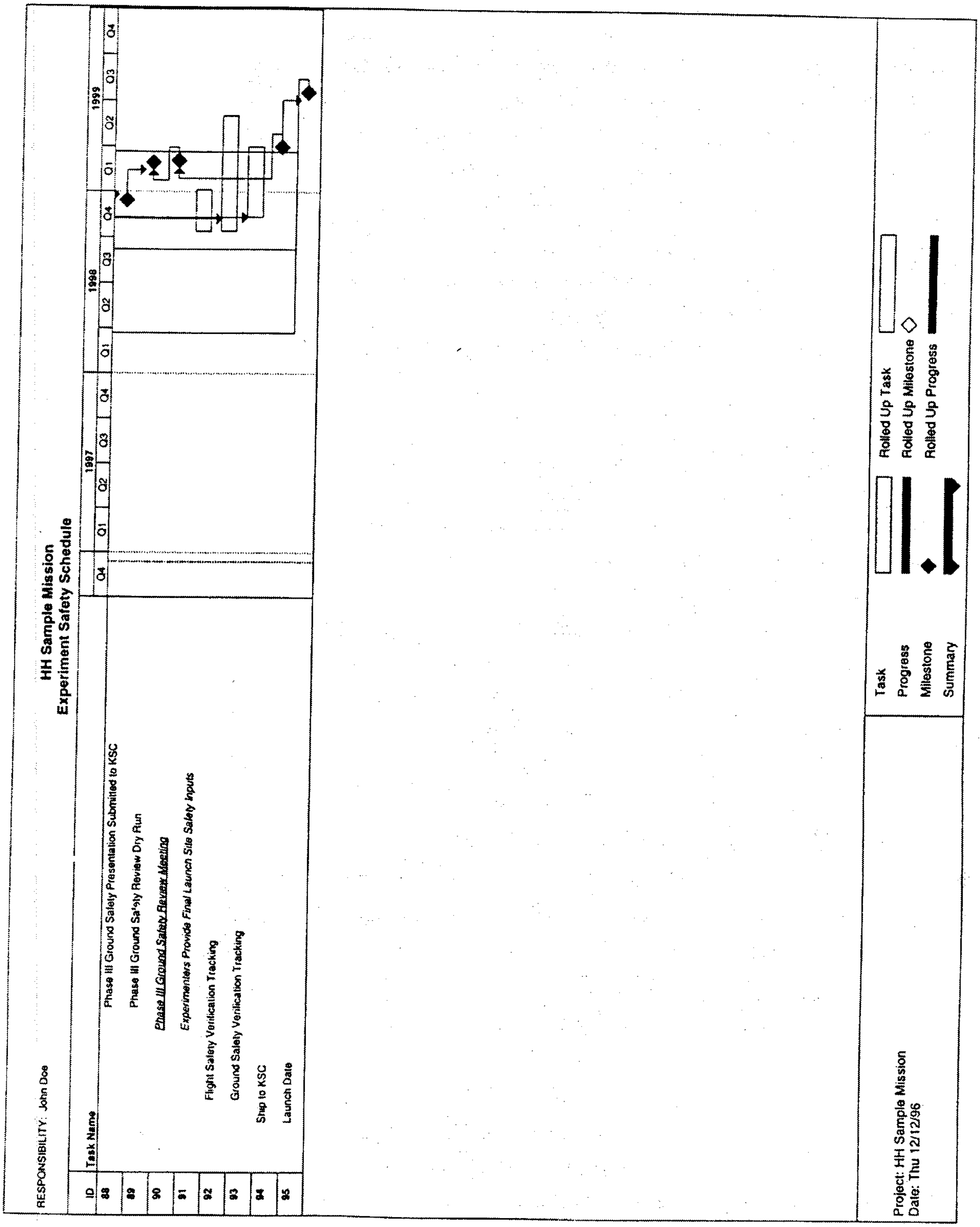

FIGURE A.15 (CONTINUED)

APPENDIX B

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Appendix B

Material

B1. OVERVIEW

As part of the System Safety Process, GSFC Materials Engineers review all materials used in HH payloads for freedom from stress corrosion cracking and to determine their potential flammability, toxicity, and offgassing[1] characteristics. Materials are also reviewed to determine their outgassing[2] and contamination characteristics so that scientific data degradation is minimized. (Note: A good rule to follow in meeting materials requirements is to house hardware in sealed containers).

B2. MATERIALS REVIEW PROCESS

a. Complete the appropriate forms applicable to your payload at a relevant point in the design process.

b. Submit completed forms to the HH Project Office, which will forward them to the HH Materials Engineer for review.

c. If any questions arise during the Materials Engineer's review, you will be contacted by telephone.

d. The Materials Engineer will document his findings at the completion of his review and forward them to you through the HH Project Office.

(Note: Some findings may require the submission of a material sample for test by GSFC or recommend an alternate material for one that is unacceptable for use.)

1. Offgassing - The emanation of volatile matter of any kind from materials into a manned pressurized volume.

2. Outgassing - The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

B3. LIST OF CANDIDATE MATERIALS

For the immediate needs of the HH and SPOC, we have generated lists of materials which, if used prudently, can form the basis of an acceptable materials design. It should be noted that while the materials listed are considered "acceptable" for space use, successful performance is not ensured without having an appropriate technical merit review by materials engineers. Nor does it assure that the selected material will not be used improperly.

This selection was based on certain criteria for polymers and metals in light of the referenced documents. Limitations regarding outgassing of polymers and the stress corrosion cracking of metals are of major concern to Shuttle payloads. In addition, test results such as flammability may not be readily available in the manufacturers' literature and may require further testing at JSC.

It is required that the selection of materials used in the design of payload structures, support brackets, and mounting hardware complies with the stress corrosion cracking criteria of the latest version of MSFC-SPEC-522. Acceptable materials taken from MSFC-SPEC-522B are given in Table B.1. Other materials need to have a Materials Usage Agreement (MUA) submitted for approval.

Refer to NASA Ref. Pub. 1124, August 1987, for lists of materials which have been tested for outgassing and have met the acceptable criteria. This criteria is that a maximum 1% Total Mass Loss (TML) and a maximum of 0.10% Collected Volatile Condensable Materials (CVCM) is acceptable. For materials that are not included, the Materials Branch of the GSFC, Code 313 should be contacted to determine their outgassing values.

Wherever more stringent outgassing criteria are needed, such as near sensitive optics, the CVCM value of 0.01% should be used. A list of these materials is included in Table B.2. Most of these materials will cure at room temperature and those that require an elevated temperature cure are indicated by an asterisk (*). In addition, those materials considered to be "non-flammable" per JSC/White Sands Test Facility (WSTF) data are indicated by a (1).

In using materials for space flight applications, several general precautions should be considered:

a. The use of electroless nickel on flexible members is not recommended due to its brittle nature.
b. Metal platings used as a corrosion protection film, should be at least 200 x 10-6 inches thick.
c. When the recommended Brayco oil and greases are used, a barrier film should be properly applied for prevention of lubricant creep.
d. The use of Ray Chem Spec 44/ or 55 wire is not prohibited, although it is classed as flammable. It is highly recommended that Teflon TFE (MIL-W-22759/11-12) or Kapton polyimide (MIL-W-81381/9-12) be used throughout the Program. Neither are flammable.
e. When using dry solid film lubricants and metal platings, allowance must be made for the lubricant thickness. Sputtered MoS2 does not change the dimension to any significant degree.
f. Formulate plans for controlling the particulate and Non-Volatile Residue (NVR) contaminants around optics.
g. Use care in mixing and curing polymeric materials.
h. Use proper identified and dated (shelf life) materials at all times.
i. Use the proper primer with paints, conformal coatings, and potting compounds.
j. Flammability data is available on a limited number of materials as shown in Table B.2.

As a final note, these attached lists should be considered as a starting point and do not negate the use of other materials. It is not the intent of these lists to limit the use of materials to a select group but rather to assist the customer by listing those which have been used in previous space projects. Selected materials should be submitted for approval through the project office on forms shown in Figures B-1 through B-6.

TABLE B.1 MATERIALS LIST ENCLOSURE MSFC-SPEC-522B ATTACHMENT A
Alloys With High Resistance To Stress Corrosion Cracking

STEEL ALLOYS

Alloy	Condition
Carbon Steel (1000 Series)	Below 180 ksi UTS
Low Alloy Steel (4130, 4340, D6AC, etc.)	Below 180 ksi UTS
Music Wire (ASTM 228)	Cold Drawn
1095 Spring Steel	Tempered
HY 80 Steel	Tempered
HY 130 Steel	Tempered
HY 140 Steel	Tempered
ASP 11	Aged
200 Series Stainless Steel (Unsensitized) (1)	All
300 Series Stainless Steel (Unsensitized) (1)	All
400 Series Ferritic Stainless Steel (404, 430, 444, etc.)	All
Nitronic 32 (2)	Annealed
Nitronic 300 (2)	Annealed
Nitronic 40 (formerly 21-6-9) (2)	Annealed
A-286 Stainless Steel	All
AM-350 Stainless Steel	SCT 1000 and Above
AM-355 Stainless Steel	SCT 1000 and Above
AM-362 (Almar 362) Stainless Steel	3 Hrs. at 1000oF
Carpenter 20Cb Stainless Steel	All
Carpenter 20Cb-3 Stainless Steel	All
Custom 450 Stainless Steel	H1000 and Above
Custom 455 Stainless Steel	H1000 and Above
15-5PH Stainless Steel	H1000 and Above
PH15-7Mo Stainless Steel	CH900
17-7PH Stainless Steel	CH900

(1) Including weldments of 304L, 316L, 321, and 347
(2) Including weldments.

ALUMINUM ALLOYS

WROUGHT		CAST	
ALLOY (1)	TEMPER (2)	ALLOY (3)	TEMPER
1000 Series	All	319.0, A319.0	As Cast
2011	T8	333.0, A333.0	As Cast
2024 Rod, Bar	T8	355.0, C355.0	T6
2219	T6, T8	356.0, A356.0	All
2618	T6	357.0	All
3000 Series	All	B358.0 (Tens-50)	All
5000 Series	All (4), (5)	359.0	All
6000 Series	All	380.0, A380.00	As Cast
7049	T73	514.0, (214)	As Cast
7149	T73	518.0, (218)	As Cast (5)
7050	T73	535.0 (Almag 35)	As Cast
7075	T73	A712.0, C712.0	As Cast
7475	T73		

(1) Including weldments of the weldable alloys.
(2) Including mechanically stress relieved (TX5X orTX5XX) tempers when applicable.
(3) The former designation is shown in parenthesis where significantly different.

(4) High magnesium alloys 5456, 5083, and 5086 should be used in controlled tempers (H111, H112, H116, H117, H323, H343) for resistance to SCC and exfoliation.

(5) Alloys with magnesium content greater than 3.0 percent are not recommended for high temperature application, 66oC (150oF) and above.

Condition

CDA No. (1)	(% Cold Rolled) (2)
110	37
170	AT, HT (3)
172	AT, HT (3)
194	37
195	90
230	40
422	37
443	10
510	37
521	37
524	0
606	0
619	40 (9% B phase)
619	40 (95% B phase)
638	0
655	0
688	40
704	0
706	50
710	0
715	0
725	40
752	50

(1) Copper Development Association alloy number.
(2) Maximum percent cold rolled for which SCC data is available.
(3) AT - Annealed and precipitation hardened.
HT - Work hardened and precipitation hardened.

TABLE B.1 (CONT'D)
NICKEL ALLOYS

Alloy	Condition
Glass Seal 52 CR (51Ni-49Fe)	All
Invar 36 (36Ni-64Fe)	All
Hastelloy B	Solution Heat Treated
Hastelloy C	All
Hastelloy X	All
Incoloy 800	All
Incoloy 825	All
Incoloy 901	All
Incoloy 903	All
Inconel 600 (1)	Annealed
Inconel 625	Annealed
Inconel 718 (1)	All
Inconel X-750	All
Monel K-500	All
Ni-Span-C 902	All
Rene' 41	All
Unitemp 212	All
Waspaloy	All

MISCELLANEOUS ALLOYS

Alloy	Condition
Beryllium S-200C	Annealed
HS 25 (L605)	All
HS 188 (1)	All
MP 35N	Cold Worked and Aged
MP159 Cold	Worked and Aged
Titanium 3A1-2.5V	All
Titanium 5A1-2.5SN	All
Titanium 6A1-4V	All
Titanium 10Fe-2V-3A1	All
Titanium 13V-11Cr-3A1	All
Titanium IMI 550	All
Magnesium M1A	All
Magnesium LA141	Stabilized
Magnesium LAZ933	All

(1) Including weldments

TABLE B.2 MATERIALS WITH LOW OUTGASSING AND FLAMMABILITY DATA AVAILABLE

MATERIALS WITH LOW OUTGASSING AND FLAMMABILITY DATA AVAILABLE

ADHESIVES, CONFORMAL COATINGS (C.C.) AND POTTING COMPOUNDS

Armstrong A-12; 3A/2B	epoxy(1)	adhesive
Armstrong A-31; 6A/4B	epoxy(1)	adhesive
Epon 828/TETA; 10A/1B	epoxy(1)	adhesive, C.C.
Epon 828/Versamid 140; 70A/30B	epoxy(1)	adhesive, C.C.
Hysol 11C; 1A/1B	epoxy	adhesive
Crest 3135/7111; 1A/1B	epoxy	adhesive
Stycast 2850/Cat. 9; 10A/0.3B	epoxy	adhesive
Stycast 2057/Cat. 9; 100A/6B	epoxy	potting
Stycast 2651MM/Cat. 9; 100A/6.5B	epoxy	adhesive, potting
Hysol C2-4259/3401	epoxy	potting
Conathane EN21; 100A116B	polyurethane	adhesive, C.C., potting
Uralane 5753LV; 1A/5B	polyurethane	C.C., potting
Solithane 113/300 Formula #4 or #21	polyurethane	C.C., potting
P.R. 1660L; 25A/100B/8 Cab-0-Sil	polyurethane	adhesive, potting
DC93500; 10A/18	silicone	adhesive, potting, C.C.
RTV 566; 0.1% Cat.	silicone	adhesive, potting, C.C.
RTV 567; 0.5% Cat.	silicone	adhesive, potting, C.C.
RTV 142	silicone	adhesive

