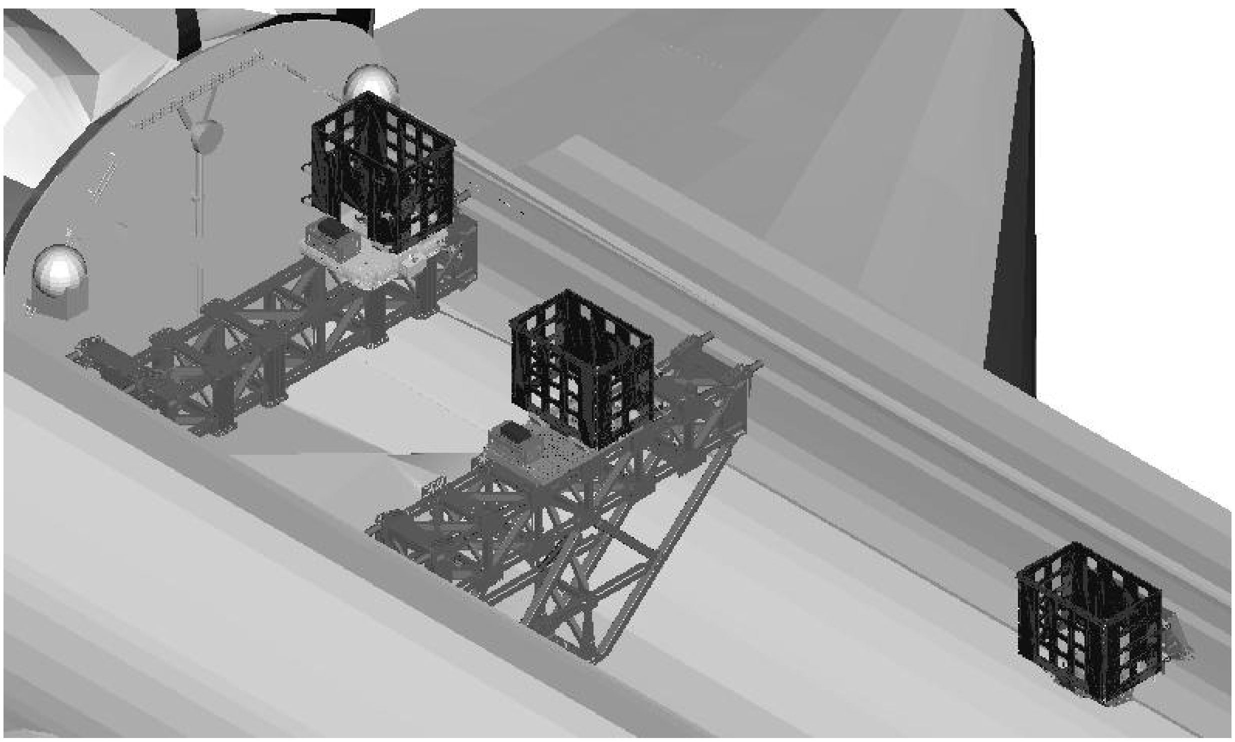
NASA Goddard Space Flight Center
Greenbelt, MD

SHELS USER'S GUIDE

SSPP-SPEC-040



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REVISIONS

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION
ASD	Acceleration Spectral Density
ASE	Airborne Support Equipment
BIA	Bus Interface Adapter
CARS	Customer Accommodations Requirements Specifications
CG	Center of Gravity
CITE	Cargo Integration Test Equipment
CPR	Customer Payload Requirements
dB	Decibels
DC	Direct Current
EED	Electro Explosive Device
EIRP	Effective Isotropic Radiated Power
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
ETU	Engineering Test Unit
EVA	Extravehicular Activity
FCP	Fracture Control Plan
FDF	Flight Data File
FEM	Finite Element Model
Femap	Finite Element Modeling and PostProcessing
FOD	Foreign Object Debris
FRAM	Flight Releasable Adjustment Mechanism
FSDP	Flight Safety Data Package
FSW	Flight Software
G / g	Gravity force
GAS	Get Away Special
GOWG	Ground Operations Working Group
Grms	Gravity root mean squared
GSDP	Ground Safety Data Package
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSRP	Ground Safety Review Panel
HESE	Hitchhiker Ejection System Electronics
HH	Hitchhiker
HRIU	Hitchhiker Remote Interface Unit
Hz	Hertz

ABBREVIATION	DESCRIPTION
ICD	Interface Control Document
ISO	International Standards Organization
IVT	Interface Verification Test
JSC	Johnson Space Center
KSC	Kennedy Space Center
lb	Pound
LMC	Lightweight MPESS Carrier
LSSP	Launch Site Support Plan
MDP	Maximum Design Pressure
MET	Mission Elapsed Time
MPESS	Multi-Purpose Experiment Support Structure
MPIB	Multipurpose Interface Box
MSVP	Mechanical Systems Verification Plan
NASA	National Aeronautics and Space Administration
NCR	Non Compliance Report
Oct	Octave
OMRSD	Operations and Maintenance Requirements Specifications Document
OPF	Orbiter Processing Facility
OSRS	Orbiter Structural Reference System
PAS	Payload Axis System
PGSC	Payload and General Support Computer
POCC	Payload Operations Control Center
PPF	Payload Processing Facility
PSIA	Pounds per Square Inch Absolute
PSRP	Payload Safety Review Panel
RD	Receive Data
RF	Radio Frequency
SD	Send Data
SDP	Safety Data Package
SHELS	Shuttle Hitchhiker Experiment Launcher System
SSP	Standard Switch Panel
SSPPO	Shuttle Small Payload Program Office
STS	Space Transportation System
SUG	SHELS Users Guide
SVP	Structural Verification Plan
TGHR	Time-critical Ground Handling Requirements
TIM	Technical Interchange Meeting
TOP	Technical Operating Procedure

ABBREVIATION	DESCRIPTION
V	Volts
VAB	Vehicle Assembly Building
VPF	Vertical Processing Facility
VTL	Verification Tracking Log
W	Weight

1 INTRODUCTION

In 1984, the National Aeronautics and Space Administration (NASA) Headquarters Office of Space Flight established the Shuttle Small Payloads Projects Office (SSPP (now SSPPO)) at Goddard Space Flight Center (GSFC) to develop and execute carrier systems for low-cost and quick reaction accommodations of secondary payloads on the NASA Space Transportation System (STS). These carrier systems range from the self-contained Get Away Special (GAS) carrier system to the more complex, such as the Hitchhiker (HH) carrier system.

To more fully enable GSFC to meet NASA's strategic goals for science, technology, and education, the SSPPO has developed an enhanced ejection capability called the Shuttle Hitchhiker Experiment Launch System (SHELS). SHELS consists of an ejection system and its supporting electronics. SHELS may be attached to the Orbiter sidewall or to a cross bay carrier. The development of SHELS was primarily overseen by the Hitchhiker project.

1.1 Purpose

The purpose of this document is to identify the SHELS system specific interface requirements and accommodations. Specifically, it is intended to be a companion document to the HH Customer Accommodations and Requirements Specifications (CARS). The SHELS User's Guide (SUG) defines and controls the design of mechanical, thermal, and electrical interfaces between SHELS users and the SHELS system. It is intended to support SHELS system users in the design and development of their SHELS payload as it relates to the SHELS system. Consequently, the SHELS customer is not released from meeting all applicable requirements imposed by the HH CARS and NSTS documents.

1.2 Point Of Contact

The NASA point of contact for SHELS is Ken Carr. He may be contacted as follows:
Launch Service Program Office
Kennedy Space Center, Code VA-B
Kennedy Space Center, FL 32899

Email: Kenneth.N.Carr@nasa.gov

2 APPLICABLE DOCUMENTS

300-PG-7120.2.2	Mission Assurances Guidelines
541-PG-8072.1.1	GSFC Fastener Integrity Requirements
740-SPEC-008	Hitchhiker Customer Accommodations & Requirements Specifications (CARS)
870-CPR-0023	Customer Payload Requirements (CPR) Template
870-PROC-666	SHELS Satellite Interface Fit Check Procedure
GPG-5900.1	Control Of Customer-Supplied Product
ICD-2-19001	Shuttle Orbiter/Cargo Standard Interfaces
K-STSM-14.1	Launch Site Accommodations Handbook for Payloads
KHB-1700.7	STS Payload Ground Safety Handbook
KHB-1710.2	Kennedy Space Center Safety Practices Handbook
MA2-00-057	Mechanical Systems Safety
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MSFC-STD-3029	Guidelines for the Selection of Metallic Materials for SCC Resistance
NASA-STD-5001	Structural Design and Test Factors of Safety for Spaceflight Hardware
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle
NASA-STD-5005	GSE Design Criteria
NSTS 07700 Volume 14	Space Shuttle System Payload Accommodations
NSTS-13830	Payload Safety Review and Data Submittal Requirements
NSTS-14046	Payload Verification Requirements
NSTS-1700.7	Safety Policy and Requirements for Payloads Using the STS
NSTS-21000-IDD-SML	Shuttle Orbiter/Small Payload Accommodation Interfaces
NSTS 21000-SIP-ATT	Shuttle/Payload Standard Integration Plan for Attached Payloads
NSTS 21000-SIP-DRP	Shuttle/Payload Standard Integration Plan for Deployable/Retrievable-Type Payloads
NSTS-37329	Structural Integration Analyses Responsibility Definition for Space Shuttle Vehicle and Cargo Element Developers
NSTS-ISS-18798	Interpretations of NSTS/ISS Payload Safety Requirements
SSPP-PROC-196	SHELS Integration Procedure
TA-92-038	Protection of Payload Electrical Power Circuits
TM-102179	Selection of Wires and Circuit Protective Devices for STS Orbiter Vehicle Payload Electrical Circuits

3 SHELS DESCRIPTION & CAPABILITIES

Figure 3-1 shows an isometric view of SHELS attached to the Orbiter sidewall. The major components shown are the ejection system thermal shroud; launch structure mounted to an adapter beam, and the electronics stack. The ejection system assembly consists of an ejection base, a Marman band, a spring/push plate assembly, and a band catcher system. The bottom of the ejection base attaches to the launch structure and the satellite is attached to the top of the ejection base at the separation plane. The satellite is attached via a Marman clamp, which releases when two separation bolts are simultaneously cut using a pyrotechnic bolt cutter. Immediately after the separation bolts are cut, a centrally mounted spring drives a push plate that launches the satellite away from the ejection system and the Orbiter.

The SHELS ejection system can be mounted to the launch structure (as shown in Figure 3-1) for a sidewall adapter beam configuration or to a Multi-Purpose Experiment Support Structure (MPESS) for a cross bay configuration. The system is designed to accommodate a wide range of satellites with minimum payload integration. SHELS may accommodate a maximum 400-pound satellite on a sidewall adapter beam, or a 500-pound satellite on an MPESS. The Center of Gravity (CG) must be located between 10.25 inches and 24.00 inches above the ejection system separation plane and within a radius of 0.25 inches about the ejection system centerline. The ejection system may be configured for ejection velocities ranging from 1 ft/sec to 4 ft/sec. The allowable satellite envelopes are shown in section 5.

Table 3-1 Weight and CG Specifications

Configuration	Weight (pounds)	CG above Separation Plane (inches)	CG from centerline (inches)	Ejection Velocity (ft/sec)	Expected Tip-Off Rate (deg/sec)
Cross Bay Carrier	500	10.25 –24	.25	1 - 4	< 3 (less than 3)
Sidewall Adapter Beam	400				

The ejection system provides mounting accommodations for two low force umbilical connectors, located near the separation plane, that are available for all flight configurations. These connectors, if implemented, will provide power and signal to a satellite prior to ejection. These interfaces are summarized below and detailed in section 1.

- 10A service divided among four circuits (i.e. 2.5A max. load each circuit)
    - This service includes satellite heater power
- One 1200 baud asynchronous command & telemetry interface (RS-422)
- Three 0-5V analog circuits
- Three 28V bi-level signals

- One Mission Elapsed Time Minute Pulse

The sidewall adapter beam assembly is an interface plate, which attaches directly to the Orbiter sidewall. Mounted in the center of the adapter beam is the launch structure. The launch structure is a premium quality, aerospace structural casting made of A356 aluminum. The ejection system assembly and thermal shroud mount to the launch structure. Mounted under the launch structure is the electronics stack. This stack contains all the necessary electronics for satellite deployment: Hitchhiker Ejection System Electronics (HESE), Hitchhiker Remote Interface Unit (HRIU), and Multi-Purpose Interface Box (MPIB).

Figure 3-2 shows an isometric view of SHELS mounted to a Hitchhiker MPESS. The MPESS is a cross bay carrier used for attaching multiple payloads on a single mission across the Orbiter cargo bay. When SHELS is flown in this type of configuration the MPESS and bridge pallet (HH or Flight Releasable Adjustment Mechanism (FRAM)) replace the adapter beam and launch structure. Figure 3-3 shows an isometric view of SHELS mounted to a Lightweight MPESS Carrier (LMC), which is another MPESS, but without keel structure and keel trunnion allowing it to be placed in the Shuttle's Payload Bay 13, which does not accept a keel trunnion. In the future it may also be qualified for placement over the top of a pre-installed payload/cargo structure, like a pressurized tunnel. The cross bay carriers use the same ejection system and electronics with a different set of harnesses.

The MPIB provides the power and Standard Switch Panel (SSP) interface to the orbiter. It is used for fusing and distributing the orbiter power, and power switching to the HRIU and HESE. It also houses circuit boards associated with the power distribution, heater telemetry, and satellite isolation electronics. The HESE provides the safety inhibits and controls to prevent inadvertent satellite deployment. Finally, the HRIU provides a non-hazardous command and telemetry interface between the SHELS and a Payload General Support Computer (PGSC) located in the crew compartment.

The thermal shroud is a lightweight structure fabricated from an aluminum honeycomb panel. The shroud is used for either sidewall or MPESS flight configurations. For all configurations the shroud provides 24 access panels located throughout the structure to allow access to a satellite. Additionally, the front panel is completely removable during any phase of integration. An optional motorized closeout cover/sun shade is available to completely enclose a satellite. SHELS can be used without the thermal shroud, but that requires customized cable routing, which has an optional services charge.

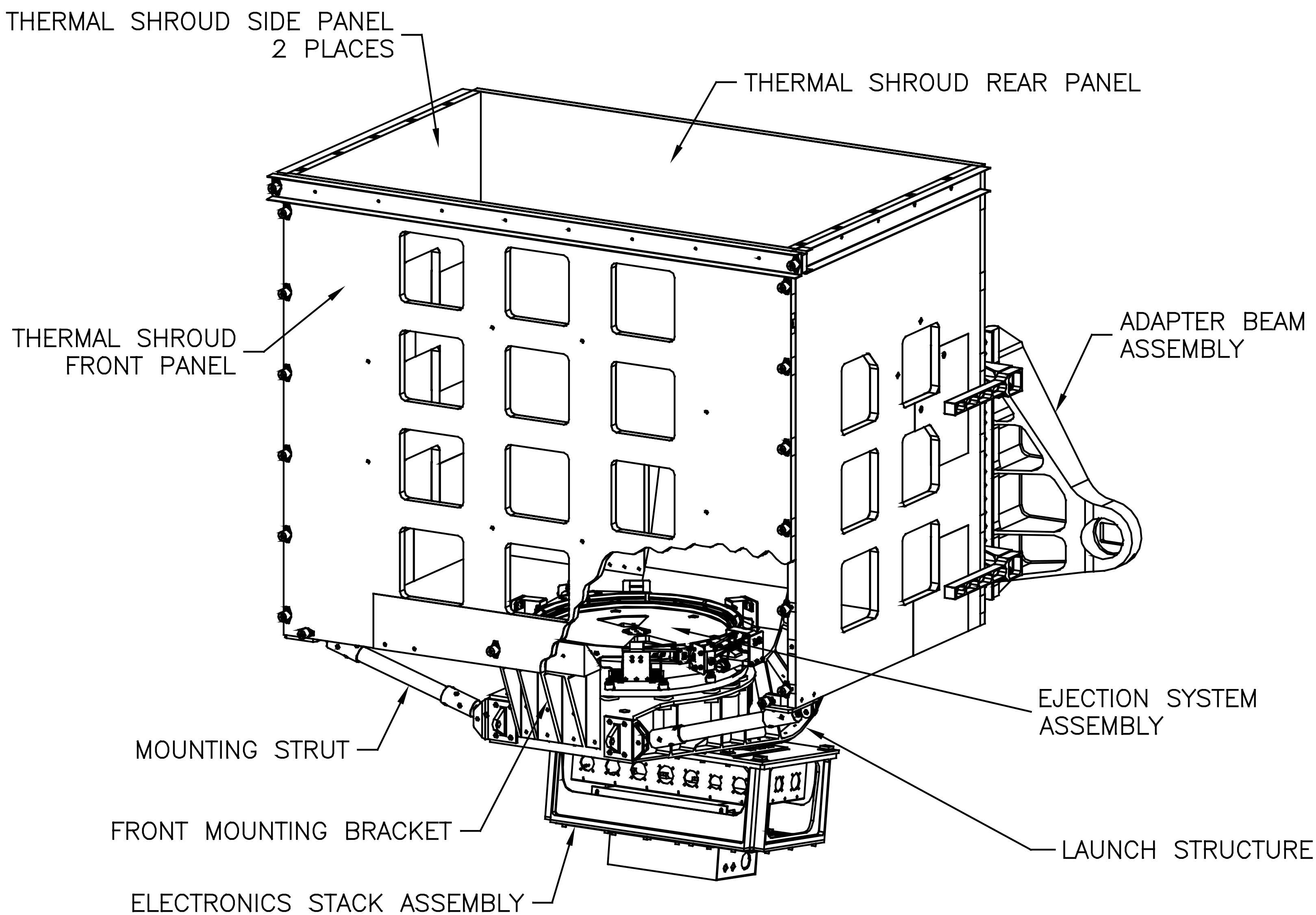

Figure 3-1 SHELS Single Beam Configuration

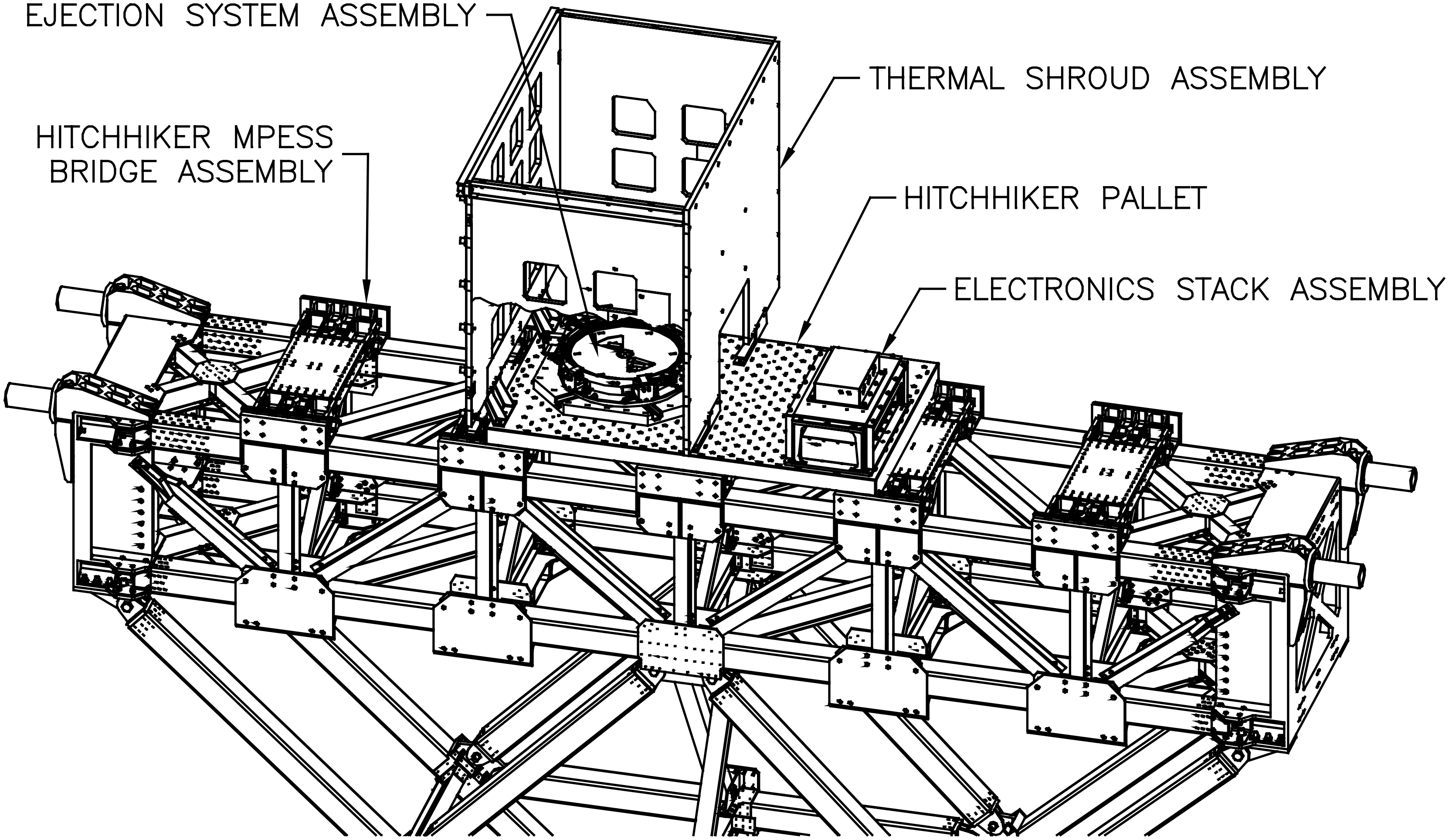

Figure 3-2 SHELS Hitchhiker MPESS Configuration (centered)