WIRE AND CABLE WITH TEFLON

(MIL-W-22759/11; MIL-W-22759/12) or Kapton polyimide
MIL-W-81381/9-12 (1)

SHRINK TUBING

Chemfluor Teflon*	(1)
ThermoFit 400 Teflon*	(1)
ThermoFit TR218 Kynor/Viton*	(1)
ThermoFit TFE-R Teflon*	(1)

ELECTRICAL CONNECTORS/FEEDTHROUGHS

AMP-Feedthrough term block 204307-6-70-39	epoxy
Appleton Connector Red/Black Phenolic/Fiberglas	
Bendix Connector PT07H-14-19P Green	
Cannon Connector MS3476 Black Phenolic	
Cannon Connector C-16 MS C-40M 39569	silicone
Cannon Connector PV6G24831/SWC16 Red	silicone
DAP Connector Insert DDM 24W7P	
Deutsch Connector 6825 RM04-4428	silicone

ELECTRICAL SHIELDS

Eccosorb MF112 Fe filled epoxy
Eccosorb MF113 Fe filled epoxy
Cho-Seal 1217 Ag filled fluorosilicon 125*
Cho-Seal 1221 Ag filled silicone aerospace 200*

FILM AND SHEET MATERIALS

Cellulose acetate butyrate 200 micron purple film	
Cronar polyester transparency film	
Genotherm HT unplasticized PVC clear film	
Mylar LA616 film	
Kapton H-film	(1)
Polychrome 8 mil film	
Tedlar 150-30 CC black film	
Ormalon TG 4030 neutral Teflon or glass cloth-heat barrier film	
Beta Marquisette woven fiberglass,Style 2530	
Fairprene VS0080 black Viton A sheet	(1)
Fluoroglas 389-7 beta cloth/PTFE coated	(1)
Cho-Therm 1677 white fluorosilicone-thermal control	
Dacron mesh E2A polyesternetting - thermal blanket	
Dacron mesh 15320 polyester netting - thermal blanket	
G401500 Ag/Teflon film	(1)

FOAMS

P-65 polyether urethane foam white methyl alcohol wash
Absafil F1200/20 glass fibers
Skybond R1 7271-12 or 18 rigid polyimide
Zerefil F700 vinyl/20 glass fibers
Scott polyester urethane 100 TPI methyl alcohol wash*

LUBRICANTS

Brayco 815Z oil	(1)
Brayco 601, 602, and 603; RP, MS and Zn grease	(1)
Apiezon L and N; grease	
Rulon A,B,C,J,LD and 123; Teflon/fiberglass solid	
MoS2 -filled vespel grade, SP3	

THERMAL INTERFACE CONTROL MATERIALS

Eccobond 57C; 1A/1B, Ag filled epoxy adhesive	
Hysol K-16; 3A/1B, epoxy adhesive	
Cho-Therm 1677 white fluorosilicon*	(1)
Cho-Therm 1671 white silicone*	
G-9042 white silicone thermal grease	(1) (2)
G9052 black silicone	(2)
BrayCo 3L-38-Zn fluorocarbon grease	(1) (2)
McGhan NVSIL 2946, two part silicone	

McGhan NVSIL CV2942
Eccosil 4954

FACING TAPE AND CABLE TIES

Stur-D-Lace 18DH - scoured	
Temp Lace 230 Teflon	(1)
Ty-Rap Ty25M Tefzel	(1)
Ty-Rap Ty307 Teflon	
Velcro midtemp Nomex polyimide fastener	

TABLE B.2 (Cont'd)

CIRCUIT BOARDS

Nema G-10 Mica/Cell55 (RCA)	
Micaply PG 418T polyimide fiberglass (MCA)	(1)
602 Teflon/fiberglass (ATL)	(1)
Duroid 5870 Teflon/fiberglass (ROG)	(1)
Duroid 5880 Teflon/fiberglass (ROG)	(1)
Multilayer board - MIL-P-55617, 55636, 13949	

LAMINATES

*Hercules 2002 M graphite fiber reinforced polyers, GFRP	
*Gy70/X-30 GFRP	(1)
*Gy 70/5208 orGy70/5209 GFRP	(1)
Hexcel-F174-120 glass cloth/polyimide prepreg.	
KG098 Teflon/fiberglass (MMM)	
Narmco 8517 epoxy/glass	
T300/934 GFRP	(1)

LABELS AND MARKING INKS

Scotchcal 8001 and 8009 - aluminum labels (3M)
Scotchcal 8005 photosensitive film (3M)
Wornow Cat-L-Ink 50-100/Cat. 9/50-900 white

MOLDING COMPOUNDS

Acrylafil G47/20 styrene/acrylonitrile/fiberglass	
AF 1006 acryl butadiene styrene	
CF 1006 styrene/fiberglass	
Dapon M - C2580-11B FR-FMC	
DF 1006-polycarbonate/fiberglass	
GF 1006-polysulfone/fiberglass	
JF 1006-polysethersulfont/fiberglass	
Lexan 500-polycarbonate	
Noryl EN26	
Stycast 0005 polystyrene	(1)
Teflon PFA-TE 9704	(1)
Tefzel	(1)
Vespel SP-5 polyimide/glass fiber	(1)

PAINTS

Chemglaze Z306 black	(1)
GSFC - 01550 white resin/ZRO	
RTV 602 Dev. 764-1A white (GSFC)	(1)

RUBBERS/ELASTOMERS

ECD 006 and 487-90 perfluoroelastomer	(1)
Fluron FS005 Viton red	(1)
Gor-Tex carbon doped expanded Teflon	(1)
Kalrez 1050 or 3018 perfluoroelastomer	(1)
Mosites 1059 Fluorel fluoracarbon	(1)
Parker O-Ring S-383-70 red silicone	
Parker O-Ring V-747-75 Viton E6G	(1)
Viton B	

TAPES

3M 415 Scotchpar - 2 sided	
3M X-1255 Kapton - 2 sided*	
3M Y-9460 Kapton transfer	
3M Y-967 Kapton transfer	
G400201 Al/Teflon	(1)
G406400 A Kapton	(1)
3M Y9339 Al flil	(1)
3M 420 Lead foil	(1)
3M 425 Al foil	(1)
3M 5 polyester	
Mystik 7375 Tedlar	(1)
Mystik 7420 Copper foil	(1)
Temp-R-Tape Kapton	(1)

NOTE: (1) - Considered non-flammable per JSC/WSTC data.
* - Other than Room Temperature (RT) cure.
(2) - Migrates when heated sufficiently.

NONMETALLIC MATERIALS IDENTIFICATION AND USAGE LIST

PAGE ______

REV ______

ELEMENT LOCATION

[ ] ORBITER CABIN [ ] ORBITER CARGO BAY

[ ] AIRLOCK [ ] SPACE LAB HABITABLE AREA

[ ] SEALED CONTAINER

CONTRACT NO ____________

HARDWARE ELEMENT ____________

CONTRACTOR ____________ PREPARED BY ____________ PHONE ________ GSFC MATLS EVALUATOR ________ DATE RECEIVED ________

PRESSURE ________ MEDIA ____________ TEMP RANGE ________ PHONE ________ DATE EVALUATED ________

PART DWG NUMBER	MATERIAL	DESCRIPTION SPEC	MFGR	AREA (mm²)	WT (KG)	THK (mm)	NONMETALLIC MATERIAL IDENTIFICATION					USAGE APPLICATION	GSFC EVALUATION		
							FLAMMABILITY	ODOR	TOXICITY	TVS	RATING SOURCE		A	NA	SA

PROCEDURE FOR COMPLETING NONMETALLIC MATERIAL IDENTIFICATION AND USAGE LIST

All nonmetallic materials listed on drawings or parts lists must be entered on this list.

Hardware Element – Enter name of element for which sheet applies. Example: Motor, signal generator, control panel, harness.

Hardware Element Location – Check location for hardware element, either Orbiter Cargo Bay, Spacelab Habitable Area, Orbiter Cabin, or Airlock.

Pressure – Enter pressure of hardware element when in operation (i.e., 14.5 psia, vacuum). If element is pressurized to higher pressure, enter maximum pressure of element.

Media – Enter media of hardware element: Air, oxygen, nitrogen, vacuum, etc.

Temperature Range – Enter operating temperature range for element.

Part No Drawing – Enter part number/drawing number which calls out material, including materials listed on parts list.

Material Nomenclature – Enter trade name of material. Example: RTV 732

Description Specification – Enter material description specification number. Example: Silicone, MIL-A 46146

MFGR – Enter manufacturer of material. Example: Dow Corning Corporation.

Area – Enter exposed surface area of material in square millimeters.

Weight – Enter weight of material.

Thickness – Enter thickness of material.

Material ratings – Enter information as found in Government reference and other documents.

Rating source – Enter source of rating. Example: RTV-732-MSFC-HDBK-527, odor data from JSC 02681.

Usage Application – Enter brief description of usage application. Example: RTV-732 – used to bond silicone rubber.

GSFC Evaluator's Comments: A = approved, NA = not approved; SA = see attached document for further comments.

FIGURE B.1 NON-METALLIC MATERIALS IDENTIFICATION AND USAGE LIST

GSFC SPACECRAFT INORGANIC[1] MATERIALS LIST

SPACECRAFT ______________ SYSTEM/EXPERIMENT ______________ GSFC T/O ______________

CONTRACTOR ______________ ADDRESS ______________

PREPARED BY ______________ PHONE ______________ DATE PREPARED ______________

GSFC MATERIALS EVALUATOR ______________ PHONE ______ DATE RECEIVED ______ DATE EVALUATED ______________

ITEM NO	MATERIAL IDENTIFICATION[2]	CONDITION[3]	APPLICATION[4]	EXPECTED ENVIRONMENT[5]	GSFC EVALUATION[6]		
					A	NA	SA

NOTES

(1) List all inorganic materials (metals, ceramics, glasses, liquids) except bearing and lubrication materials which should be listed on form GSFC 18-59C.

(2) Give name of material, identifying number, manufacturer.
E.g., Aluminum 6061-T6
Electroless nickel plate, Enplate Ni-410, Enthone, Inc.
Fused silica, Corning 7940, Corning Glass Works.

(3) Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
E.g., Heat treated to R_c 60 hardness, gold electroplated, brazed
Surface coated with VDA and MgF_2
Cold worked to Full Hard condition and welded by TIG process, electroless nickel plate.

(4) Give details of where on the spacecraft the material will be used (component) and its function.
E.g., Electronics box structure in attitude control system, not hermetically sealed.

(5) Give the details of the environment the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
E.g., T/V: -20°C/+60°C, 2 weeks, 10^{-5} torr, UV
Storage: up to 1 year at RT
Space: -10°C/+20°C, 2 years, 150 mi. alt., UV, electron, proton

(6) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comments.

FIGURE B.2 GSFC SPACECRAFT INORGANIC MATERIALS LIST

GSFC SPACECRAFT POLYMERIC[1] MATERIALS LIST

SPACECRAFT ________ SYSTEM/EXPERIMENT ________ GSFC T/O ________

CONTRACTOR ________ ADDRESS ________

PREPARED BY ________ PHONE ________ DATE PREPARED ________

GSFC MATERIALS EVALUATOR ________ PHONE ________ DATE RECEIVED ________ DATE EVALUATED ________

AMOUNT CODE		
Area cm^2	Vol. cc	Wt. gm
1. 0-1	A. 0-1	a. 0-1
2. 2-100	B. 2-50	b. 2-50
3. 101-1000	C. 51-500	c. 51-500
4. >1000	D. >500	d. >500

ITEM NO	MATERIAL IDENTIFICATION[2]	MIX FORMULA[3]	CURE[4]	AMOUNT CODE	EXPECTED ENVIRONMENT[5]	REASON FOR SELECTION[6]	GSFC EVALUATION[7]		
							A	NA	SA

NOTES

(1) List all polymeric (organic) materials total systems except lubrication materials which should be listed on form GSFC 18-59C.

(2) Give name of material, identifying number, manufacturer.
E.g., Epoxy, Epon 828, Shell Chem., Co.

(3) Provide proportions and name of resin, hardener (catalyst), filler, etc.
E.g., 828/V140/Silflake 135 as 5/5/38 bwt.

(4) Provide cure cycle details.
E.g., 8 hrs @ RT + 2 hrs @ 150°C

(5) Provide the details of the environment the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
E.g., T/V: -20°C/+60°C, 2 weeks, 10^{-5} torr, UV
Storage: up to 1 year at RT
Space: -10°C/+20°C, 2 years, 150 ml. alt., UV, electron, proton

(6) Provide any special reason(s) why the material was selected. If for a particular property, please give the property.
E.g., Cost and availability
RT curing and low expansion

(7) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comments.

FIGURE B.3 GSFC SPACECRAFT POLYMERIC MATERIALS LIST

GSFC SPACECRAFT LUBRICATION LIST

SPACECRAFT ________ SYSTEM/EXPERIMENT ________ GSFC T/O ________

CONTRACTOR ________ ADRESS ________

PREPARED BY ________ PHONE ________ DATE PREPARED ________

GSFC MATERIALS EVALUATOR ________ PHONE ________ DATE RECEIVED ________ DATE EVALUATED ________

ITEM NO.	COMPONENT TYPE, SIZE, MATERIAL(1)	COMPONENT MANUFACTURER & M. F. R. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES(2)	SPEED, TEMP., ATM, OF OPERATION(3)	TYPE OF LOADS & AMT.(4)	OTHER DETAILS(5)	GSFC EVALUATION(6)		
								A	NA	SA

NOTES

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e. g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation (<30°), LO = large oscillation (<30°), CS = continuous sliding, IS = intermittent sliding.
No. of wear cycles: A(1-10^2), B(10^2-10^4), C(10^4-10^6), D($>10^6$).

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed
CPM = cm/min. (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness.
If SB, give dia. of bore and width. If torque available is limited, give approx. value.

(6) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comments.