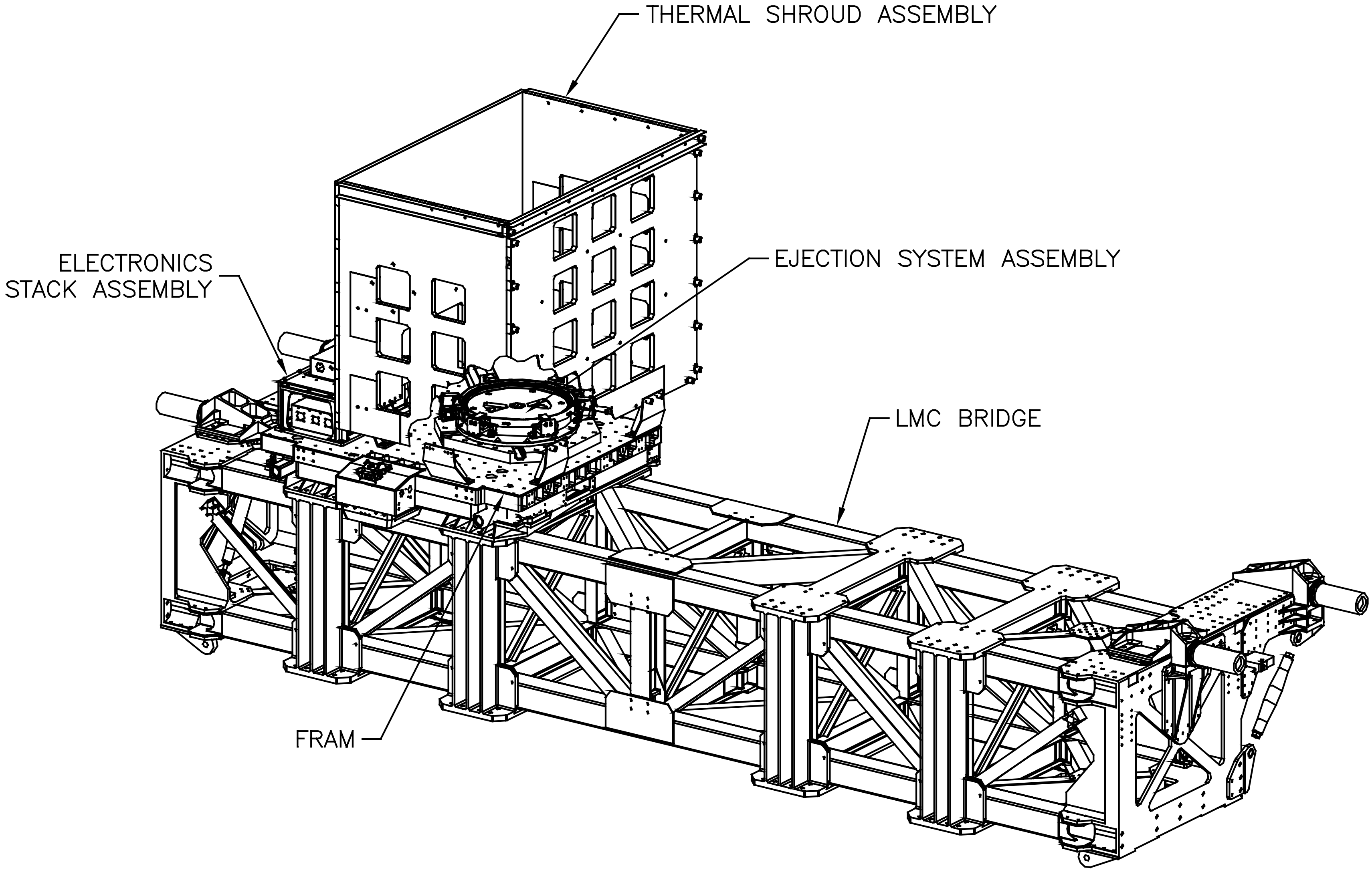

Figure 3-3 SHELS LMC Configuration

4 CUSTOMER DOCUMENTATION

Payloads flying aboard the Shuttle must satisfy a wide variety of requirements and also submit the appropriate documentation. Since the Shuttle is a human rated vehicle, safety precautions must be observed for all payloads utilizing it. The critical customer documents include[1], but are not limited to, the Customer Payload Requirements (CPR), Carrier-to-Customer Interface Control Document (ICD), Flight and Ground Safety Data Packages (FSDP / GSDP), Fracture Control Plan (FCP), Mechanical Systems Verification Plan (MSVP), and Structural Verification Plan (SVP).

The formats listed below are standard CAD or model formats for electronic deliverables from a customer. Other formats may be accepted, but prior arrangements must be made with HH.

- STEP files for Pro-Engineer models
- IGES/DXF files for AutoCAD drawings
- Femap compatible files for structural and thermal models

4.1 Customer Payload Requirements (CPR) Document

The SHELS customer shall prepare a CPR document (http://sspp.gsfc.nasa.gov/documents/doc/cpr.doc), which specifies all interface requirements and parameters. The CPR contains thermal, mechanical, electrical, attitude control, alignment, test and checkout, contamination control, environmental, mission operations, and shipping and handling requirements. It should also include block diagrams and any available customer-prepared interface drawings and schematics.

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

4.2 SHELS Carrier-to-Experiment Interface Control Document (ICD)

Upon signature of the CPR, Hitchhiker shall develop with the customer a SHELS to customer satellite ICD. The ICD defines and details specific interfaces and requirements between the SHELS carrier hardware and the customer satellite hardware, i.e. specific pin-outs, etc. A secondary function of the ICD is to define responsibility for end product deliverables. The ICD is meant to be an agreement between Hitchhiker and the customer to delegate specific hardware assignments. The baseline ICD should be submitted prior to the Phase II Safety Review at JSC.

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[1] Full documentation requirements are identified in the HH CARS document.

4.3 Safety Data Package (SDP)

The SHELS customer shall prepare Safety Data Packages (SDPs) for both flight and ground phases to ensure compliance with payload requirement documents and NASA payload safety policy. The requirements are contained in the following documents: NSTS 1700.7, *Safety Policy and Requirements for Payloads using the Space Transportation System*; KHB 1700.7, *Space Shuttle Payload Ground Safety Handbook;* KHB 1710.2, *Kennedy Space Center Safety Practices Handbook*; and NSTS 13830, *Payload Safety Review Data Submittal Requirements*. The packages will be submitted to the assigned Hitchhiker Safety Engineer and reviewed extensively by the Hitchhiker team prior to GSFC data package submittal to the JSC Payload Safety Review Panel (PSRP) or the KSC Ground Safety Review Panel (GSRP). The satellite SDP will be incorporated into integrated flight and ground SHELS SDPs that are presented to the Flight PSRP and the GSRP, respectively. As part of the process, hazard reports are generated in support of the flight and ground SDPs. From the hazard reports, Verification and Tracking Logs (VTLs) will be generated to track the hazard report verification status. All SHELS customer ground safety VTL items **must** be closed prior to satellite shipment to KSC. The flight hazards shall be closed out no later than 2 weeks prior to Launch.

4.4 Verification Plans

The verification plans document compliance with payload safety requirements for the SSP and ISS Program. The preparation information for the SVP is contained in NSTS 14046, *Payload Verification Requirements,* for the FCP in NASA-STD-5003, and for the MSVP in NSTS-ISS-18798, Section 7.3, Letter MA-00-057. NSTS-37329, *Structural Integration Analyses Responsibility Definition for Space Shuttle Vehicle and Cargo Element Developers* states the requirements that need to be met and at what stage the presentation needs to be made to the SWG and PSRP. Each of the Phase 0/I and Phase II verification plan documents, when submitted to GSFC for initial comments, begin a review cycle five months prior to their respective safety reviews at JSC. Reference the milestone schedule in CARS for more details.

4.5 SHELS Procedural Milestones

Table 4-1 lists a timeline for a typical HH payload. All questions concerning safety requirements and documentation should be directed to the SSPPO as noted in section 1.2, *Point of Contact*.

Table 4-1 Milestone Schedule for Typical Hitchhiker Payloads

Milestone	DATE TO BE COMPLETED (Launch - Month)
NASA Headquarters approves experiment for flight as a HH payload	L-24
Quarterly Status / TIMS	~Quarterly
SHELS customer submits CPR to GSFC/SSPPO	L-24
SHELS customer accommodation meeting at GSFC	L-23
SHELS customer submits preliminary Phase 0/I Safety Data and Structural Verification Plan	L-20
SHELS customer submits preliminary FEM	L-16
Completion of Payload to Carrier ICD	L-15
SHELS customer submits Phase II Safety Data Package	L-14
SHELS customer submits Structural Verification Report	L-13
SHELS customer submits final FEM	L-9
SHELS customer submits Phase III Safety Data Package	L-8
Ground VTLs Closed	L-8
SHELS customer hardware delivered to GSFC	L-7
SHELS customer/carrier integration completed	L-6
Hitchhiker payload shipped to launch site	L-4
Hitchhiker payload installed in Orbiter	L-3
LAUNCH	L-0
SHELS customer equipment returned	L+1

Note: For a more detailed milestone schedule see 740-SPEC-008, *Hitchhiker CARS.*

5 SATELLITE REQUIREMEMNTS

SHELS is designed to mount in a variety of locations that will maximize a payloads opportunity for flight. However, not all locations offer the same capabilities. For example, the payload envelope on a cross bay carrier is potentially larger than the payload envelope on the sidewall. Also, the maximum payload weight for the sidewall is 100 pounds less than the maximum payload weight for a cross bay carrier. The design loads are also different for both mounting locations. Although many flight configuration options exist, the SHELS user should carefully consider the design of their satellite, and be aware of any limitations they may unknowingly impose upon themselves because of physical size, payload weight, and design loads. Ideally, a satellite would be designed for sidewall mounting, which accommodates a lesser weight and payload envelope than cross bay mounting, yet analyzed to the highest design loads. Designing a satellite to merely fit within the payload envelope for a sidewall payload is not enough. All variables need to be considered. This idealized combination will produce a robust payload capable of mounting in any location throughout the Orbiter. Satellites that can only be flown in one configuration (e.g. bridge only) will substantially reduce their manifesting opportunities.

5.1 Design Requirements

All satellites must be designed to be “safe without services”. This means that the satellite must not pose any hazards to the Shuttle when data, power, or crew services are not available. The following sections discuss further requirements to be considered in any SHELS customer satellite design.

5.1.1 Envelopes

Hitchhiker assumes that most SHELS customers will desire a thermal shroud to protect the satellite from the cargo bay environment prior to ejection from the Orbiter. A standard thermal shroud is available from Hitchhiker for use on all satellites. The HH thermal shroud payload envelope is limited to the envelope shown in the sidewall configuration (Reference Figure 5-1). The shroud can be used on the sidewall or on the cross bay carrier to maximize manifesting options.

If a satellite exceeds the available payload envelope shown for a sidewall configuration then it will be limited to a cross bay carrier mission. Additionally, if the satellite exceeds the sidewall payload envelope then the standard thermal shroud is no longer a valid option. A new thermal shroud will need to be manufactured with a larger payload envelope, which will accommodate the larger satellite. This is an optional service charge. SHELS can be used without the thermal shroud, but that requires customized cable routing, which is also an optional services charge.

5.1.1.1 Satellite Envelopes

Figure 5-1 defines the static satellite envelope for a payload mounted on a sidewall adapter beam. The payload envelope shown is based the thermal shroud dimensions. Figure 5-2 and Figure 5-3 show the static satellite envelops for a payload mounted on a Hitchhiker cross bay carrier. Figure 5-2 shows the envelope for a payload mounting in the center of the cross bay carrier and Figure 5-3 shows the payload mounted off to one side of the cross bay carrier. Since variability in configuration exists for cross-bay payloads, stated dimensions are for general reference. Actual dimensions would be defined within the ICD.

Another option available to a payload is the previously mentioned Lightweight MPESS Carrier (LMC). This option is similar to the Hitchhiker cross bay carrier, but the payload envelope is different because the LMC mounts in a different Orbiter bay than the Hitchhiker cross bay carrier and the pallets location is also different. Figure 5-4 shows the payload envelope for the LMC cross bay carrier.

All satellites must also conform to the stiffness limits specified in Section 5.1.6, *Vibration Frequency Constraints*. Dimensions must be within the appropriate envelope to ensure no contact between the satellite and any other hardware during any phase of the mission. Satellite protrusions that violate the specified envelopes will be evaluated on a case-by-case basis. The dynamic envelope is .34 inches away from any thermal shroud panel. Protrusions from either the static or dynamic envelopes may be acceptable, but will require further coordination and special approval from Hitchhiker.

Hitchhiker will perform a static fit check clearance test and a tip off analysis for each payload to ensure positive clearance margins during flight. In order for Hitchhiker to complete this assessment, satellite descriptions must include an accurate definition of the physical location of all points on the satellite that are within one inch of the allowable envelope. The dimensions must include the maximum manufacturing tolerances.

The location of where a payload will mount is based upon many factors. The size and weight play a significant role and could restrict a payload from flight as an Orbiter sidewall payload. Conversely, the LMC cross bay carrier currently mounts in Orbiter bay 13 only. Each cross bay carrier represents a unique opportunity for flight, although these locations may not be available to Hitchhiker. Ultimately, the final decision resides in which positions are available to the SSPPO/Hitchhiker program.

The customer must supply a preliminary height, width, and depth by the Phase 1 safety review and the final height, width, and depth by the Phase 2 safety review.

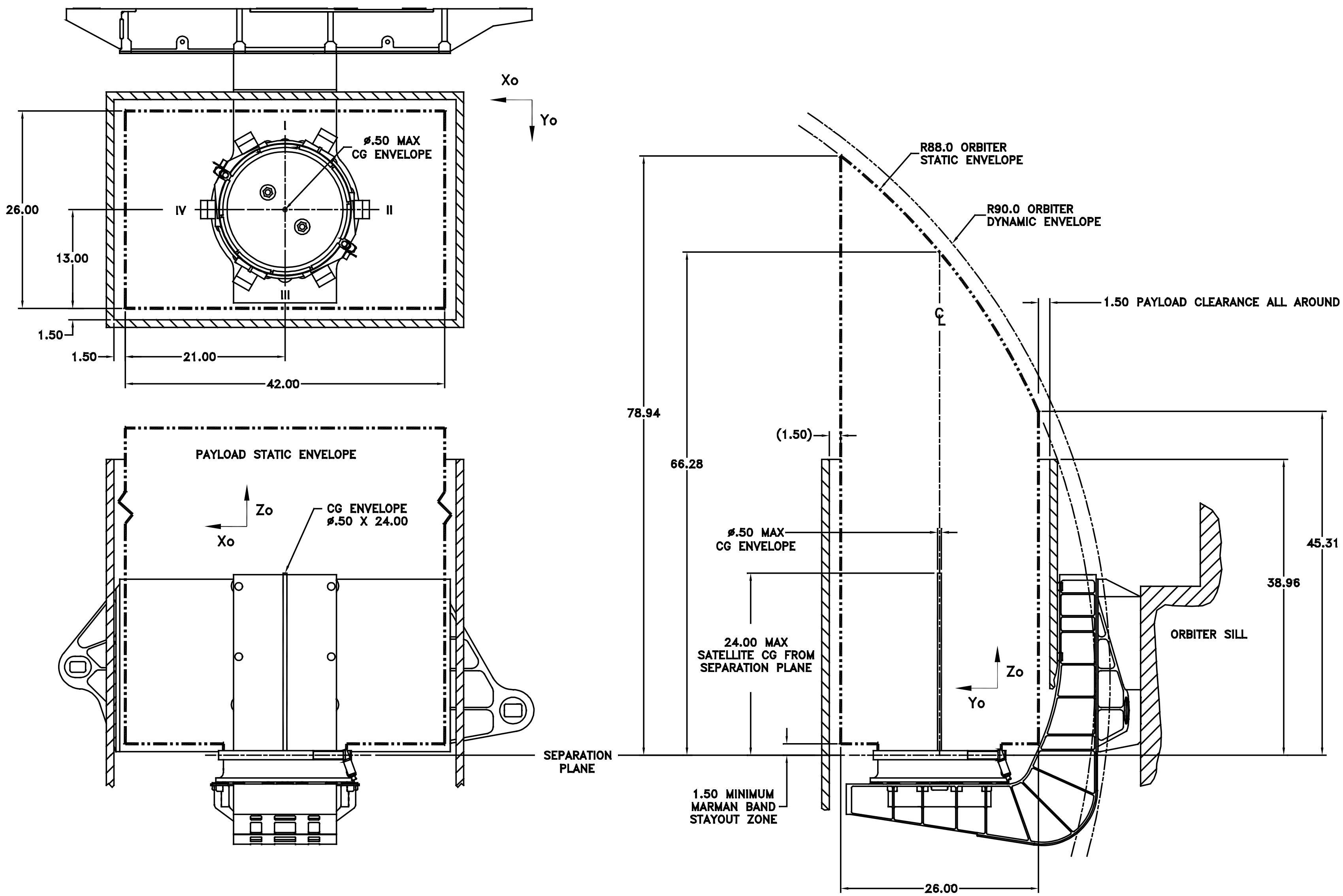


Figure 5-1 SHELS Static Envelope on the Sidewall Adapter Beam

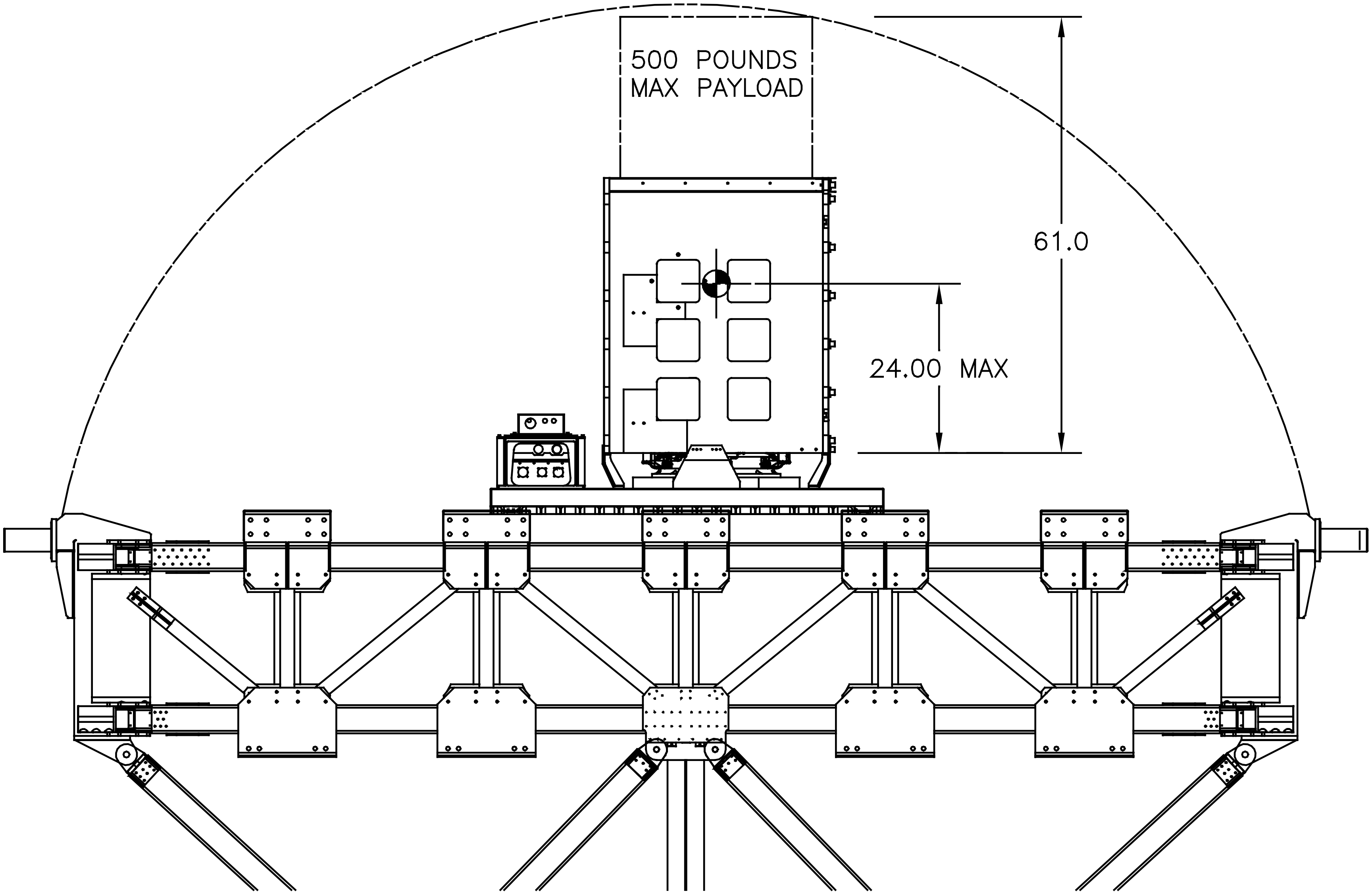


Figure 5-2 SHELS Static Envelope on a Hitchhiker Cross Bay Carrier, Payload Centered

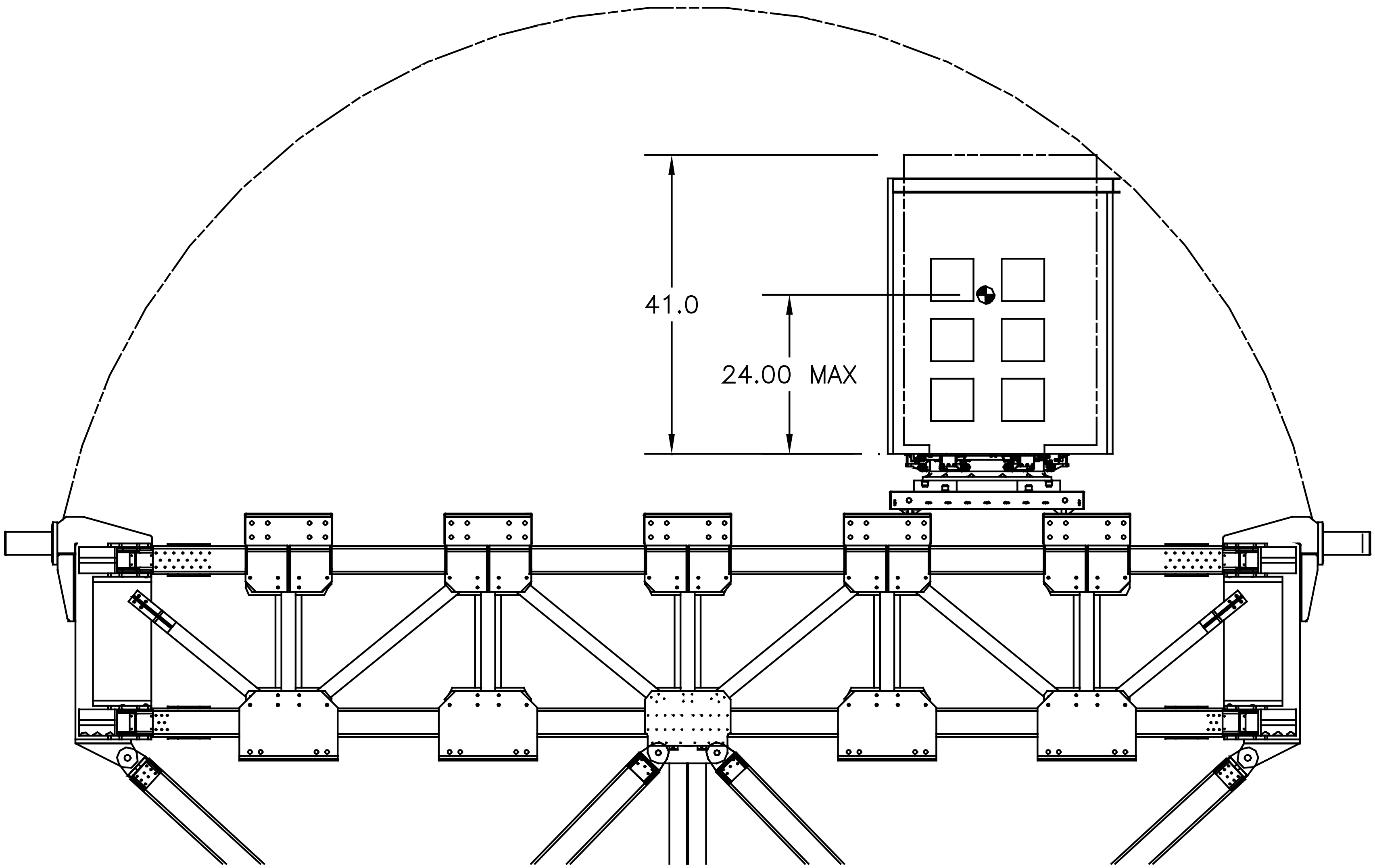


Figure 5-3 SHELS Static Envelope on a Hitchhiker Cross Bay Carrier, Payload Off-Set