FIGURE B.4 GSFC SPACECRAFT LUBRICATION LIST

GSFC SPACECRAFT MATERIALS PROCESS LIST

SPACECRAFT ____________ SYSTEM/EXPERIMENT ____________ GSFC T/O ____________

CONTRACTOR ____________ ADRESS ____________

PREPARED BY ____________ PHONE ____________ DATE PREPARED ____________

GSFC MATERIALS EVALUATOR ____________ PHONE ____________ DATE RECEIVED ____________ DATE EVALUATED ____________

ITEM NO.	PROCESS TYPE[1]	CONTRACTOR SPEC. NO.[2]	MIL., ASTM, FED., OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L. PROCESSED[3]	SPACECRAFT/EXP. APPLICATION[4]	GSFC EVALUATION[5]		
						A	NA	SA

NOTES

1) Give generic name of process, e. g., anodizing (sulfuric acid).

2) If process is proprietary, please state so.

3) Identify the type and condition of the material subjected to the process.
E. g., 6061-T6

4) Identify the component or structure of which the materials are being processed.
E. g., Antenna dish

5) Evaluator's comments to be filled in by GSFC evaluator. A = approved, NA = not approved, SA = see attached document for further comments.

FIGURE B.5 GSFC SPACECRAFT MATERIALS PROCESSES LIST

MATERIAL USAGE AGREEMENT		C	USAGE AGREEMENT NO.:		REV.	PAGE OF
PROJECT:	SYSTEM:	SUBSYSTEM:	ORIGINATOR:		ORG./CONTRACTOR	
PART NUMBER(S)	USING ASSEMBLY(S)		ITEM DESCRIPTION		ISSUE	
MATERIAL DESIGNATION	MANUFACTURER		SPECIFICATION		PROPOSED EFFECTIVITY	
MATERIAL CODE			LOCATION	ENVIRONMENT		
THICKNESS	WEIGHT	EXPOSED AREA	HABITABLE 0	PRESSURE PSIA	TEMPERATURE of	MEDIA
			NONHABITABLE 0			
APPLICATION						
RATIONALE:						
ORIGINATOR:			PROGRAM MANAGER:			DATE :
MATERIALS APPLICATIONS EVALUATION BOARD DISPOSITION						
CHIEF:	DATE	APPROVE	REJECT DEFER		MAEB MEMO NR.	
SECRETARY:					EFFECTIVITY	
REMARKS:						

FIGURE B.6 MATERIAL USAGE AGREEMENT FORM

APPENDIX C

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C1. ACCESS LOW RATE DATA POST MISSION CUSTOMER DATA PRODUCTS

This appendix describes the ACCESS low rate post mission customer data products and their formats. ACCESS records avionics user data subsets and generates user data products. The final product is an ISO 9660 standard CD of files, with each file containing one data type. The data is stored in the files as binary data in the form of packets, as described in tables 2.13 through 2.18 of the CARS document. Asynchronous (UART) data is stored as formatted data, with an E5 header, even if the user received the data as unformatted real time during the mission. The packets within the files will be in the order in which they are received.

Data files stored to CD can be accessed with any machine that uses the ISO 9660 standard. A hardcopy of the files on the CD will be included with the data product. This listing will include the filenames of each file on the CD in the order that they are stored in the product.

Data files are named as defined below:

TABLE C.1 USER DATA FILES FILENAME

Data Type	Msg Type in Packet	Real-time Filename
Asyncronous (UART)	2	USER#.UAR
Analog	3	USER#.ANA
HH Ancillary	4	USER#.CCG
STATUS	6	USER#.LNK
STATUS	5	USER#.CMD

Note: The symbol # above stands for the customer identification number (CID) on the packets.

TABLE C.2 USER LOW RATE DATA FILES

Data Type	Msg Type in Packet	Real-time Filename	Record Length (bytes)
(Asynchronous UART)	2	USER#$.UAR	max 132, min 11
Customer Analog Data	3	USER#$.ANA	43
HH Ancillary Data Message	4	USER#$.CCG	21
Command Completion Status	5	USER#$CMD	13
Data Link Status	6	USER#$.LNK	12

Note:

- \# represents the customer identification number (CID) on the packet.
- $ represents the version of that file (i.e., USER1A.UAR, USER1B.UAR, ...); files are in the order in which they were received.

C2. POST MISSION CUSTOMER DATA PRODUCTS: MEDIUM RATE DATA

This appendix describes the medium rate data post-mission data products and formats generated by ACCESS for each customer. ACCESS records all avionics user medium rate data subsets via the Medium Rate DeMux Unit (MRDU) and generates user data products.

The data is recorded as one binary file that contains a continuous stream of user medium rate data. This data is written to a file in blocks of 10 user frames each, except the last block which may contain less than 10 user frames. Once the file has 215MB of data, a new file is automatically started.

The final data product for the customer is stored on ISO 9660 standard CDs. Data files stored to CD can be accessed with any CD-ROM that uses the ISO 9660 standard. On each CD, there will be multiple files of 215MB or less containing a continuous stream of user data. There will be no headers or trailers. Only customer data received with a correct customer sync and customer ID will be stored to the CD.

There may be separate CDs for real-time data recorded during the mission and for data played back after the mission. The number of CD's will depend on the file sizes.

Table C.3 shows the medium rate data files naming convention.

TABLE C.3 USER MEDIUM RATE DATA FILES

Date Type	Real-time Filename	Playback Filename	File Size
Medium Rate Data	USER#$.MRD	PB#$.MRD	Up to 215 MB

Note:
- \# represents the customer identification number (CID) on the packet.
- $ represents the version of that file (i.e., USER1A.MRD, USER1B.MRD, ...); files are in the order in which they were received.

Appendix D

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APPENDIX D
HITCHHIKER GROUND DATA SYSTEM, FACILITIES, AND OPERATIONS

D1. HITCHHIKER GROUND SYSTEM OVERVIEW

The overall objective of the HH Ground System is to provide efficient service to a variety of customers and "transparent" interfaces such that the experiment-provided Customer Ground Support Equipment (CGSE) can be used for experiment design and development, as well as mission operations. To meet this objective, the HH Project requires the Mission Operations and Data Systems Directorate to provide standardized capabilities available to project organizations and the Engineering Directorate to provide specific HHC and customer data processing and CGSE interfaces via the Advanced Carrier Customer Equipment Support System (ACCESS).

Figure D.1 shows an overview of the HH ground system. The CGSE has the primary responsibility for providing the payload command and telemetry processing functions. Payload commands may also be executed from the ACCESS but this method is primarily used for contingency purposes only. The ACCESS provides the normal mode for commanding the HHC avionics. In addition, limited capability for commanding the HHC via an AFD switch panel is available to the crew. This capability is solely for activation and deactivation of the HHC and payload power, and for safing a payload in a contingency situation.

Commands initiated by the CGSE together with any commands from the ACCESS are transmitted from the HH Payload Operations Control Center (POCC) to the JSC MCC utilizing the NASA Communications (NASCOM) capabilities. Following execution of standard MCC command management functions, the commands are uplinked to the Orbiter and HHC via the White Sands Complex (WSC).

Command acknowledgment capabilities are available in the system. The MCC generates a Command Acceptance Pattern (CAP) and transmits it to the HH POCC and the Shuttle/POCC Interface Facility (SPIF). The SPIF processes the CAPs for auditing purposes and provides display information which is available to the operations personnel within the HH POCC. The CAP and HHC command monitor information can be made available to the CGSE as an option.

Telemetry received at the GSFC POCC via NASCOM includes the JSC composite data stream from the JSC MCC and the HHC medium rate composite data stream from the WSC. The JSC composite data stream includes the HHC low rate data stream downlinked via the Payload Data Interleaver (PDI), CAPS, and Calibrated Ancillary System (CAS) data.

Downlinked Shuttle systems telemetry, also called Shuttle ancillary data, is received at the JSC in counts, not engineering units. All parameters, called measurement stimulus identifiers -- MSIDs, are captured and calibrated into engineering units. These MSIDs are available to users via the CAS in realtime and via the Orbiter Data Reduction Complex (ODRC) non-realtime. The available MSIDs are transmitted to GSFC as CAS data.

The HHC low rate data stream is processed by the ACCESS to extract the HHC internal data stream and individual experiment data stream(s). The ACCESS extracts Orbiter CAS data for processing and forwarding to the individual experiment CGSE(s) and for recording. The ACCESS also demultiplexes the HHC medium rate composite data stream to extract the individual experiment data stream(s) and the HHC low rate data stream. The ACCESS processes the data following the mission to provide post mission data products for delivery to the customer.

The SPIF also receives the JSC composite data stream. This facility extracts and records various Orbiter information such as CAS data and formats it for display and hardcopy. These displays are made available to the operations personnel within the POCC via Closed Circuit Television (CCTV). The SPIF provides the Orbiter data to the Flight Dynamics Facility (FDF) as input for orbit and attitude display generation. In addition, the SPIF supports the JSC interface by providing several other services including data facsimile.

The FDF supports the HH and customer operations personnel by processing the Orbiter data obtained from the SPIF into a range of displays. These displays include alphanumeric information, world map plots and other graphical displays. The display information is available to the operations personnel within the POCC via CCTV. The FDF will, as an optional service, provide mission analysis for science operations.

ACCESS provides capability for remote workstations (usually at the JSC Customer Support Room (CSR)) via a TCP/IP connection.

Customer GSE in the POCC may connect to the Internet via a standard ethernet ten-Base-T connection for communication to a customer remote site or other Internet function.

In addition, the Project is developing a specification for connecting customer GSE to ACCESS via TCP/IP in place of or addition to the RS-232 connections. This will allow command and low speed data products to be communicated with a remote customer location via the Internet as well as CGSE in the POCC and allow remote preflight checkout of CGSE to ACCESS communications without the need for bringing customer equipment to GSFC. Customers interested in the TCP/IP option should contact the Project Office for details.

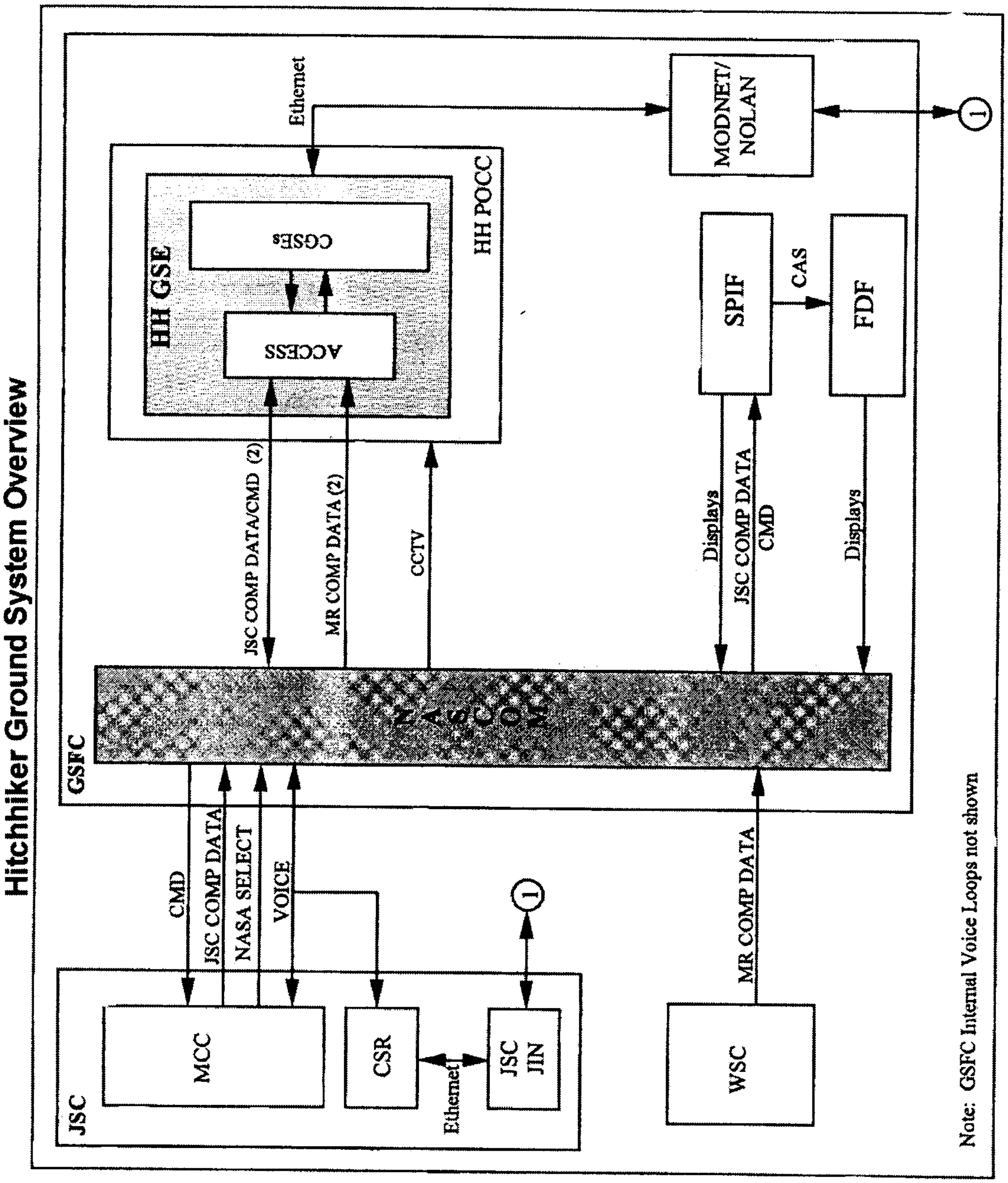

FIGURE D.1 HITCHHIKER GROUND SYSTEM OVERVIEW

D2. HITCHHIKER FLIGHT OPERATIONS TEAM (FOT) AND PAYLOAD OPERATIONS CONTROL CENTER (POCC)

Figure D.2 illustrates the HH POCC. The POCC is located in the Attached Shuttle Payload Center (ASPC) at the GSFC in Building 14, Room S287. The POCC is composed of a Mission Operations Area, an Experimenter Area, and a Common Area. The POCC Experimenter Area is approximately 800 square feet to accommodate experiment operators and equipment. Access to the control center is controlled with key cards. The POCC Experimenter Area will be provided with flexible and reconfigurable workstations for each experiment (four total).