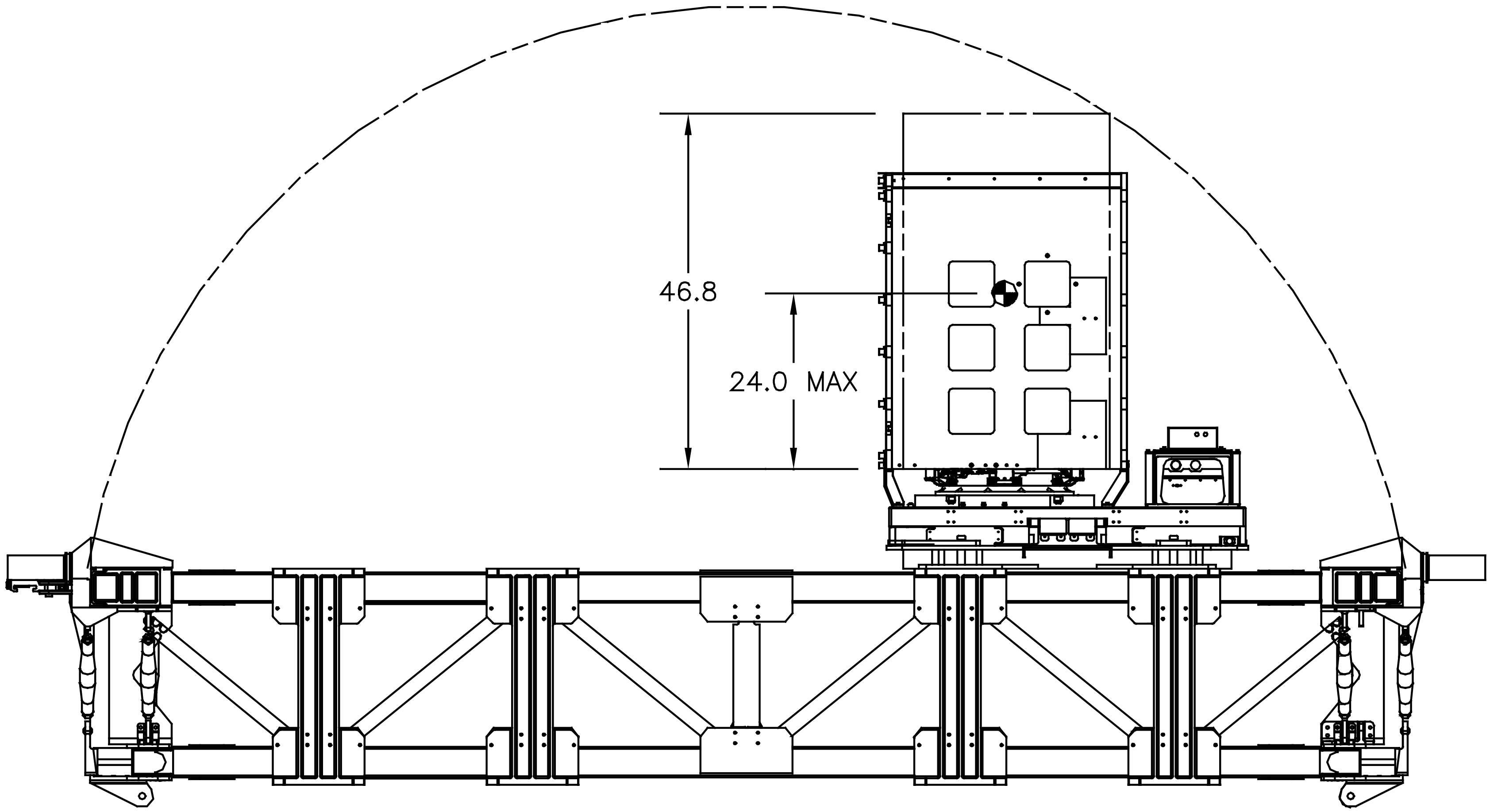


Figure 5-4 SHELS Static Envelope on an LMC Cross Bay Carrier

5.1.1.2 Integration Areas / Crane Heights

Satellite integration at GSFC occurs nominally in one of the following Building #5 locations; clean room (W59A), clean tent (W51), or integration room W45. Other locations are available at GSFC, but special arrangements through Hitchhiker will be required. Crane heights and clean room environments vary by location. Table 5-1 lists the crane heights and clean room environments for each location.

Table 5-1 Crane Hook Heights and Cleanliness

Area	Crane Height Available length for lifting	Class
Clean Room	11' 6"	10k
Clean Tent[2]	15' 5"	10k
Integration Room	19' 9"	100k-300k

5.1.1.3 Satellite Lifting Fixture Envelopes

The satellite will be lifted with an overhead crane for integration to the SHELS hardware. Therefore, the satellite will require either built in lifting points or an experimenter supplied lifting fixture. Regardless of which lifting method is chosen, the load path must also accommodate lifting an additional 35 pounds to account for the SHELS ejection system assembly integrated at the separation plane. The integration sequence requires the ejection system to be attached to the satellite at the separation plane with the Marman band. Next, this combined assembly will be lifted for the next phase of integration. Details on the flow of integration are provided in Section 7.

Additional limitations exist if the payload is mounting to the launch structure and the experimenter supplied lifting fixture option is chosen. For this configuration, the area in which integration occurs is confined and working room more restricted, because the launch structure could be close to the satellite. Figure 5-5 shows the available envelope for a lifting fixture along with major dimensions and components labeled. This envelope is critical to maintain adequate clearance from the launch structure, thermal shroud, and transportation dolly.

Integration onto an MPESS is relatively unencumbered when compared to adapter beam integration. The MPESS provides a clear and easily accessible area to perform integration activities. Ideally, all GSE will be above the separation plane.

[2] The crane for this facility is outside the clean tent area.

Additionally, there are other design requirements if the SHELS user opts for the experimenter supplied lifting fixture. Many of these requirements can be found in NASA-STD-5005, *Ground Support Equipment Design Criteria,* but the following GSFC requirements must also be taken into consideration.

GSFC Requirements/Constraints

1. The lift assembly GSE shall not exceed the envelope specified in Figure 5-5. This only applies to sidewall configurations.
2. The suspended assembly shall be within 2.5 degrees of horizontal at the ejection system interface.
3. The overall lift assembly height (lift point to bottom of separation plane) shall be no greater than 5 ft 3 inches if used in the clean room and integrated to the super dolly.
4. Overall lift assembly height (lift point to bottom of separation plane) shall be no greater than 9 ft 2 inches if used in the clean tent and integrated to the super dolly.
5. Overall lift assembly height (lift point to bottom of separation plane) shall be no greater than 13 ft 6 inches if used in the integration room and integrated to the super dolly.

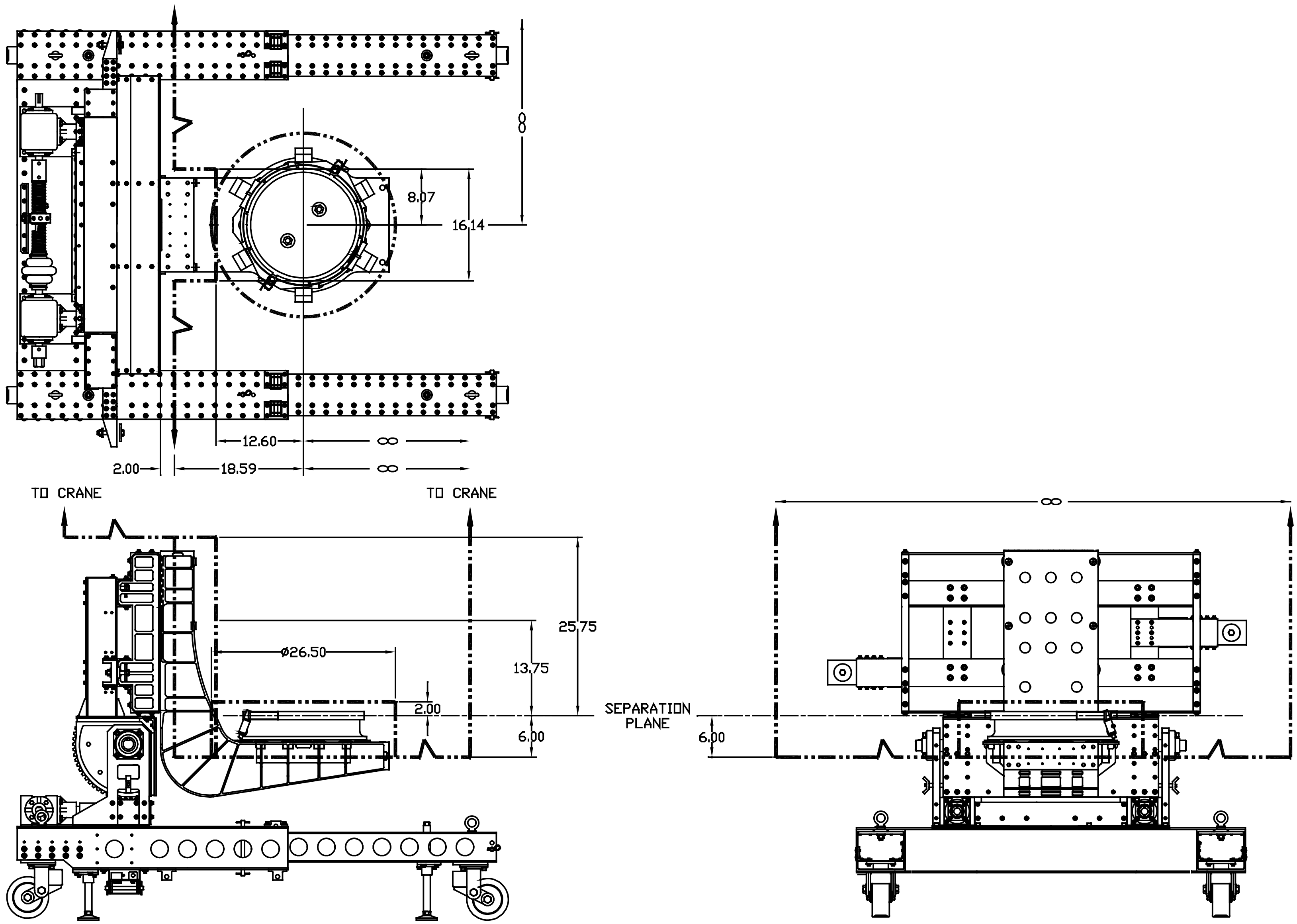


Figure 5-5 Lifting Fixture Envelope for a Sidewall Adapter Beam Configuration

5.1.2 Mass Properties

Preliminary satellite weight, CG, moments and products of inertia (about the satellite CG) shall be provided in the CPR document. The basis for these numbers shall also be provided (i.e., estimated, calculated from fabrication drawings, or actually measured). In addition, the preliminary finite element model must be provided prior to the phase 1 safety review. The customer must provide a final finite element model, measured satellite weight, CG, and mass moments of inertia data to Hitchhiker prior to the phase 2 safety review. Mass properties shall be submitted using the following units: inches, pounds, and slug-ft^2. The satellite CG must be within the previously defined envelopes as defined in Figure 5-1 through Figure 5-4.