The Experimenter Area will be provided with one 3'x7' (approximate) console per two operator positions for each experiment and at least 1 quad power outlet (110V AC at 15 A) for each operator position. One Voice Distribution System (VDS) key set for each operator position will be located in the Experiment Area. The VDS provides an interface to the voice communications network between the various NASA centers and also within the GSFC. Both black and white (b/w) and color CCTV displays with both b/w and color snap capability for every two operator positions will be located in the Experimenter Area. Two large screen color CCTV monitors, two UTC clocks, two MET clocks (with MET day), two countdown clocks, and four external telephone lines/units with data capability are situated in the Experimenter Area. Ten Base-T Network connections are also available in the experimenter areas.

Environmental conditioning in the POCC will maintain equipment temperatures at 21oC + 2oC, with a relative humidity of 50% + 10%.

The POCC Common Area of approximately 200 square feet accommodates a refrigerator, microwave, coffee machine, equipment storage area, xerox machine, and coat rack.

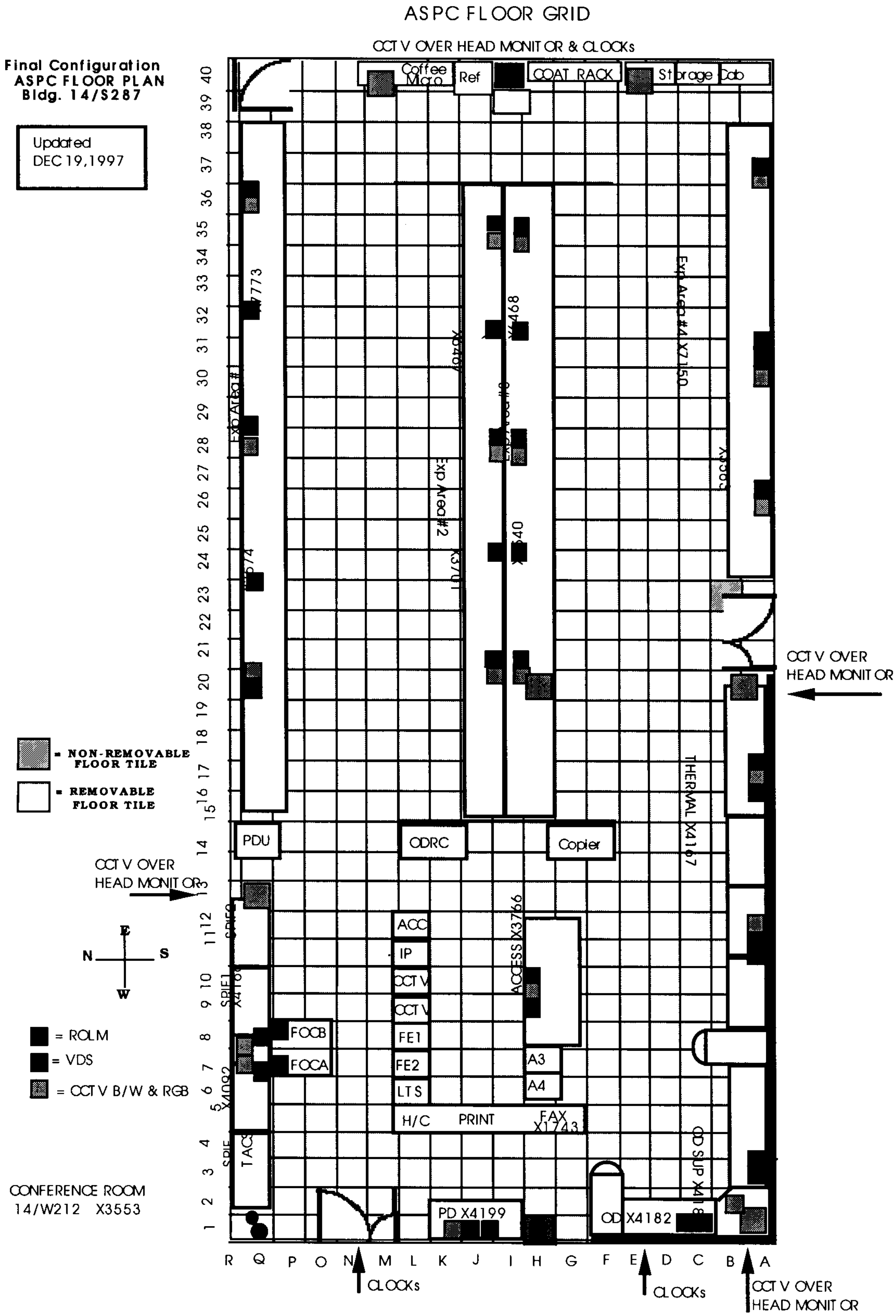

FIGURE D.2 ASOC FLOOR PLAN

D3. HITCHHIKER MISSION READINESS TESTING

A series of tests will be performed by the GSFC Mission Readiness Manager (MRM) in support of the HH customer to verify the readiness of ground facilities to support the HH mission. These tests will verify the functionality of the Ground Data System (GDS) with the payload and the JSC MCC. The HH customer will have completed all payload engineering tests prior to participation in HH mission readiness testing.

Three kinds of tests will be run:

1. Payload to GDS Interface Verification Test (IVT) (L-6 mos)
2. GDS Integration and Test (I&T) (L-6 mos to L-1 wk)
3. JSC IVT (L-4 mos to L-2 wks)

The Payload to GDS IVT will verify the ability of the CGSE (located in the HH POCC) to send commands to and receive telemetry from the payload. During these tests, telemetry from the payload will be recorded. These HH Payload Tapes will be used in future GSFC ground system tests and simulations in lieu of a real time payload telemetry stream. Some of the HH Payload MR Tapes will be forwarded by the MRM to the WSC to be used as the source of payload telemetry during those GDS I&Ts used to verify MR telemetry interfaces between the WSC and the GSFC. Some of the HH Payload LR Tapes will be forwarded by the MRM to the JSC Shuttle Avionics Integration Laboratory (SAIL) for the production of SAIL Tapes. SAIL Tapes will be the source of payload telemetry during the JSC IVT.

GDS I&T involving all of the elements of the HH ground system will verify the end-to-end capability of the operational GDS. The HH Payload Tapes will be the source of payload telemetry during the GDS I&T. Prior to the first Joint Integrated Simulation (JIS), CAS data will be provided through playback of past mission CAS Tapes. CAS Tapes recorded during the first JIS will be the CAS source during future tests. The GDS will be functionally verified within a week of a simulation.

JSC IVTs will verify command and LR telemetry interfaces between the JSC MCC and GSFC and will be performed at the same time that the payload is being integrated at the KSC. The payload telemetry will be provided through playback of the SAIL Tapes. JSC IVTs are normally scheduled immediately prior to each JIS.

Following the final GDS I&T (typically one week prior to the mission), the HH ground system will be completely verified and placed under configuration control by the MRM.

D4. HITCHHIKER OPERATIONS TRAINING

The HH Project and MRM will coordinate various training activities to ensure the operational readiness of the ground data systems and personnel supporting the HH mission. The HH Project will have completed all system tests prior to participation in simulations.

Three kinds of training shall be provided:

1. Classroom Training (L-2 yrs to L-3 mos)
2. Goddard Internal Simulations (GISs) (L-3 mos to L-2 wks)
3. Joint Integrated Simulations (JISs) (L-3 mos to L-2 wks)

A series of classroom training sessions will be held to familiarize customers with HH and Orbiter services, data systems configurations, and all aspects of mission operations. There are three sessions of training. Session #1 occurs at L-2 years, Session #2 occurs at L-6 months, and Session #3 occurs at L-3 months.

GISs will be conducted to exercise operational procedures and train operations personnel. During the GISs, the ground system will be configured using only GSFC facilities, requiring the participation of all elements of the GSFC complex involved in the mission. These simulations will test GSFC internal data, management, and operations interfaces. HH POCC procedures will be emphasized during these exercises.

The GISs will simulate selected portions of the planned mission timeline. The GDS will be configured to simulate normal operations as closely as possible.

JISs will be conducted to establish operability of the overall ground system including the links to the JSC MCC. During the JISs, the ground system will be configured as for mission operations. The JSC MCC will check commands, generate CAPs, and generate the composite data stream except for the HH PDI data. The HH payload telemetry will be simulated via playback of the HH Payload Tapes from the GSFC. The simulated CAS data sent from JSC will be recorded during the first JIS. This recorded CAS data will be played back during future tests and simulations.

JISs will be treated as an actual flight for the crew and all ground operations personnel and involve all facilities participating in the mission including the GSFC, the JSC MCC and other NASA centers and/or remote POCCs. The crew will participate from the Orbiter simulator at the JSC.

The JISs will simulate selected portions of the planned mission timeline. Coordination between the JSC MCC and the HH POCC will be emphasized during these exercises. These simulations will test data, management, and operations interfaces. Activities may require multiple-shifts coverage of multiple-day events.

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APPENDIX E
NASA HITCHHIKER PROGRAM
CUSTOMER PAYLOAD REQUIREMENTS (CPR)

E.1 INTRODUCTION

This Customer Payload Requirements (CPR) plan begins the contractual process and defines preliminary agreements between NASA/GSFC and the HH customer concerning the unique information needed for the preparation, flight and disposition of the payload. The general plans for the handling of HH payloads are defined in the HH CARS Document #740-SPEC-008 (formerly #HHG-730-1503-07).

Upon signature of this CPR plan, the payload customer agrees to meet all applicable requirements, (i.e. mechanical, electrical and thermal interfaces and deliverables, safety assessments and deliverables, etc.) as specified in the HH CARS document, for flight as a HH payload. In addition, signature of this CPR plan certifies that this payload contains no items having commercial value to be used for commemorative purposes and financial gain.

The CPR plan is considered a Quality Record as defined by ISO 9000 and, as such, will become a controlled document within the NASA/GSFC HH Configuration Management Office. It is not, however, intended as an iterative definition of customer requirements. Therefore, no effort will be made to update the CPR plan after initial approval.

Instead, customer requirements provided in the CPR plan 2will be used as the preliminary input to all necessary documents required by the NSTS, specifically the Payload Integration Plan (PIP) and associated PIP Annexes. Thereafter, the PIP and PIP Annexes will be iterated to reflect evolving customer requirements. Signature of this CPR plan by the customer provides authority to the HH Mission Manager to represent the payload customer in the review and approval of the PIP and PIP Annexes.

The PIP and PIP Annexes are maintained under configuration control at NASA/JSC as part of the Flight Data File (FDF). Copies of these documents are available to the payload customer upon request.

ATTACHMENT E.1
NASA HITCHHIKER PROGRAM
CUSTOMER PAYLOAD REQUIREMENTS (CPR)

HITCHHIKER PROGRAM

CUSTOMER PAYLOAD:

CUSTOMER:

DATE:

CUSTOMER APPROVAL:

NASA APPROVAL:

Payload Manager	Date	HH Mission Manager	Date
Payload Organization	Date	HH Project Manager	Date

TABLE E.1 CUSTOMER DATA

CUSTOMER PAYLOAD NAME: ______________________________

CUSTOMER PAYLOAD ACRONYM: ______________________________

CUSTOMER NAME, ADDRESS, AND TELEPHONE NUMBER: ______________

____

____

NAMES AND PHONE NUMBERS OF CUSTOMER CONTACTS:

PROGRAM MANAGER: ______________________________

PAYLOAD MANAGER: ______________________________

SAFETY: ______________________________

ELECTRICAL: ______________________________

SOFTWARE: ______________________________

MECHANICAL: ______________________________

THERMAL: ______________________________

OPERATIONS: ______________________________

SCIENCE: ______________________________

CALENDAR INTERVAL DURING WHICH FLIGHT IS REQUESTED: ____________

EARLIEST DATE AT WHICH QUALIFIED PAYLOAD WILL BE AVAILABLE: ______

E2. PAYLOAD DESCRIPTION

E2.1 Mission Objectives

Provide a brief description of the mission objectives of this payload.

E2.2 Physical Description

The payload consists of physically separate assemblies which are listed in Table E.2. For each assembly the weight, size, and field of view (if any) requirements are given, along with allowable ranges for operating and nonoperating (storage) temperatures and average power dissipation. Photographs or detailed drawings of each assembly are enclosed. The mounting requirements are either "Standard canister," "Opening-lid canister," "Plate", or "Direct". Figure E.1 is a sketch showing the assemblies and any cables interconnecting the assemblies, the location of the Carrier standard electrical interconnects, the location of surfaces requiring fields of view, and the location of any items requiring access such as purge ports or "red-tag" covers.

E2.3 Payload Functional Description And Method

Provide a brief functional description of the payload, describing the role each element plays in achieving the mission objectives. This description must cover all modes of operation.

E2.4 Operational Scenario

E2.4.1 Operations Description

Provide a brief description of the operations scenario to achieve the mission objectives. Describe the manner in which the payload will be operated, including any necessary interaction between astronauts or ground operations personnel and the payload.

E2.4.2 Critical Procedures

Identify any operations procedures which are critical to mission success or payload safety.

TABLE E.2 PAYLOAD ASSEMBLIES

PAYLOAD ASSEMBLIES

ASSEMBLY NAME	WEIGHT (lbs)	SIZE			MOUNT TYPE	FOV (deg)	OPERATING TEMPERATURE		NON-OPERATING TEMPERATURE		STORAGE TEMPERATURE	
		X (in)	Y (in)	Z (in)			MIN	MAX	MIN	MAX	MIN	MAX

(CUSTOMER SUPPLIED DRAWING)

FIGURE E.1 PAYLOAD GENERAL ARRANGEMENT

E3. PAYLOAD REQUIREMENTS FOR CARRIER STANDARD SERVICES

E3.1 Carrier To Payload Electrical Interfaces

E3.1.1 Hitchhiker Payloads

The payload will meet the standard electrical interface requirements (including connectors, pin assignments, impedances, signals, levels, etc.), specified in the CARS. This payload will require of the standard signal interface connections or "ports" and ________ of the standard power interface connections or "ports". For each of the ports, a copy of Table E.3.1.1 must be filled in to show which of the standard electrical services will be required by the payload. Unused services will be left open circuited in the payload unless other termination is required by GSFC.

E3.1.2 HH-J Payloads

The payload will meet the standard electrical interface requirements (including connectors, pin assignments, impedances, signals, levels, etc.), specified in the CARS. HH-J payloads are allotted a subset of the standard signal interface functions. This payload will require ________ of the standard signal interface connections or "ports".

(NOTE: HH-J payloads have the option of orbiter power or battery power. Choose which of the following two sentences describes your option.)

This payload will also require ________ of the standard power interface connections or "ports".

or

This payload will supply internal batteries to power the experiment.

For each of the ports, a copy of Table E.3.1.2 must be filled in to show which of the HH-J electrical services will be required by the payload. Unused services will be left open circuited in the payload unless other termination is required by GSFC.

TABLE E-3.1.1 STANDARD AVIONICS PORT REQUIREMENTS (HH CUSTOMERS)

PORT NUMBER: .... __________

SIGNAL INTERFACE CONNECTION

NUMBER OF BILEVEL COMMANDS (4 MAX) (2.4.2): .... __________

NUMBER OF THERMISTORS (3 MAX) (2.4.7.2): .... __________

ASYNCHRONOUS UPLINK (2.4.4): .... __________ CPS

ASYNCHRONOUS DOWNLINK (2.4.5): .... __________ CPS

MEDIUM RATE KU-BAND DATA RATE (2.4.6): .... __________ KB/S

ANALOG DATA (2.4.7.1): .... __________

IRIG-B GMT (2.4.8): .... __________

GMTMIN (2.4.8): .... __________

CREW PANEL SWITCHES (2.4.10): .... __________

ORBITER CCTV INTERFACE (2.4.12): .... __________

PORT TO PORT INTERCONNECT REQUIRED (2.4.11): .... __________

POWER INTERFACE CONNECTION

POWER CIRCUIT A – 10 AMPS MAX: .... __________ AMPS

POWER CIRCUIT B – 10 AMPS MAX: .... __________ AMPS

POWER CIRCUIT HTR - 2.5 AMPS MAX: .... __________ AMPS

TOTAL ENERGY REQUIRED A&B:. .... __________ KWH

OTHER (DEFINE): .... __________

TABLE E-3.1.2 HH-J AVIONICS PORT REQUIREMENTS

PORT NUMBER: .... __________

SIGNAL INTERFACE CONNECTION

NUMBER OF BILEVEL COMMANDS (4 MAX) (2.5.2.5): .... __________

NUMBER OF THERMISTORS OR MALFUNCTION INPUTS (3 MAX)
(2.5.2.3 & 2.5.2.10): .... __________

ANALOG DATA (2.5.2.4): .... __________

RELAY K1 (2.5.2.2): .... __________

RELAY K2 (2.5.2.2): .... __________

CAN TO CAN INTERCONNECT REQUIRED (2.5.2.6): .... __________

POWER INTERFACE CONNECTION

POWER CIRCUIT A - AMPS MAX (10 AMPS MAX): .... __________ AMPS

POWER CIRCUIT B - AMPS MAX (10 AMPS MAX): .... __________ AMPS

POWER CIRCUIT HTR - AMPS MAX (10 AMPS MAX): .... __________ AMPS

TOTAL ENERGY REQUIRED A&B (4 Kwh MISSION MAX): .... __________ KWH

OTHER (DEFINE): .... __________

E3.2 Carrier To Payload Mechanical Interfaces

The payload will meet the standard mechanical interface requirements specified in the CARS. Mechanical drawings and other documentation will be supplied in sufficient detail for GSFC to perform user accommodation studies and ultimately draft the MICD. Section 2 of CARS addresses most of the information required for accommodation studies. The MICD Requirement Information List in Section 3.1.1.3.2 of the CARS lists the data required for inclusion on the MICD.

E3.3 Carrier To Payload Thermal Interfaces

The customer will meet the standard thermal interface requirements specified in Section 2.2 of the CARS. A description of the thermal design concept for the payload follows:

E3.4 Ground Operations Requirements

Table E.4 defines the handling and ground services required by the payload. Ranges are expected to be typical clean room environments unless otherwise specified by the customer.

TABLE E.4 GROUND OPERATIONS REQUIREMENTS

(Ranges are expected to be cleanroom environments unless specified uniquely.)

a. MAXIMUM AND MINIMUM ALLOWED STORAGE TEMPERATURES: .... _____

b. MAXIMUM AND MINIMUM ALLOWED RELATIVE HUMIDITY: .... _____

c. CLEANLINESS REQUIREMENT FOR PAYLOAD INTEGRATION & TESTING: ..... _____

d. CUSTOMER SUPPLIED GROUND SUPPORT EQUIPMENT REQUIRED TO SERVICE PAYLOAD. (EXCLUDING CGSE IN SECTION 3.4): .... _____

e. REQUIREMENTS FOR GASES OR LIQUIDS: .... _____

f. REQUIREMENTS FOR PAYLOAD SERVICING AT GSFC: .... _____

AT KSC: .... _____

g. REQUIREMENTS FOR ACCESS DURING ORBITER INTEGRATION: .... _____

h. REQUIREMENTS FOR ACCESS ON LAUNCH PAD: .... _____

i. REQUIREMENTS FOR POST-LANDING ACCESS: .... _____

j. ANY OTHER SPECIAL REQUIREMENTS FOR HANDLING AT INTEGRATION AND TEST OR LAUNCH SITE: .... _____

k. SIZES AND WEIGHTS OF ITEMS REQUIRED FOR SHIPMENT TO INTEGRATION OR LAUNCH SITES (EXCLUDING CGSE OF Table E.14): .... _____

ITEM	SIZE	WEIGHT

E3.5 Safety

Table E.5 requires a "no" or "yes" answer to items related to payload safety. Details of items identified "yes" are also given.

TABLE E.5 PAYLOAD SAFETY RELATED ITEMS

a.	CONTAINS PRESSURIZED VOLUME(S):	________
b.	CONTAINS RADIOACTIVE MATERIAL:	________
c.	CONTAINS LIGHT OR RF SOURCE:	________
d.	EXTERNAL ELECTRIC OR MAGNETIC FIELDS:	________
e.	EXTERNAL ELECTRICALLY CHARGED SURFACE:	________
f.	EXTERNAL HOT OR SHARP SURFACE:	________
g.	CONTAINS TOXIC MATERIAL (E.G., HG, BE):	________
h.	CONTAINS OUTGASSING MATERIAL:	________
i.	VENTS FLUIDS OR GASES:	________
j.	CONTAINS CRYOGENS:	________
k.	HAS MOVING EXTERNAL PARTS:	________
l.	CONTAINS EXPLOSIVE DEVICES:	________
m.	CONTAINS OR GENERATES EXPLOSIVE OR FLAMMABLE MATERIAL OR GAS:	________
n.	CUSTOMER SUPPLIED GSE CONTAINS RADIOACTIVE MATERIAL, LIGHT OR RF SOURCES, PRESSURIZED VOLUME:	________
o.	BATTERIES:	________
p.	ANY OTHER HAZARD:	________

DESCRIPTION OF IDENTIFIED HAZARD(S):

E3.5.1 Safety Matrix

The Payload Safety Matrix and Descriptive Data Form contained in Appendix A, figures A.4, A.5, A.6 and A.7 should be used to provide an estimate of payload safety hazards. The intent of the forms is to assist in tabulating identified hazards associated with payloads and GSE. Directions for preparing these forms are given in Appendix A, page A-10 for the Payload Safety Matrix and A-13 for the Descriptive Data Form.

E4. MISSION OPERATIONS REQUIREMENTS

On-orbit operations are provided by the Mission Operations Manager using the facilities of the GSFC Mission Operations and Data Systems Directorate. The following information is necessary to determine the support required for the payload. (All paragraphs apply to both HH and HH-J payloads.)

E4.1 Operational Scenario

Provide a more detailed description of your experiment operations. Include overall mission operations as well as individual cycles such as activation, outgassing, cooldown, warmup, door open, checkout, calibration, data take and deactivation. Define the duration of each phase. Include information on orbiter inclination, orbiter altitude, orbiter attitude and whether operations must occur during orbit day or night. Clearly identify which of these items are required vs desired.

E4.2 Experiment Power

In Table E.6, provide power profiles for your equipment. Each phase of your experiment operations should be included. The "idle" power involves the powering of base equipment; base equipment is activated once, at the beginning of the payload activation and draws power continuously until the final payload deactivation. The "nominal" power is considered the typical power dissipation during the actual experiment data take phases of the operations; the "peak" power is the maximum (short term) power dissipation during the experiment data take phases of operations.

TABLE E.6 EQUIPMENT POWER PROFILE

PHASE/EQUIPMENT	Power (watts)			COMMENT/DURATION Attitude
	Idle	Nominal	Peak	

E4.3 Thermal Operations

Describe the thermal operations of your experiment, i.e. do you have heaters? Are they commandable or thermostatically controlled? Describe your thermal constraints in Table E.7 below:

TABLE E.7 THERMAL CONSTRAINTS

Thermostatic Equipment	Duty Cycle (Percent)	Power (watts)	Comment/Duration/Attitude
			Bay-to-Sun (Hot)
			Bay-to-Earth (Nominal)
			Bay-to-Space (Cold)

PAYLOAD with heaters OFF:

Attitude	Maximum Duration	Recovery Time	Effect if Violated
Bay-to-Sun			
Bay-to-Earth			
Bay-to-Space			

PAYLOAD with heaters ON:

Attitude	Maximum Duration	Recovery Time	Effect if Violated
Bay-to-Sun			
Bay-to-Earth			
Bay-to-Space			

E4.4 Experiment Commanding

E4.4.1 Hitchhiker Customers

Describe your command methodology such as time tagged, sequenced and/or realtime commands. Include a commanding timeline for each cycle. Command times should be broken down into the smallest reasonable periods to provide maximum flexibility with the orbiter and other payloads. Identify any hazardous or time-critical commands.

E4.4.2 HH-J Customers

Activation and deactivation of the payload will be via PGSC by a crew member. The crew will activate the payload by setting relays K3 and K4. If required, define which of the following commands need to be sent, at what intervals, and in what sequence.

TABLE E.8 PAYLOAD CONTROL FUNCTIONS

RELAY	State	Payload Functions	Intervals
K1	Hot (H) Latent (L)		
K2	Hot (H) Latent (L)		
Bilevel 1	High Low		
Bilevel 2	High Low		
Bilevel 3	High Low		
Bilevel 4	High Low		

E4.4.3 Critical Commands

Identify any critical commands which, if incorrectly transmitted, could damage the payload.

E4.5 Experiment Telemetry

E4.5.1 Hitchhiker Customers

Your experiment telemetry (low rate, medium rate and/or video) is described in Tables E.9 and E.10. Is the data continuous or packet-type output? Produce a telemetry timeline for each cycle. How much telemetry is required/desired for each cycle? How many hours total do you expect to downlink data during the mission? Describe any data recording capabilities as well as any need for dumping such data. Will the data be dumped forward or backward? Are there any expected anomalies in the down link data (i.e., timing jumps, burst data, fill data)?

TABLE E.9 LOW RATE DATA STREAM CONTENTS

(NOT REQUIRED FOR HH-J)

COMMANDS/TELEMETRY	BAUD	RS232	RS422
Commanding to ACCESS	**1200**		
Async Data Unformatted	**1200**		
Async Data Formatted	**19.2k**		
Analog Data	**19.2k**		
ACCESS Ancillary Data	**19.2k**		
Shuttle Orbit/Attitude Data	**19.2k**		
PCM-A	**19.2k**		
PCM-B	**19.2k**		
Command Status	**19.2k**		
Data Link Status	**19.2k**		
ACCESS AIA Data	**19.2k**		

Refer to CARS section 2.4.11.2 for a description of the data formats.

TABLE E.10 MEDIUM RATE DATA CHARACTERISTICS

Experiment Name	Rate (Kbps)	Frame Sync Pattern (Hex)	Frame Counter Location	Minor Frame (mf) Size (bytes)	Major Frame Size (mf)	FILL PATTERN
Ex:						
DXS	100	0005BB2	BYTE 2	1024	256	FFF

E4.5.2 HH-J Customers

Using Table E.11, define the sampling interval of any payload telemetry and whether the crew needs the data displayed. Are the commands that need to be sent as determined by telemetry readings?

TABLE E.11 PGSC PAYLOAD STATUS DATA

TELEMETRY	SAMPLING INTERVAL	DISPLAYED
Thermistor 1		
Thermistor 2		
Thermistor 3		
Analog		
K3 Current Draw		
K4 Current Draw		

E4.6 Crew Involvement

Describe any special crew operations such as photographic coverage or Payload General Support Computer (PGSC) interaction with the payload. Switch panel and attitude maneuver control need not be specified.

E4.7 Orbiter Pointing

Describe any orbiter orientations required/desired for each cycle of your experiment operations, such as attitude hold, rotation, target track, gravity gradient, free drift, etc. Deadbands should be specified as well as durations for each orientation. Identify your restrictions to orbiter pointing in Table E.12.

TABLE E.12 ORBITER POINTING RESTRICTIONS

Restriction	Duration	Angle	Effect If Violated
RAM			
Sun			
Moon			
Earth			
Earthlimb			
Umbra			

E4.8 Instrument Field Of View

Describe your instrument Field of View (FOV). Include the instrument axis orientation and origin relative to the orbiter, instrument motion, field of view location and size.

E4.9 Contamination Constraints

Identify your contamination constraint tolerance in Table E.13.

TABLE E.13 CONTAMINATION CONSTRAINTS

Contaminant	Duration of Exposure	Time Until Operations Resume	Effect if Violated
Payload bay lights on			
Flash Evaporator System			
(FES) operations			
Fuel Cell Purge (FCP) Operations			
Vernier Reaction Control System (VRCS) burns			
Primary Reaction Control System (PRCS) burns			
Orbital Maneuvering System (OMS) burns			
Electron Contamination Regions (ECR)			
Water Dumps			
South Atlantic Anomaly (SAA)			

E4.10 Customer Supplied Ground Support Equipment (CGSE)

E4.10.1 Hitchhiker Customers

The payload will require two customer-supplied and operated CGSEs. One (the operations system) will provide control and display during integration and test activities of the payload to carrier, system tests, end-to-end tests, Joint Integration Simulations, and flight operations at GSFC. The other (the test system) will support the functional tests, CITE tests, and Orbiter IVT test at KSC. Table E.14 provides information about the CGSEs. Diagram E.1 indicates the configuration of the CGSE and the ACCESS both for testing and for operations.