5.1.3 Satellite Orientation

After the satellite has been manifested on a shuttle and assigned a position (e.g., sidewall, bay 7, port) every effort will be made to keep the satellite orientation the same relative to the Shuttle coordinate system. This means that if the payload must change from its original position the satellite will not rotate or change from its original orientation. It will remain orientated in the same direction and only the physical location will change. Note, while this will work for a payload moving from the orbiter sidewall to a cross bay carrier, this option may not work in the opposite direction because the satellite envelope may be too large to fit the Orbiter sidewall envelope as shown in Figure 5-1. Figure 5-6 shows the Orbiter coordinate system.

The ejection system baseplate and Marman band are keyed, which defines the orientation of the satellite relative to the ejection system. The ejection baseplate has 4 shear tabs protruding from the mounting surface that defines its orientation to the launch structure or an adapter plate for mounting to a bridge pallet. Finally, the ejection plate assembly, which houses the separation connectors and ejection spring, can be mounted to the ejection baseplate in 30-degree increments. All these variables combined contribute to a versatile system that allows a payload multiple mounting options.

5.1.4 Satellite Integrity and Factors of Safety

During the process of creating the CPR document with SSPP, consideration must be given to the preliminary weight, shape, and frequency of the payload and how this could affect the design loads and method of structural testing. This is particularly true for the coupled loads results from the sidewall adapter beam mounting configuration, which is more sensitive to changes in these parameters than the cross-bay mounted configuration. A structural testing approach that will meet the translational and rotational design load and factor of safety requirements should also be considered while creating the CPR.

All SHELS satellites shall be designed to withstand the launch, on-orbit, reentry, and landing environments of the Orbiter without failures, leaking hazardous fluids, or releasing anything that could damage the Orbiter or cause injury to the crew.

The satellite structural integrity shall be verified by subjecting it to structural testing at 1.2 times the limit load. Structural analyses must show positive margins with safety factors of 1.25 on yield and 1.4 on all ultimate failure modes, such as shear or tensile failure or buckling. Pressure vessels, lines, fittings, and sealed containers shall be designed in accordance with NSTS 1700.7.

Ground Support Equipment (GSE) must be designed using factors of safety of 5.0 for ultimate and 3.0 for yield failure. Additionally, all GSE must be proof tested to two times (2X) the working load for a minimum of one (1) minute. Refer to NASA-STD-5005 for further GSE design criteria.

5.1.5 Limit Acceleration Load Factors

Table 5-2 provides generalized design limit load factors for a SHELS satellite. These loads are selected to envelope the worst case launch and landing load environment, which is a combination of steady state, low frequency, transient loads and high frequency vibration loads. NASA may supply refined design loads, which may be lower, after an updated, higher-fidelity Shuttle math model is released. Final flight limit loads will be derived from the Shuttle coupled loads analysis performed for the Shuttle mission on which the customer is manifested. Smaller, nonstructural components and assemblies mounted to the spacecraft should be designed using load factors that account for the transmissibility between the spacecraft primary structure and the component or assembly. When the transmissibility cannot be measured or estimated adequately, the loads given in Table 5-3 shall be used. Use of loads other than those in Table 5-2 and Table 5-3 for safety critical components/assemblies requires Hitchhiker approval.

The load factors are in g's and should be considered as positive and negative, simultaneous, and in all possible combinations. All accelerations should be applied from the customer's payload cg using the Shuttle coordinate system, as shown in Figure 5-6. Any thermally induced loading shall be combined with the above loads. On orbit thermal loading must also be considered.

Table 5-2 Generalized Hitchhiker Payload/Instrument Structure Design Limit Load Factors

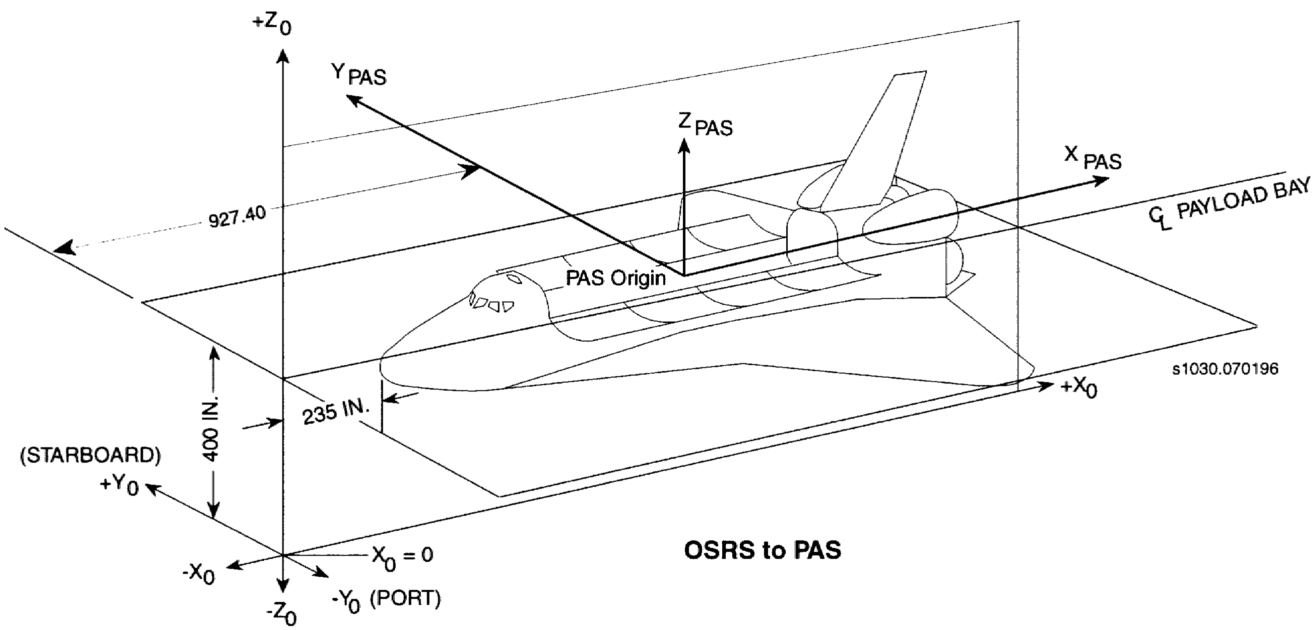
Load Factor (g)		
NX	NY	NZ
±11.0	±9.0	±7.0

Angular Acceleration rad/sec^2		
RX	RY	RZ
+85	+75	+65

Table 5-3 Hitchhiker Tertiary Assembly/Component Design Load Factors

Weight (lb)	Load Factor (g)	
	Primary Axis	Secondary Axes
<20	±40	±12
20-50	±31	±9.3
50-100	±22	±6.6

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



OSRS Orbiter Structural Reference System

PAS Payload Axis System

Figure 5-6 Orbiter Coordinate System

5.1.6 Vibration Frequency Constraints

A SHELS satellite shall have a first fundamental frequency of 35 Hz or greater, modeled as a single point constraint at the ejection system interface. However, it is desirable to have the first fundamental frequency above 50 Hz because the verification requirements increase significantly for any payload with a fundamental frequency less than 50 Hz. These requirements are described in greater detail in section 5.2.2, *Structural Modeling Requirements.*

5.1.7 Random Vibration and Acoustic Noise

SHELS spacecraft shall be designed to withstand the vibroacoustic environment of the Orbiter without failure. General Orbiter component random vibration test specifications are included in section 5.3.3, *Random Vibration Testing*.

5.1.8 Pressure Profile

The maximum cargo bay ascent pressure decay rate (i.e., dP/dt) is shown in Figure 5-7 with a maximum value of 0.445 psi/second. Orbiter payload bay vent door opening occurs at altitudes between 70,000 and 94,000 feet. The re-pressurization rate of the payload bay will not exceed 0.184 psi/sec during descent.

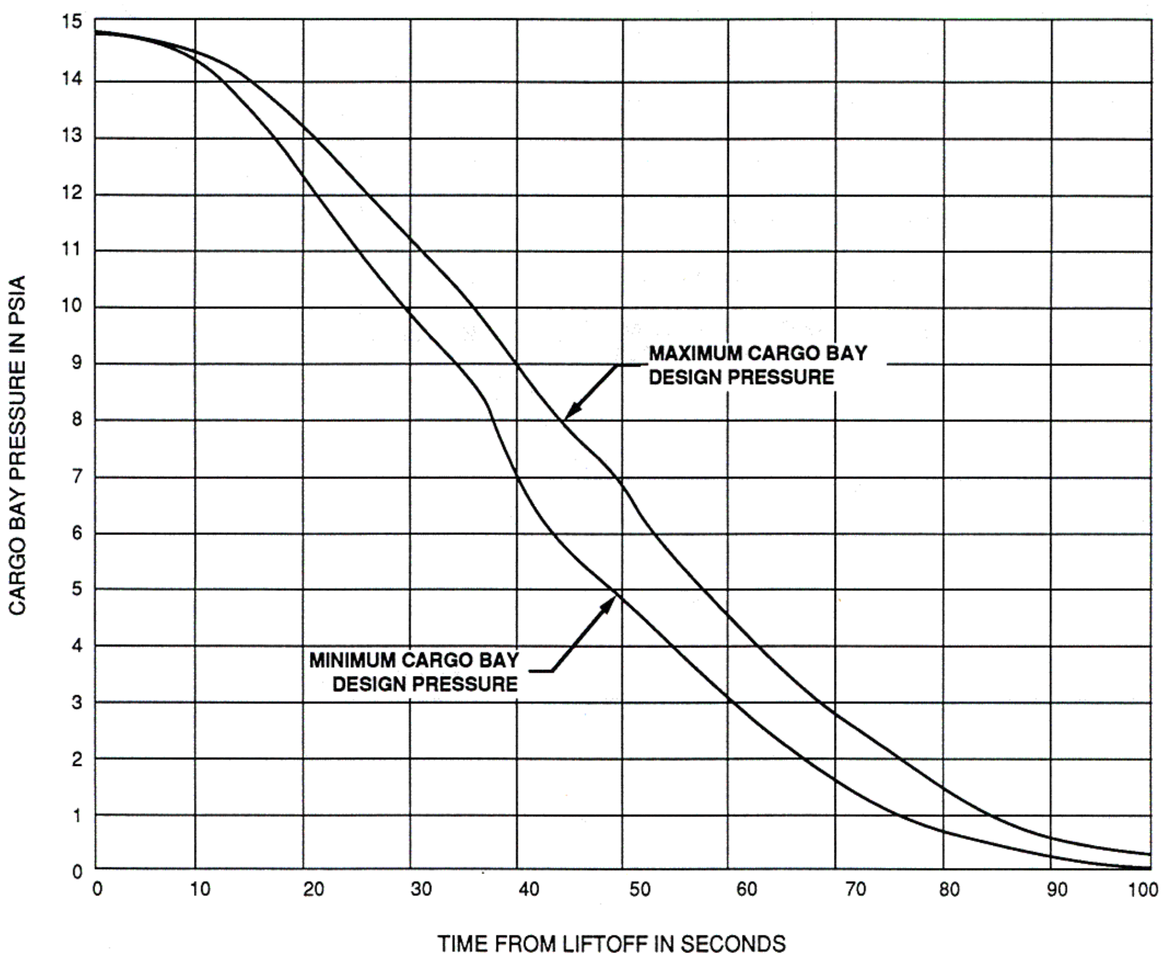


Figure 5-7 Orbiter Payload Bay Internal Pressure Histories During Ascent

5.1.9 Shock Environment

High frequency shock occurs upon Marman band separation during satellite deployment from SHELS. Shock levels at the interface due to Orbiter events are not significant when compared to those of the Marman band. The shock level dissipates rapidly with distance and number of joints between the shock source and the component of interest, as is typical of this type of shock. The shock data provided will aid in designing satellite components that might be sensitive to shock loading. Shock levels are defined in section 5.3.4 *SHELS Shock Testing.*

5.1.10 Materials

Allowable mechanical properties of structural materials shall be obtained from MIL-HDBK-5. Only the materials with high resistance to stress corrosion cracking listed in Table I of the latest version of MSFC-STD-3029 shall be used. A list of materials must be submitted to Hitchhiker as early in satellite development as possible.