E4.10.2 HH-J Customers

The payload does not require a customer-supplied and operated CGSE. Analog and/or temperature data collected during the mission will be available post-flight.

TABLE E.14 CUSTOMER GROUND SUPPORT EQUIPMENT (CGSE)
(NOT REQUIRED FOR HH-J)
TEST SYSTEM

TYPE/MAKE OF UNIT	WEIGHT	POWER (Voltage/Current)

Will the CGSE transmit commands?______________________________
Will the CGSE receive low rate data?______________________________
Will the CGSE receive medium rate data?______________________________
Number of standard 115 VAC outlets required:______________________________
Floor space required:______________________________Sq.Ft.

OPERATIONAL SYSTEM

If there will be a backup system, describe that separately (i.e., equipment available but not set up, not backup, etc.)

TYPE/MAKE OF UNIT	PURPOSE	WEIGHT	POWER (Voltage/Current)

Number of standard 115 VAC outlets required: ______________________________
Floor space required: ______________________________Sq.Ft.
Air conditioning required? ______________________________
Will the CGSE transmit commands? ______________________________
Will the CGSE receive low rate data? ______________________________
Will the CGSE receive playback data? ______________________________
During/Post mission? ______________________________
Will the CGSE receive medium rate data? ______________________________
Will the CGSE receive orbit/attitude data? ______________________________

DIAGRAM E.1

CGSE/ACCESS CONFIGURATION

(NOT REQUIRED FOR HH-J)

TEST:

OPERATIONS:

E4.11 Payload Operations Control Center (POCC) Requirements

E4.11.1 Hitchhiker Customers

Approximately how many people/positions do you intend to have in the POCC during the mission? Identify the positions.

How many customer space units will you require? One customer space unit includes:

1 3' x 5' table
2 standard outlets
1 video outlet port
1 data phone
1 call director (2 people can talk/listen)
1 color display unit

Identify any additional requirements not listed above.

Will you need additional space for non-operations personnel that will be monitoring the mission?

E4.11.2 HH-J Customers

POCC commanding and telemetry downlink of HH-J payloads is not available.

E4.12 Post-Mission Data Products

E4.12.1 Hitchhiker Customers

Do you desire Calibrated Ancillary System (CAS) parameter data?______________

Do you desire to receive post-mission products of your telemetry data? _________

If yes, complete the following:

PRODUCT	MEDIUM	TEST CD
Low Rate Tim	CD	
Medium Rate Tim	CD	

Data will be provided on Compact Disks (CDs).

What name and address should these products be sent to?

E4.12.2 HH-J Customers

Telemetry and commanding sequence log files captured during the mission will be available on 3.5" floppy disk.

E5. PAYLOAD REQUIREMENTS FOR OPTIONAL SERVICES

This section will contain descriptions and estimated costs for any optional services to be provided.

E6. TBDS AND DUE DATES

Identify any TBDs and associated due dates in Table E.15.

TABLE E.15 TO BE DETERMINED ITEMS

SECTION	DESCRIPTION	DUE DATE

Note: Upon signature of this CPR the customer assumes agrees to meet all the applicable customer requirements, i.e safety, mechanical and thermal model delivery, etc. as specified in the CARS document, for flight as a Hitchhiker payload.

Appendix F

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APPENDIX F
THERMAL BLANKET REQUIREMENTS

F1. INTRODUCTION AND SUMMARY

The intent of this Appendix is to provide the principle investigators for Shuttle-borne experiments enough information to design and fabricate insulation systems to protect scientific instruments from Shuttle environmental temperature extremes. While special requirements occasionally dictate the localized use of a foam or batt insulation, the great majority of payloads will be insulated with Multi-Layer Insulation (MLI) discussed in this section. Special requirements, however, occasionally dictate localized use of a foam or batt insulation.

A typical MLI contains 10 to 50 layers of a metallized film, with alternating layers of a low-density spacer material. MLI relies on low-contact conduction between layers, low-gas conduction in the vacuum environment, and highly reflective metal surfaces to minimize both conduction and radiation heat transfer. This information is intended primarily for the experimenter with relatively little spacecraft experience who is adapting a near-room-temperature laboratory or sounding rocket-class instrument for flight on the Shuttle.

The information provided has been compiled from existing data sources, including the Shuttle Payload Accommodations Handbook (Reference 1*), a Lockheed study of MLI insulation (Reference 2*), and from Grumman insulation data and fabrication procedures developed over a period of years in support of the Apollo lunar landing vehicle.

F2. REQUIREMENTS FOR HH APPLICATION

F2.1 Temperature Extremes

During pre-launch checkout, launch, and re-entry, the temperature of a payload insulation system is not under the experimenter's control. Since the multilayer insulation is composed of many very light-weight layers of aluminized film and spacer material, its temperature will closely follow the Shuttle bay environment temperature. The highest environment temperature reached in any of these mission phases occurs during re-entry when vents allow air in to minimize the pressure differential across the Shuttle structure. This has been established in Reference 1 as 80oC.

This criteria, along with flammability, has led to the selection of aluminized polymide (Kapton) as the standard insulation material for Shuttle payloads. Kapton is not flammable, and does not shrink or degrade at temperatures up to approximately 400oC. On-orbit, the insulation outer layer temperature depends upon the properties of the external coating and on the orientation of the surface to the sun and the Earth. Typically, insulation outer layer surface temperatures are expected to fall in the -160oC to 90oC range.

- See subsection F.3 for references

F2.2 Humidity

Aluminized Kapton is irreparably damaged by liquid water. Water dissolves the vapor-deposited aluminum which provides the high-radiation reflectance necessary for an efficient insulation system. Normal humidity levels of 30 to 50 percent existing in the laboratory or in the Shuttle bay during ground checkout will not harm the insulation system. The main consideration of exposure to normal humidity prior to thermal vacuum testing or flight is that it will require sufficient time in a vacuum to desorb the water molecules from the blanket before optimum blanket performance is reached. High humidity may be experienced during landing, so insulation systems should be inspected prior to re-use. In any application where high humidity, or indeed actual condensation on the MLI blanket is anticipated, consideration should be given to the use of gold-coated Kapton rather than the standard aluminized Kapton.

F2.3 Launch And Re-Entry Pressure Transients

Sufficient vent paths must be provided in the insulation system to prevent a pressure differential from tearing individual layers or ballooning the entire assembly away from the payload. The launch profile is the critical pressure transient, since typically, the blanket is only moderately restrained (by tape, velcro, or stand-offs) to resist motion away from the payload. To minimize lost mission time, the MLI venting system must allow rapid inner-layer venting and, hence, a rapid attainment of high effectiveness. An increasing external pressure during re-entry is less significant, since it will usually only result in slight compression of the blanket against the payload structure. Care must be taken in the design of the MLI system however, to allow repressurization of the experiment cavity.

F2.4 Off-Gassing Constraints

Any payload to be flown on the Shuttle must be designed to meet off-gassing criteria. The concern is that a molecular cloud in the vicinity of the Shuttle, plus actual condensation of off-gassed molecules on optical surfaces, can greatly degrade experiments. The primary NASA criteria is to require use of materials that exhibit less than a 1% TML, and .1% collected Volatile Condensible Material (VCM) when heated to 125oC for the NASA standard test described in Reference 3 (see subsection F.3).

F2.5 Grounding

A relatively new criteria imposed on Shuttle payloads is the grounding of the insulation system. Since the multiple alternating layers of spacer and metallized film can act as a large capacitor covering essentially the entire payload, NASA requires layer-to-layer grounding to avoid electrostatic charge buildup.

F2.6 External Coating Reflectance

NASA has established the goal of minimizing reflections off payload surfaces that could hamper the astronaut's visibility, affect crew tasks, or degrade neighboring experiments. Therefore, although specular reflecting surfaces are not forbidden, it is desirable to use diffuse reflecting external surfaces on insulation blankets. Paints and cloth coverings are generally diffuse, but a commonly used external layer is a thicker (2 mil) layer (for handling protection) of aluminized

Kapton (Kapton side out), and this is a primarily specular surface. Another common surface used to obtain a low-solar absorptivity is silver-coated Teflon (Teflon side out), which can be obtained in either specular or diffuse versions. Until a firm criteria is established, the acceptability of specular outer surfaces will probably be determined by each Shuttle vehicle manager, based on the experiments and anticipated crew tasks for that flight.

An important design consideration for external blankets is the so-called "greenhouse" effect. This occurs when the outermost layer is semi-transparent to solar energy (beta cloth, plain Kapton). If the next outermost layer has a lower temperature, then the solar energy absorbed in the layer will result in a high-layer temperature and the energy will be re-radiated equally from both sides of the layer. Therefore, when a semi-transparent outermost-layer is used, the next layer should be one-side aluminized Kapton with the Kapton side out so that the energy absorbed in this layer is primarily re-radiated to the outer layer and then to space.

F2.7 Flammability

This is an extermely important criteria requiring controlled testing of any new materials contemplated for Shuttle use. Fortunately, non-flammable materials are available that are completely acceptable for MLI systems. These are aluminized Kapton for the reflective layer and various dacron and glass nets for the separator.

F2.8 Acceleration, Vibration, And Acoustic Environments

MLI systems are extremely light (.1 lb/ft2). Hence, they are relatively easy to secure to the payload to survive the Shuttle acceleration, vibration, and acoustic environments during launch and re-entry. These design criteria are fully discussed in Reference 1 (see subsection F.3).

F2.9 Weight

The maximum weight of the payload MLI systems is not a Shuttle requirement but must be considered for standoff design and cost. The experimenter should estimate a realistic blanket-performance goal. By making use of the relatively simple design approaches and fabrication techniques discussed in this report, it is possible to obtain the highest effectiveness for a given blanket weight.

F2.10 Other Factors

There are a number of mission unique-factors the experimenter must consider. These include installation time, on-orbit access, post landing access, and re-usability.

F3. REFERENCES

1. Space Shuttle System Payload Accommodation, JSC07700 Volume XIV, Revision F.

2. NASA CR-134477 "Thermal Performance of Multi-layer Insulation", Lockheed Final Report, April 1974.

3. NASA Reference Publication 1014 "An Outgassing Data Compilation of Spacecraft Materials", January 1978.

4. Stimpson, L.D., and Jaworski, W., "Effects of Overlaps, Stitches and Patches on Multilayer Insulation", Progress in Astronautics and Aeronautics, Volume 31, 1973.

5. NASA SP 5027 "Thermal Insulation Systems", 1967.

6. Holmes, V.L., et. al., "Measurement of Apparent Thermal Conductivity of Multilayer Insulations at Low Compressive Loads", AIAA Paper 72-367, 1972.

Appendix G

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APPENDIX G

ALGORITHMS FOR ATTITUDE CONVERSIONS SIMPLIFIED CALCULATION OF SHUTTLE BODY AXIS ATTITUDES USING M50 QUATERNIONS

G1. INTRODUCTION

This appendix outlines simplified equations that can be used to calculate Shuttle body axis attitudes using M50 body quaternions in the Shuttle downlink. Both an analytical background and a simplified set of equations that can be used by a programmer will be provided. In addition, a sample personnel computer (PC) program in BASIC is provided for reference in Table G.1.

G2. ANALYTICAL APPROACH

NOTE: This section is an excerpt from the document titled: Payloads Mathematical Specifications, CSC/SD-85/6024, Prepared for NASA under Contract NAS5-27888, July, 1985.

A vector in Shuttle body axis coordinates, V_{by}, can be expressed as:

$$V_{by} = \{A_s\}_{M50} V_{M50}$$

where:

$\{A_s\}_{M50}$ = Attitude matrix relative to the Mean 2000 System (M50)

V_{M50} = Vector in M50 coordinate system

then,

$$V_{M50} = \{A_s\}_{M50}^{-1} V_{by}$$
$$= \{As\}_{M50}^{T} V_{by}$$

NOTE: Since $\{A_s\}_{M50}$ is orthogonal, its inverse is equal to the transpose.

The attitude matrix {As}M50 can be constructed from the Shuttle M50 body quaternion as follows:

$$\{A_s\}_{M50} = \begin{matrix} A11 & A12 & A13 \\ A21 & A22 & A23 \\ A31 & A32 & A33 \end{matrix}$$

where: $A11 = q1^2 + q2^2 - q3^2 - q4^2$

$A12 = 2(q2q3 - q1q4)$

$A13 = 2(q2q4 + q1q3)$

$A21 = 2(q2q3 + q1q4)$

$A22 = q1^2 - q2^2 + q3^2 - q4^2$

$A23 = 2(q3q4 - q1q2)$

$A31 = 2(q2q4 - q1q3)$

$A32 = 2(q3q4 + q1q2)$

$A33 = q1^2 - q2^2 - q3^2 + q4^2$

and (q1, q2, q3, q4) are the elements of the Shuttle M50 body quaternion.

For the i^{th} Shuttle body axis:

$(i)_{M50} = (A1i^{-1}, A2i^{-1}, A3i^{-1})^T_{M50}$

Hence $(RA_i)_{M50} = Tan^{-1} \dfrac{A2i^{-1}}{A1i\text{-}1M50}$

And $(Dec_i)_{M50} = Tan^{-1} \dfrac{A3i^{-1}}{(A1i^{-1})^2 + (A2i^{-1})^2}$

Where $(RA^i)_{M50}$ = Right Ascension of the i_{th} body axis of the Shuttle in the M50 system

$(Dec_i)_{M50}$ = Declination of the i_{th} body axis of the Shuttle in the M50 system.