5.1.11 Non-Metallic Materials

Use of non-metallic material shall be restricted to those materials which have a maximum collectable volatile condensable material content of 0.1% or less and a total mass loss of 1.0% or less in accordance with 303-PG-7120.2.2.A Mission Assurances Guideline (MAG). Hitchhiker will provide the customer a list of approved materials for use in the thermal/vacuum environment upon request.

5.1.12 Sharp Edges and Extra Vehicular Activity (EVA) Compatibility

Customer hardware shall be designed to minimize the likelihood of personal injury from contact with sharp corners, edges, protrusions, or recesses in accordance with NSTS 07700 Volume 14, Appendix 7. In general, this means rounding exposed edges and corners to a minimum radius of 0.03 inches. Edges and corners at the top of the payload which are near or actually protrude into astronaut EVA sidewall tether corridors shall be suitably protected or rounded to a minimum radius of ½ inch. Edges or protrusions, which for operational reasons cannot meet this requirement, must be coordinated with Hitchhiker on a case-by-case basis.

5.1.13 Kick Loads

All Hitchhiker payloads must provide a kick load analysis of their satellite. A kick load is defined as a 125-pound force applied over a 0.5-inch area. Figure 5-8 through Figure 5-10 show the EVA translation corridor relative to the sidewall and cross bay carrier payloads. The following items detail the necessary steps to properly assess kick loads on a satellite.

1. The entire satellite must be assessed for impact from kick loads. Worst-case situations must be assumed for the analysis. Catastrophic hazards resulting from kick loads must be identified and include the following:

a) The release of mass with associated weight of more than 0.25 pounds.

b) The creation of a sharp edge or protrusion within the 21.5-inch radius (EVA translation corridor).

2. If there are no hazards identified as a result of the assessment, no further action is required.

3. If there are hazards identified as a result of the assessment, and the location is outside of the 45.5-inch radius and there is no planned *EVA* for this region, then "Keep Out zones" may be established.

4. If there are hazards identified as a result of the assessment, and the location is inside of the 45.5-inch radius (24 inch buffer) or there is planned EVA for this region, then a Non Compliance Report (NCR) is required if the experiment hardware cannot be adequately guarded or otherwise protected. If the hazard is the creation of a sharp edge or protrusion, then only the area within the 21.5-inch radius need be considered.

To maximize manifesting opportunities, a payload should not have any hazards within the 45.5-inch radius. A hazard within this region should be avoided if at all possible because it may more than likely result in the de-manifesting of the payload. Alternatively, the payload should consider redesigning the area of interest which cannot meet the kick load requirements / assessment as defined above.

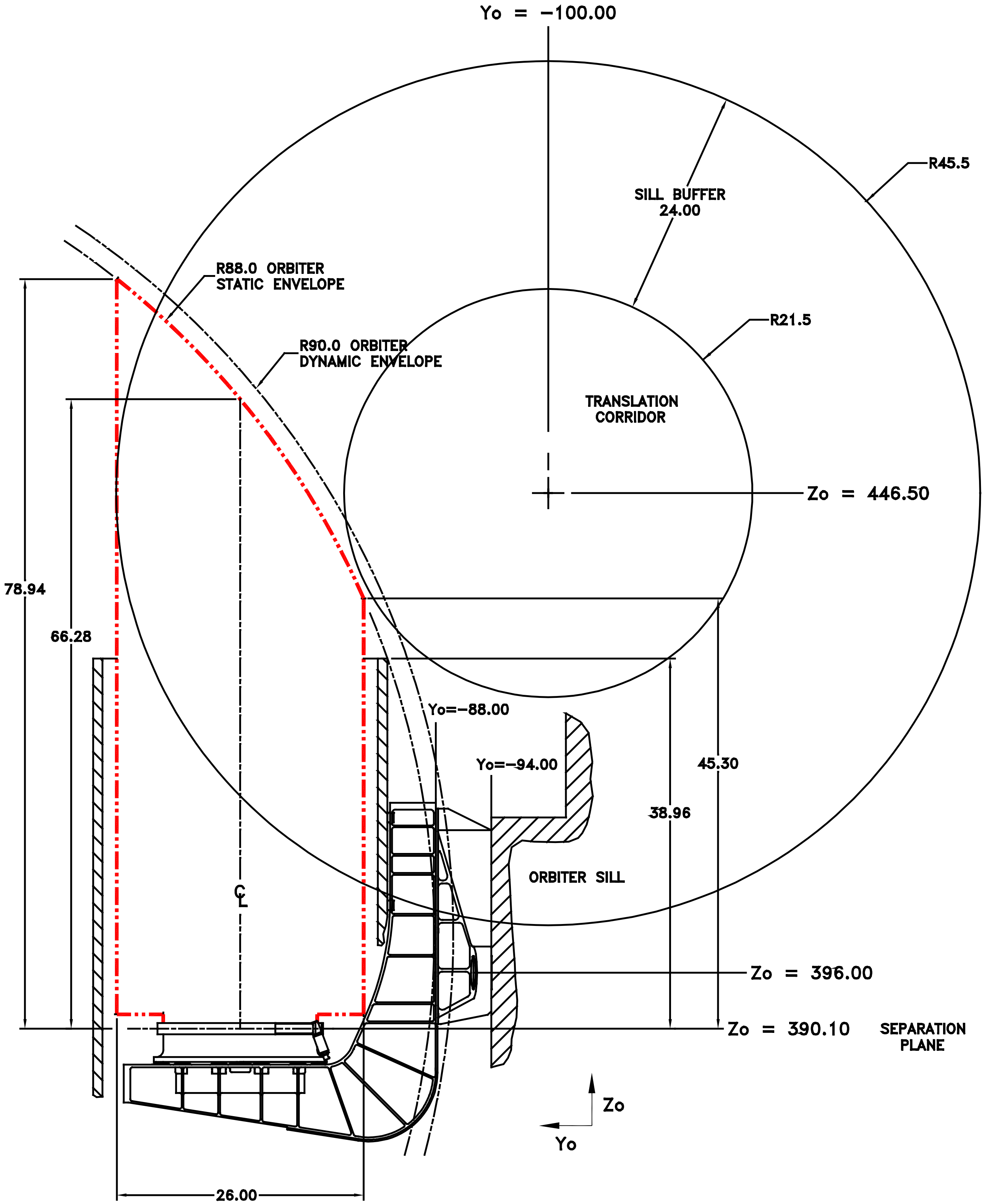


Figure 5-8 Sidewall Payload EVA Translation Corridor (**port side shown)**

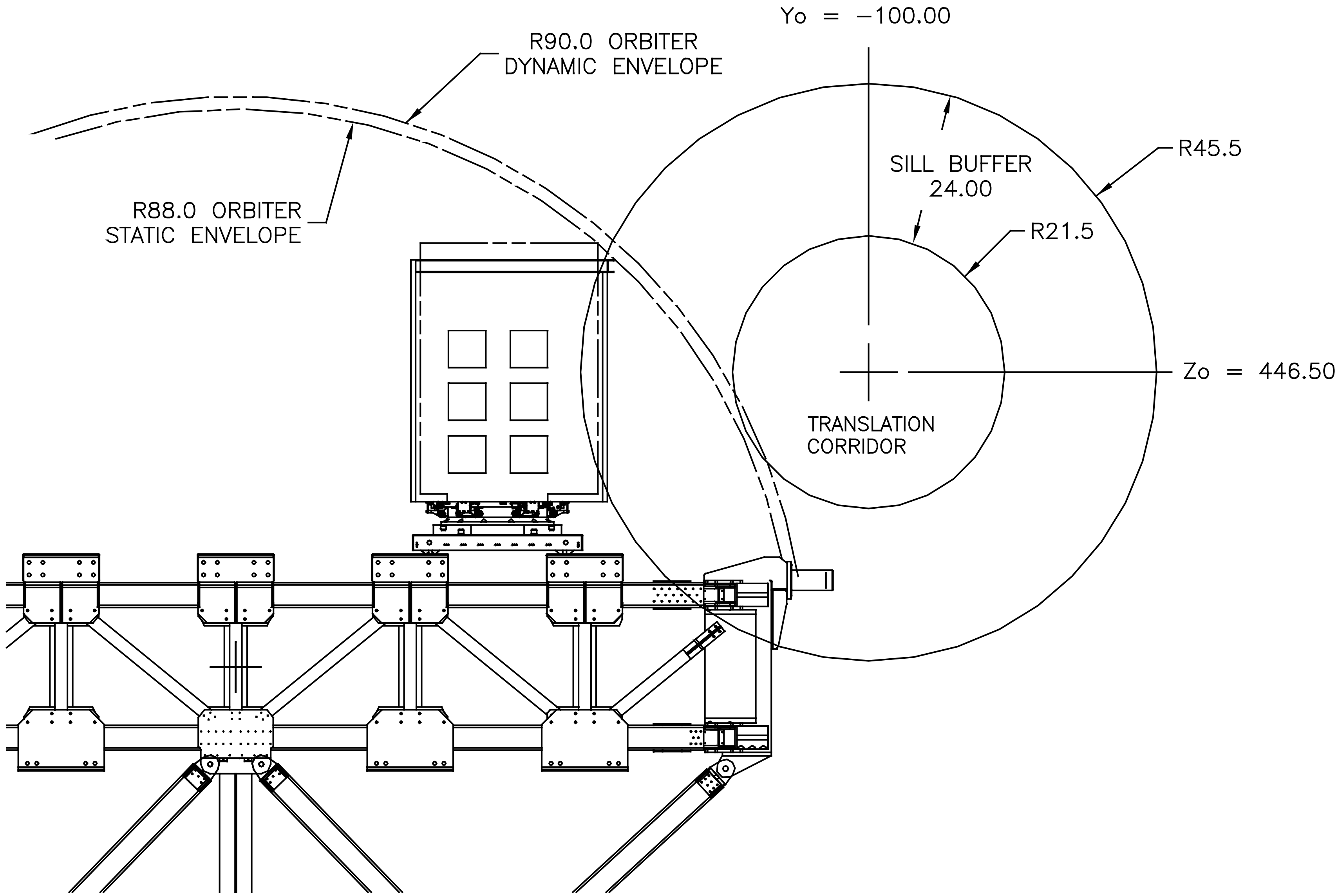


Figure 5-9 HH Cross Bay Carrier EVA Translation Corridor (port side shown)