* The Shuttle M50 Pitch/Roll/Yaw attitudes can easily be calculated by forming the matrix {K} as follows:

$\{K\} = \{A_s\}_{M50} \{R\}^{-1}$

where $\{R\}$ = Identity matrix

$$= \begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

and therefore $= \{R\}^{-1} = \{R\}^T = \{R\}$

Hence:

$\{K\} = \{A_s\}_{M50}$

Then, the Pitch, Roll, and Yaw using a 2-3-1 Euler rotation can be calculated:

$Pitch_{M50} = Tan^{-1} (-K13/K11)\ 0 \leq p < 2$

$Roll_{M50} = Tan^{-1}(-K32/K22) \quad 0 \leq R < 2$

$Yaw_{M50} = Sin^{-1}(K12) \quad -\pi/2 \leq Y \leq \pi/2$

To calculate the Shuttle body axis Pitch, Roll, Yaw attitudes in the LVLH coordinate system, one needs to form the {K} matrix as above and repeated here again:

$$\{K\} = \{A_s\}_{M50} \{R\}^{-1}$$

Where {R} = a matrix formed using the Shuttle position vector (r) and velocity vector (v) in the M50 coordinate system. The position and velocity vectors are obtained from the Shuttle ancillary downlink.

and

$$\{R\} = \begin{matrix} U_1^T \\ U_2^T \\ U_3^T \end{matrix}$$

where

$$U_1 = U_2 \text{ X } U_3$$

$$U_2 = \frac{-(r \text{ X } v)}{r \text{ X } v}$$

$$U_3 = \frac{-r}{r}$$

Since the {R} matrix is orthogonal, then

$$\{R\}^{-1} = \{R\}^T$$

Hence:

$$\{K\} = \{A_s\}_{M50} \{R\}^T$$

Then, the Pitch, Roll, and Yaw body axis attitudes in the LVLH system can be calculated using a 2-3-1 Euler rotation as follows:

$Pitch_{LVLH} = Tan^{-1}(-K13/K11) \quad 0<P<2$

$Roll_{LVLH} = Tan^{-1}(-K32/K22) \quad 0<R<2$

$Yaw_{LVLH} = Sin^{-1}(K12)$ - □/2<Y<□/2

G3. PC PROGRAMMING APPROACH

Simple computer programming approach using quaternions to calculate Shuttle attitudes in: M50 Right Ascension and Declination; M50 Pitch/Roll/Yaw; and LVLH Pitch/Roll/Yaw.

Step 1

Obtain the Shuttle M50 body quaternion (Q1, Q2, Q3, Q4)

Set radians to degrees constant:

RTOD = 57.2957795

Note: If high precision is required, it is suggested that double precision be used.

Step 2

Calculate the elements of the matrix {As} as follows:

```
A11  =  Q1**2+Q2**2-Q3**2-Q4**2
A12  =  2.*(Q2*Q3-Q1*Q4)
A13  =  2.*(Q2*Q4+Q1*Q3)
A21  =  2.*(Q2*Q3+Q1*Q4)
A22  =  Q1**2-Q2**2+Q3**2-Q4**2
A23  =  2.*(Q3*Q4-Q1*Q2)
A31  =  2.*(Q2*Q4-Q1*Q3)
A32  =  2.*(Q3*Q4+Q1*Q2)
A33  =  Q1**2-Q2**2-Q3**2+Q4**2
```

Step 3

Calculate RA and Dec of each Shuttle axis in degrees using the transpose of matrix {As} as follows:

X Shuttle M50 Body Axis (Out Nose):

```
RAX = ATAN2(A12/A11)*RTOD
IF(RAX.LT.0.0)RAX=RAX+360.0
DECX=ATAN2(A13/SQRT(A11**2+A12**2))*RTOD
```

Y Shuttle M50 Body Axis (Out Right Wing):

```
RAY=ATAN2(A22/A21)*RTOD
IF (RAY.LT.0.0)RAY=RAY+360.0
DECY=ATAN2(A23/SQRT(A21**2+A22**2))*RTOD
```

Z Shuttle M50 Body Axis (Out Bottom of Fuselage):

```
RAZ=ATAN2(A32/A31)*RTOD
IF(RAZ.LT.0.0)RAZ=RAZ+360.0
DECZ=ATAN2(A33/SQRT(A31**2+A32**2))*RTOD
```

-Z Shuttle M50 Body Axis (Up Out of Payload Bay):

```
RANZ=RAZ+180.0
IF(RANZ.GE.360.0)RANZ=RANZ-360.0
DECNZ=-DECZ
```

Step 4

Calculate the M50 Pitch/Roll/Yaw using a 2-3-1 Euler rotation:

```
PITCH=ATAN2(-A13/A11)*RTOD
IF(PITCH.LT.0.0)PITCH=PITCH+360.0
ROLL=ATAN2(-A32/A22)*RTOD
IF(ROLL.LT.0.0)ROLL=ROLL+360.0
YAW=ARSIN(A12)*RTOD
(Note: Yaw defined between -90 and +90)
```

Step 5

To calculate the LVLH Pitch/Roll/Yaw Shuttle body axis attitudes using the 2-3-1 Euler rotation, obtain the Shuttle position (R1, R2, R3) and velocity (V1, V2, V3) vectors in M50 from the Shuttle ancillary downlink.

Step 6

Calculate the {R} matrix:

```
RMAG=SQRT(R1**2+R2**2+R3**2)
U3X=-R1/RMAG
U3Y=-R2/RMAG
U3Z=-R3/RMAG
RXVX=R2*V3-R3*V2
RXVY=R3*V1-R1*V3
RXVZ=R1*V2-R2*V1
RXVMAG=SQRT(RXVX**2+RXVY**2+RXVZ**2)
U2X=-RXVX/RXVMAG
U2Y=-RXVY/RXVMAG
U2Z=-RXVZ/RXVMAG
U1X=U2Y*U3Z-U2Z*U3Y
U1Y=U2Z*U3X-U2X*U3Z
U1Z=U2X*U3Y-U2Y*U3X
```

Step 7

Using the transpose of {R}, calculate the {K} matrix where:

{K} = {As}M50 {R}T

and

{R}T =

U1X	U2X	U3X
U1Y	U2Y	U3Y
U1Z	U2Z	U3Z

and

{As}M50 was calculated before

Hence the code to calculate {K} is:

```
K11=A11*U1X+A12*U1Y+A13*U1Z
K12=A11*U2X+A12*U2Y+A13*U2Z
K13=A11*U3X+A12*U3Y+A13*U3Z
K21=A21*U1X+A22*U1Y+A23*U1Z
K22=A21*U2X+A22*U2Y+A23*U2Z
K23=A21*U3X+A22*U3Y+A23*U3Z
K31=A31*U1X+A32*U1Y+A33*U1Z
K32=A31*U2X+A32*U2Y+A33*U2Z
K33=A31*U3X+A32*U3Y+A33*U3Z
```

Step 8

Calculate the LVLH Shuttle body axis Pitch/Roll/Yaw attitudes using a 2-3-1 Euler rotation:

```
PITCH=ATAN2(-K13/K11)*RTOD
IF(PITCH.LT.0.0)PITCH=PITCH+360.0

ROLL=ATAN2(-K32/K22)*RTOD)
IF (ROLL.LT.0.0)ROLL=ROLL+360.0

YAW=ARSIN(K12)*RTOD
```

(Note: since JSC normally represents yaw positive, then add 360 if negative)

```
IF(YAW.LT.0.0)YAW=YAW+360.0
```

G4. GSFC CONTACT

If there are additional questions or problems, these can be directed to:

Deputy Project Manager
NASA/GSFC, Code 870
Greenbelt, Maryland 20771
(301) 286-2193 (FAX 301-286-1694)

TABLE G.1 PC PROGRAM IN BASIC FOR CALCULATING SHUTTLE BODY AXIS ATTITUDE

```
10 REM PROGRAM (IN BASIC) TO CALC ATTITUDE FROM
20 REM FROM M50 SHUTTLE BODY QUATERNIONS
30 RTOD#=180#/3.14159265#
40 PRINT "INPUT Q1"
50 INPUT Q1#
60 PRINT "INPUT Q2"
70 INPUT Q2#
80 PRINT "INPUT Q3"
90 INPUT Q3#
100 PRINT "INPUT Q4"
110 INPUT Q4#
120 PRINT
130 PRINT "THE INPUT QUATERNION IS"
140 PRINT Q1#,Q2#,Q3#,Q4#
150 REM
160 REM PART I : CALCULATE RIGHT ASCENSION AND DECLINATION IN M50
170 REM
180 PRINT
190 PRINT
200 PRINT "THE RIGHT ASCENSION AND DECLINATION IN M50 IS"
210 PRINT
220 PRINT
230 REM CALCULATE MATRIX A
240 A11#=Q1#^2+Q2#^2-Q3#^2-Q4#^2
250 A12#=2#*(Q2#*Q3#-Q1#*Q4#)
260 A13#=2#*(Q2#*Q4#+Q1#*Q3#)
270 A21#=2#*(Q2#*Q3#+Q1#*Q4#)
280 A22#=Q1#^2-Q2#^2+Q3#^2-Q4#^2
290 A23#=2#*(Q3#*Q4#-Q1#*Q2#)
300 A31#=2#*(Q2#*Q4#-Q1#*Q3#)
310 A32#=2#*(Q3#*Q4#+Q1#*Q2#)
320 A33#=Q1#^2-Q2#^2-Q3#^2+Q4#^2
330 REM THEN TRANSPOSE MATRIX A AND CALC RA+DEC FOR EACH
340 REM SHUTTLE BODY AXIS (INCLUDING X, Y, Z, AND -Z)
350 REM -Z=UP OUT OF SHUTTLE BAY
360 REM  X=OUT NOSE OF SHUTTLE
370 REM  Y=OUT RIGHT WING
380 REM  Z=OUT THE UNDERSIDE OF SHUTTLE FUSELAGE
390 RAX#=ATN(A12#/A11#)*RTOD#
400 IF A11#<0 THEN RAX#=RAX#+180#
410 IF A11#>0 AND A12#<0 THEN RAX#=RAX#+360#
420 DECX#=ATN(A13#/SQR(A11#^2+A12#^2))*RTOD#
430 PRINT "RA +X (DEG)=",RAX#,"DEC +X (DEG)=",DECX#
440 RAY#=ATN(A22#/A21#)*RTOD#
450 IF A21#<0 THEN RAY#=RAY#+180#
460 IF A21#>0 AND A22#<0 THEN RAY#=RAY#+360#
470 DECY#=ATN(A23#/SQR(A21#^2+A22#^2))*RTOD#
480 PRINT "RA +Y (DEG)=",RAY#,"DEC +Y (DEG)=",DECY#
490 RAZ#=ATN(A32#/A31#)*RTOD#
```

Table G.1 (Cont'd)

```
500 IF A31#<0 THEN RAZ#=RAZ#+180#
510 IF A31#>0 AND A32#<0 THEN RAZ#=RAZ#+360#
520 DECZ#=ATN(A33#/SQR(A31#^2+A32#^2))*RTOD#
530 PRINT "RA +Z (DEG)=",RAZ#,"DEC +Z (DEG)=",DECZ#
540 RANZ#=RAZ#+180#
550 IF RANZ#>=360# THEN RANZ#=RANZ#-360#
560 DECNZ#=-DECZ#
570 PRINT "RA -Z (DEG)=",RANZ#,"DEC -Z (DEG)=",DECNZ#
580 PRINT
590 PRINT
600 REM PART II : CALCULATE M50 PITCH/ROLL/YAW USING 2-3-1 EULER SEQ
610 REM CALCULATE THE K MATRIX AS FOLLOWS:
620 REM          T
630 REM  K = (A)  (R)
640 REM     ( 1  0  0 )
650 REM  R = ( 0  1  0 )
660 REM     ( 0  0  1 )
670 REM        T
680 REM R = (R)
690 REM SINCE R=IDENTITY MATRIX, THEREFORE MATRIX K = MATRIX A
700 REM USING A 2-3-1 ROTATION CALCULATE PITCH/ROLL/YAW (M50)
710 REM WHERE 0<=PITCH<360, 0<=ROLL<360, AND -90<=YAW<=90
720 REM HOWEVER, YAW IS MODIFIED TO BE BETWEEN 270 AND 90 GOING THRU 0
730 PITCH#=ATN(-A13#/A11#)*RTOD#
740 IF A11#<0 THEN PITCH#=PITCH#+180#
750 IF A11#>0 AND -A13#<0 THEN PITCH#=PITCH#+360#
760 ROLL#=ATN(-A32#/A22#)*RTOD#
770 IF A22#<0 THEN ROLL#=ROLL#+180#
780 IF A22#>0 AND -A32#<0 THEN ROLL#=ROLL#+360#
790 REM ACTUALLY YAW#=ARCSIN(A12#)*RTOD#  , BUT MY PC BASIC DOESN'T
800 REM HAVE THE ARCSIN, HENCE THE RADICAL CALCULATION
810 YAW#=ATN(A12#/(SQR(1#-A12#^2)))*RTOD#
820 IF YAW#<0 THEN YAW#=YAW#+360#
830 PRINT
840 PRINT "SHUTTLE M50 PITCH/ROLL/YAW (2-3-1 EULER SEQ)"
850 PRINT
860 PRINT "PITCH (DEG)=",PITCH#,"ROLL (DEG)=",ROLL#,"YAW (DEG)=",YAW#
870 PRINT
880 PRINT
890 REM
900 REM PART III : CONVERT ATTITUDE TO LVLH PITCH/ROLL/YAW IN A
910 REM  2-3-1 EULER SEQUENCE
920 REM
930 REM INPUT ORBIT POSITION AND VELOCITY VECTORS(FT AND FT/SEC)
940 PRINT "INPUT R1"
950 INPUT R1#
960 PRINT "INPUT R2"
970 INPUT R2#
980 PRINT "INPUT R3"
```

Table G.1 (Cont'd)

```
990 INPUT R3#
1000 PRINT "INPUT V1"
1010 INPUT V1#
1020 PRINT "INPUT V2"
1030 INPUT V2#
1040 PRINT "INPUT V3"
1050 INPUT V3#
1060 PRINT "THE INPUT RADIUS VECTOR (FT) IS"
1070 PRINT R1#,R2#,R3#
1080 PRINT
1090 PRINT "THE INPUT VELOCITY VECTOR (FT/SEC) IS"
1100 PRINT V1#,V2#,V3#
1110 PRINT
1120 PRINT
1130 REM NOW CALCULATE THE R MATRIX USING THE R AND V VECTORS
1140 RMAG#=SQR(R1#^2+R2#^2+R3#^2)
1150 U3X#=-R1#/RMAG#
1160 U3Y#=-R2#/RMAG#
1170 U3Z#=-R3#/RMAG#
1180 RXVX#=R2#*V3#-R3#*V2#
1190 RXVY#=R3#*V1#-R1#*V3#
1200 RXVZ#=R1#*V2#-R2#*V1#
1210 RVMAG#=SQR(RXVX#^2+RXVY#^2+RXVZ#^2)
1220 U2X#=-RXVX#/RVMAG#
1230 U2Y#=-RXVY#/RVMAG#
1240 U2Z#=-RXVZ#/RVMAG#
1250 U1X#=U2Y#*U3Z#-U2Z#*U3Y#
1260 U1Y#=U2Z#*U3X#-U2X#*U3Z#
1270 U1Z#=U2X#*U3Y#-U2Y#*U3X#
1280 REM WE NOW HAVE R=(U1,U2,U3) MATRIX
1290 REM      ( U1X#  U1Y#  U1Z# )
1300 REM  R = ( U2X#  U2Y#  U2Z# )
1310 REM      ( U3X#  U3Y#  U3Z# )        T
1320 REM NOW HOWEVER TAKE THE TRANSPOSE OF R = R
1330 REM
1340 REM  T  ( U1X#  U2X#  U3X# )
1350 REM  R = ( U1Y#  U2Y#  U3Y# )
1360 REM     ( U1Z#  U2Z#  U3Z# )
1370 REM                         T
1380 REM NOW CALCULATE THE K MATRIX = (A) (R)
1390 K11#=A11#*U1X#+A12#*U1Y#+A13#*U1Z#
1400 K12#=A11#*U2X#+A12#*U2Y#+A13#*U2Z#
1410 K13#=A11#*U3X#+A12#*U3Y#+A13#*U3Z#
1420 K21#=A21#*U1X#+A22#*U1Y#+A23#*U1Z#
1430 K22#=A21#*U2X#+A22#*U2Y#+A23#*U2Z#
1440 K23#=A21#*U3X#+A22#*U3Y#+A23#*U3Z#
1450 K31#=A31#*U1X#+A32#*U1Y#+A33#*U1Z#
1460 K32#=A31#*U2X#+A32#*U2Y#+A33#*U2Z#
1470 K33#=A31#*U3X#+A32#*U3Y#+A33#*U3Z#
1480 REM IN A 2-3-1 ROTATION CALC PITCH/ROLL/YAW
```

Table G.1 (Cont'd)

```
1490 PITCH#=ATN(-K13#/K11#)*RTOD#
1500 IF K11#<0 THEN PITCH#=PITCH#+180#
1510 IF K11#>0 AND -K13#<0 THEN PITCH#=PITCH#+360#
1520 ROLL#=ATN(-K32#/K22#)*RTOD#
1530 IF K22#<0 THEN ROLL#=ROLL#+180#
1540 IF K22#>0 AND -K32#<0 THEN ROLL#=ROLL#+360#
1550 YAW#=ATN(K12#/(SQR(1#-K12#^2)))*RTOD#
1560 IF YAW#<0 THEN YAW#=YAW#+360#
1570 PRINT
1580 PRINT "SHUTTLE LVLH PITCH/ROLL/YAW (2-3-1 EULER SEQ)"
1590 PRINT
1600 PRINT "PITCH (DEG)=",PITCH#,"ROLL (DEG)=",ROLL#,"YAW (DEG)=",YAW#
1610 PRINT
1620 PRINT "DONE"
1630 REM TEST EXAMPLE : INPUTS ARE Q1=.2209538, Q2=.4641501, Q3=.8537468,
1640 REM  Q4=-.0828158,  R1=-16732867, R2=-12040024, R3=7815002.5,
1650 REM  V1=11329.191, V2=-21052.605, V3=-8160.598
1660 REM TEST EXAMPLE : RESULTS ARE RA+X=119.624,DEC+X=17.481
1670 REM                    RA+Y=36.305 ,DEC+Y=-20.274
1680 REM                    RA+Z=172.015,DEC+Z=-62.703
1690 REM                    RA-Z=352.015,DEC-Z=62.703
1700 REM      M50 PITCH=212.502, ROLL=353.456, YAW=56.009
1710 REM     LVLH PITCH=179.339, ROLL=269.727, YAW=1.739
720 END
```

Appendix H

TABLE OF CONTENTS

APPENDIX H

APPLICABLE DOCUMENTS

JSC

1. JSC-09604, Rev. F, (Also MSFC-HDBK-527, Rev. F), Materials Selection for Space Hardware Systems, September 1988

2. JSC-20545, Rev. A, Simplified Design Options for STS Payloads, April 1988

3. NSTS-22648, Flammability Configuration Analysis for Spacecraft Applications, October 1988

4. NSTS 1700.7B, Safety Policy and Requirements for Payloads Using the Space Transportation System, January 1989

5. NASA Reference Publication 1124-2, Outgassing Data for Selecting Spacecraft Materials, November 1990

6. Shuttle Orbiter/Cargo Standard Interfaces, ICD-2-19001, (and subsequent IRN's) Revision K

7. TA-92-038, Protection of Payload Electrical Power Circuits, February 1993.

GSFC

8. S-313-100, GSFC Fastener Integrity Requirements, Revision B, May 1996

9. GSFC-731-0005-83, Rev. B, General Fracture Control Plan for Payloads Using the Space Transportation System, November 1988

10. GEVS-SE, General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components, January 1990

11. GSFC SPOC Thermal Design Handbook, September 1985

MSFC

12. MSFC-SPEC-522A, Design Criteria for Controlling Stress Corrosion Cracking, November 1977

KSC

13. KHB 1700.7, Rev. B, STS Payload Ground Safety Handbook, September 1992

OTHER

14. MIL-HDBK-5F, Metallic Materials and Elements for Aerospace Vehicle Structures, December 1991***

13. EIA-232-D, Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange, Electronic Industries Association, January 1987

These documents may be acquired by contacting the Hitchhiker Project/Customer Support Office (See Page 1-2).

***This document can be obtained by contacting the:

Naval Publishing & Printing Service Office
700 Robbins Avenue
Philadelphia, PA 19111-5094

APPENDIX I
LIST OF ACRONYMS AND ABBREVIATIONS

A	Amps
ABA	Adapter Beam Assembly
ACKS	Acknowledgment
ACCESS	Advanced Carrier Customer Equipment Support System
AFD	Aft Flight Deck
AIA	Avionics Interface Assembly
ANSI	American National Standards Institute
APC	Autonomous Payload Controller
APOCC	Attached Payloads Operations Control Center
ASP	Attached Shuttle Payloads
ASPC	Attached Shuttle Payload Center
Aux	Auxiliary
b/s	Bits Per Second
Baud	Typically one bit per second
BBXRT	Broad Band X-Ray Telescope
BC	Byte count
BPI	Bits Per Inch
CAP	Command Acceptance Pattern
	Crew Activity Plan
CARS	Customer Accommodations and Requirements Specifications
CAS	Calibrated Ancillary System
CC	Crew Controller
CCGSE	Customer/Carrier Ground Support Equipment
CCI	Command Concentrator Interface
CCT	Computer Compatible Tape
CCTV	Closed Circuit Television
CG	Center of Gravity
CGSE	Customer Ground Support Equipment
CH	Channel
CID	Customer Identification
CIR	Cargo Integration Review
CMD(S)	Command(s)
CMF	Command Management Facility
CMRT	Customer Medium Rate Tape
CNE	Center Network Environment
CPR	Customer Payload Requirements
CRT	Cathode Ray Tube
CSR	Customer Support Room
CVCM	Collected Volatile Condensable Material
dB	Decibel
oC	Degrees Centigrade
DAP	Digital Autopilot
DC	Direct Current
DEC	Declination
	Digital Equipment Corporation
DCL	Digital Command Language
Dia.	Diameter

DMR	Detailed Mission Requirements
DOD	Department of Defense
DOL	Discrete Output, Low Level
DOMSAT	Domestic Communication Satellite
DPS	Data Processing System
DPST	Double-Pole Single Throw
DT	Delay Time
e.g.	such as
EAFB	Edwards Air Force Base
EGSE	Electrical Ground Support Equipment
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EOF	End of File
EOV	End of Volume
FDF	Flight Dynamics Facility
	Flight Data File
FM	Frequency Modulated
FOR	Flight Operations Review
FOT	Flight Operations Team
FOV	Field of View
FP	Flight Plan
FPS	Flight Planning System
FS	Factor of Safety
FSU	Frame Synchronizer Unit
FT	Foot/Feet
FVP	Flight Verification Payload
G,g	Gravity
Ga.	Gauge
GAS	Get Away Special
GDS	Ground Data System
GIS	Goddard Internal Simulations
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GPC	General Purpose Computer
GSTDN	Ground Spaceflight Tracking and Data Network
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HES	Hitchhiker Ejection System
HH	Hitchhiker
HHC	Hitchhiker Carrier
HH-C	Hitchhiker-C
HH-S	Hitchhiker-S
HH-J	Hitchhiker-JR
HMDA	Hitchhiker Motorized Door Assembly
HRIU	Hitchhiker Remote Interface Unit
HTS	Hitchhiker Timeline System
Hz	Hertz
IAD	Interface Agreement Document
ICD	Interface Control Document

i.e.	that is,
I/F	Interface
I&T	Integration and Tests
IPD	Information Processing Division
IRIG-B	Inter-Range Instrumentation Group, Type B
JIN	Johnson Information Network
JIS	Joint Integrated Simulation
JSC	Johnson Space Center
K	Kilo, Thousand
Kb/s	Kilo bits/second
KSC	Kennedy Space Center
KHz	Kilo Hertz
KSC	Kennedy Space Center
KUSP	Ku Band Signal Processor
KWHR	Kilowatt-Hour
LAN	Local Area Network
lbs.	pounds (Weight)
LEP	Lower End Plate
LR	Low Rate
LRDPS	Low-Rate Data Processing System
LRGSE	Low Rate Ground Support Equipment
LVLH	Local Vertical/Local Horizontal
Max	Maximum
Mb/s	Mega bits per second
MCC	Mission Control Center
MCCH	Mission Control Center Houston
MDM	Multiplexer De-Multiplexer
MET	Mission Elapsed Time
MGMT	Management
MGSE	Mechanical Ground Support Equipment
MHz	Megahertz
MICD	Mechanical Interface Control Drawing
Min	Minimum
MLI	Multi-Layer Insulation
mm	millimeter
MM	Mission Manager
MOD	Mission Operation Division
	Mission Operations Document
MODNET	MO&DSD Operational/Development Network
MOWG	Mission Operations Working Group
MPE	Mission Peculiar Equipment
MPESS	Mission Peculiar Equipment Support Structure
MPS	Mission Planning System
MR	Medium Rate
MRDM	Medium-Rate De-Multiplexer
MRDPS	Medium-Rate Data Processing System
MRGSE	Medium Rate Ground Support Equipment
MRM	Medium Rate Multiplexer
	Mission Readiness Manager

MS	Mass Storage
	Margin of Safety
ms	Millisecond
MSFC	Marshall Space Flight Center
MSL	Materials Science Laboratory
MSM	Mission Support Manager
MTR	Magnetic Tape Recorder
MTU	Master Timing Unit
MUA	Material Usage Agreement
MUX	Multiplexer
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NDE	Nondestructive Evaluation
NOLAN	NASCOM Operational Local Area Network
NGT	NASA Ground Terminal (TDRS)
NRZ	Non-Return to Zero
NSP	Network Signal Processor
NSTS	National Space Transportation System
NTSC	National Television Standard Committee
NVR	Non-Volatile Residue
OIT	Obiter Integration Test
O.D.	Outside Diameter
OPF	Orbiter Processing Facility
OPS	Operations
ORDC	Orbiter Data Reduction Center
ORR	Operational Readiness Review
OSF	Office of Space Flight
PAM	Payload Assist Module
PC	Personel Computer
PCM	Pulse Code Modulation
PDI	Payload Data Interleaver
PGSC	Payload and General Support Computer
PI	Principal Investigator
PIP	Payload Integration Plan
POCC	Payload Operations Control Center
POWG	Payload Operations Working Group
PPS	Pulse Per Second
PSAT	Predicted Site Acquisition Table
PSID	Pounds-Per-Square-Inch Differential
PSP	Payload Signal Processor
PTC	Passive Thermal Control
PWR	Power
RA	Right Ascension
RD	Receive Data
Rev.	Revision
RF	Radio Frequency
RTN	Return
RMS	Remote Manipulator System
RT	Real-Time

SAA	South Atlantic Anomaly
SAIL	Shuttle Avionics Integration Laboratory
SD	Send Data
SDP	Safety Data Package
SDPF	Sensor Data Processing Facility
SDR	System Design Review
SMC	Standard Mixed Cargo
SMCH	Standard Mixed Cargo Harness
SPA	Small Payload Accommodations
SPASP	SPA Switch Panel
SPIF	Standard Payload Interface Facility
SPOC	Shuttle Payload of Opportunity Carrier
SQ	Square
SRR	System Requirements Review
SSP	Standard Switch Panel
SSPO	Space Shuttle Program Office
SSPP	Shuttle Small Payloads Project
STS	Space Transportation System
TAE	Transportable Applications Executive
TAGS	Text and Graphic System
TBD	To Be Determined
TBS	To Be Supplied
TCL	TAE Control Language
TDRSS	Tracking and Data Relay Satellite System
TIM	Technical Interchange Meeting
TN	TDRSS Network
TLM	Telemetry
TML	Total Mass Loss
TOD	True of Date
TSP	Twisted Shielded Pair
TTL	Transistor-Transistor Logic
TV	Television
UART	Universal Asynchronous Receiver Transmitter
UCAT	User Calibrated Ancillary Data Tapes
UNF	United States National Fine
US	United States, Microsecond
VAB	Vehicle Assembly Building
VCM	Volatile Condensable Material
VDC	Volts Direct Current
VDS	Voice Distribution System
VF	Voltage False
VMS	Virtual Memory System
VNoise	Voltage Noise
VT	Voltage True
WSC	White Sands Complex
WSTF	White Sands Test Facility
W	Watts
YSI	Yellow Springs Instrument Company