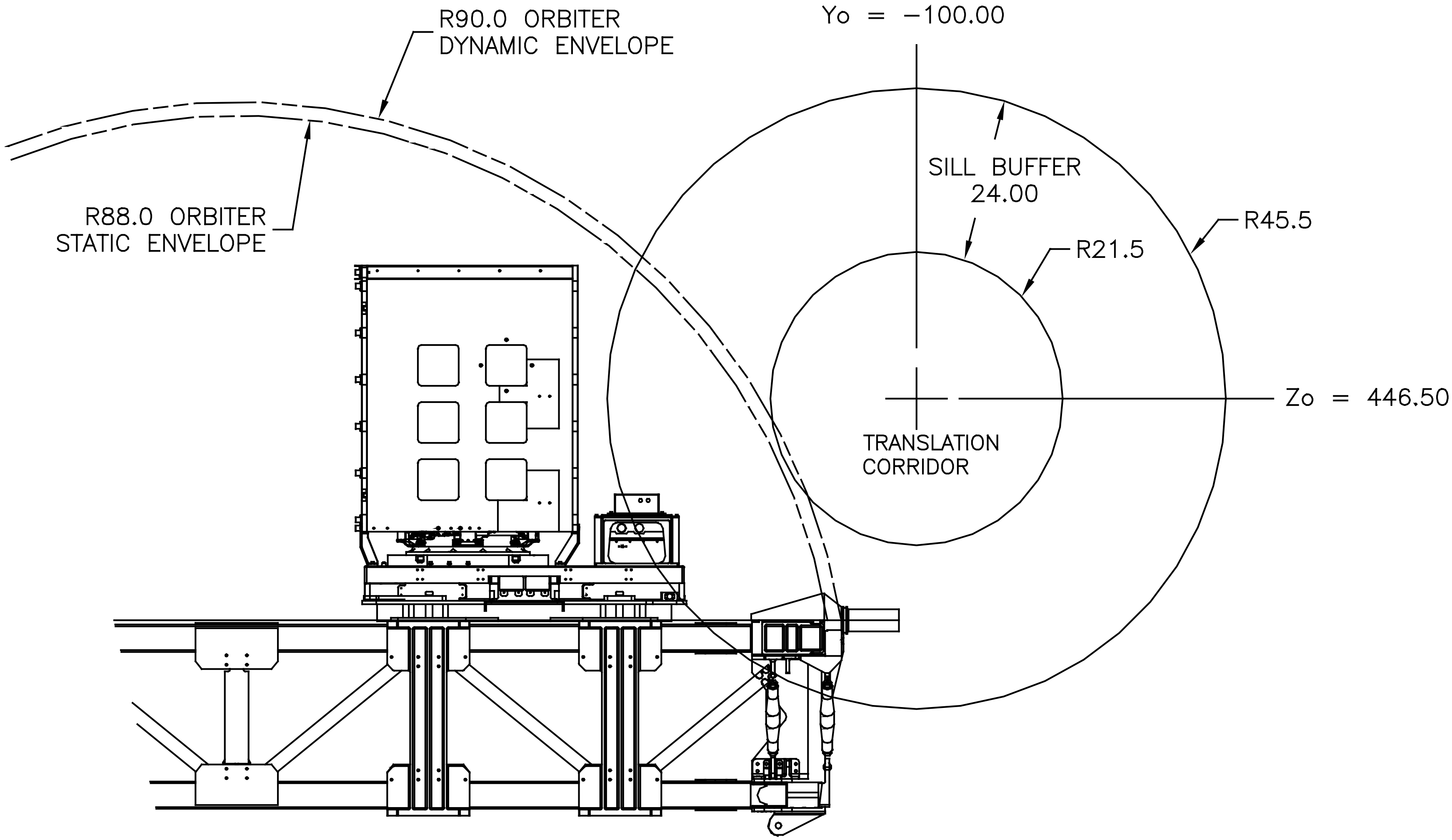


Figure 5-10 LMC Cross Bay Carrier EVA Translation Corridor (port side shown)

5.1.14 Thermal Design Requirements

A test correlated thermal model and a list of the payload external surface properties, such as area (size), thermal coatings, absorptivity (α), emissivity ($\in$), and reflectivity, shall be provided by the SHELS customer. The SHELS customer will be responsible for obtaining approval from Hitchhiker regarding any proposed nonstandard thermal coatings.

5.1.14.1 Heater Power

Heater power for the satellite customer may be provided upon request. Heater power is an optional service. Heater power is provided to the satellite in the form of 28VDC power from the orbiter via the Hitchhiker electronics. Heaters are to be installed in/on the satellite by the customer prior to delivery to Hitchhiker. The power is provided separately from satellite power. The service is deactivated for ascent and is typically activated within three hours of reaching orbit. Once activated, the heater bus is left on for the duration of the mission or until deployment. If the satellite is returning, heater power is available until several hours before reentry.

There are two classifications of heater power: safety critical and mission success. Implementing the required fault tolerance for safety critical heater power requires additional optional services beyond the mission success heaters. Mission success heater power is single string and zero-fault tolerant. Satellites requesting mission success heater power must still meet the safe without services requirements.

If heater power is required to meet safety requirements then two-fault tolerant power is required. Implementing two-fault tolerance power requires optional services for additional carrier flight hardware and safety analysis. Safety critical power is mission specific. Further discussion is beyond the scope of this document.

Mission success heater power is provided via the power separation connector. Up to nine one-ampere circuits can be provided. These circuits are separate from satellite power. Each circuit is 28VDC unregulated orbiter power. At 28VDC each heater circuit could provide as much as 24W using a resistive element. Actual realized power will be dependent on the implementation.

5.1.14.2 Heater Safety

Each heater must not create a safety hazard either individually or as a system. For a mission success heater, it needs to be shown that if the heaters are on at 100% duty cycle and at the worst case (typically the high bus voltage) that they do not create a hazard, such as overheating. If the system is shown not to be safe, fault tolerant inhibits will be required on the satellite.

For systems with one to four heaters assume they are all failed on simultaneously. If five or more heaters are used, assume four heaters fail on simultaneously that result in the worse case. This methodology establishes the safety of the heater system with margin. This can be accomplished via a thermal analysis or test.

Another method to show safety compliance and avoid analysis is to use three thermostats of established reliability per heater string. Two are required to be in series with the power and one in series on the return leg. This configuration is considered two-fault tolerant for the heater failed on case.

5.1.14.3 Heater Design and Implementation Considerations

There are a number of design considerations to be taken into account to deploy a heater system. Any heater system must be safe at all times and must not create additional safety concerns.

Each of the heater circuits are separately fused to provide a maximum de-rated current of 1A. This current cannot be exceeded under any circumstance including bus voltage fluctuations. The individual circuits cannot be tied together. Since power is from the orbiter, all associated heater wiring must be in compliance with JSC safety interpretation letter TA-92-038. The Hitchhiker electronics provides the required circuit protection. The heaters powered by SHELS must be on separate circuits from other satellite systems (i.e not shared).

The orbiter power bus can vary +/-4VDC. A voltage drop can also occur due to resistance of the wiring leading to the heaters. The wiring resistance is mission dependent. Consequently actual heater power can vary considerably and must be accounted for in the design.

Typically, resistive heater elements are used. These need to be sized based on the highest bus voltage (32VDC) at the maximum allowed current (1A). Resistive heaters generally have a tolerance associated with them. They can be greater than +/-10%. The element's resistance tolerance must be taken into account in the design. The tolerance often results in a higher resistance value procured than used in ideal calculations. The net effect is slightly less heater power. If required, tighter tolerancing can be achieved through procuring a large lot and screening for specific values. In some cases vendors can accommodate special needs.

Resistive heaters are often secured by an adhesive. These adhesives have varying characteristics that are sometimes temperature dependent. Often, there is a W/area rating that cannot be exceeded. This characteristic will affect the size of the heater. Exceeding this rating may require demonstrating that an adhesive failure does not pose a safety hazard.

An alternative implementation would be to use a constant current source. This would eliminate the variations due to changes in the bus voltage. Any constant current controller would be the satellite customer's responsibility and is not a Hitchhiker service.

In most cases it is undesirable to have the heaters on at full power all the time. SHELS does not provide a control loop for cycling heater power. Often, a thermostatic switch (T-Stat) is used to cycle the heater power. If a bi-metallic T-Stat is used, it must be hermetically sealed. T-Stats are recommended based on their simplicity and proven flight history.

Other implementations can be used so long as they are demonstrated to be safe and not exceed the maximum allowable current.

As an additional optional service, thermistor inputs can be added to the signal umbilical interface. Up to ten YSI-44006 type NTC thermistors can be supported. These would need to be installed by the customer on the satellite prior to delivery to NASA.

The heater specification along with the predicted dissipation, duty cycle and HH bus usage shall be supplied to Hitchhiker.

5.1.14.4 Thermal safety

The customer must be aware of all safety concerns of their payload, 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 <u>anytime</u> during the mission. In addition to performing all safety analyses, payloads must be able to fly in the attitudes and time durations as specified in tables 4-2, 4-3 and 4-5 of the SSP Standard Integration Plans (NSTS 21000-SIP-ATT and NSTS 21000-SIP-DRP). On Shuttle missions that require docking with the ISS, the payload may be required to assess docked attitudes and durations other than the above requirements. The attitudes are described in more detail in CARS. It is desirable to be able to withstand these extreme cases longer than the ICD requirement for manifesting reasons. 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.

5.1.15 Thermal Blanket Attachment Requirements

Specific thermal blanket attachment methods are determined on a case-by-case basis depending on payload design, possible contamination constraints, availability of attachment hardware, etc. Typically a combination of various methods is used to attach the blankets to the payload. Straps (or wires) are required for the grounding of all thermal blankets with an area greater than 100 cm^2. Grounding of thermal blankets can be non-structural and shall be in accordance with the Orbiter core ICD-2-19001. More details on blanket construction can be found in the document “Construction of SSPP Thermal Blankets” document number SSPP-SPEC-058.

5.1.16 Electrical

5.1.16.1 Wiring

If the umbilical interface is used, all associated wiring in the satellite must be in compliance with JSC safety interpretation letter TA-92-038 with regard to wire sizing. SHELS provides circuit protection devices for power. The de-rated currents for power must not be exceeded. If smaller sized wire is used on the satellite than what SHELS is fused for, then the satellite must add additional circuit protection devices.

The current ratings of the umbilical wiring per JSC TA-92-038 shall not be exceeded in flight or during ground processing.

5.1.16.2 Inhibits

If there are any safety critical systems, then fault tolerant inhibits will be required. Typical safety concerns are battery charging, RF transmitters, and deployment mechanisms. Often inhibits take the form of electrical circuits. All safety inhibit schemes must be approved prior to being implemented. Inhibits must be verifiable in the full flight configuration on SHELS. Often a separate inhibit verification connector on the satellite is used.

Inhibits cannot be removed once installed into the orbiter.

5.1.16.3 Connectors and Closeout Covers

Any connectors used for servicing the satellite must be socket on the satellite side if power from the satellite is present. Power and signal connectors should be selected to avoid confusion and mismating.

All servicing connectors require closeout covers. If the connector requires access in the orbiter, the handling and tools should be reduced to a minimum. The use of loose parts is discouraged due to Foreign Object Debris (FOD) concerns. It is recommended that connectors requiring access in the orbiter be circular, scoop proof, and use bayonets (i.e. Mil-C-38999 Series I). Flight tethered locking caps are commercially available for use in closeout.

5.1.16.4 Satellite Structural Bonding

The satellite shall have an electrical bond between structural elements <1.0 Ohm resistance. The satellite shall have an electrical bond to SHELS when mounted on the ejection system of <1.0 Ohm resistance.

5.1.17 Electromagnetic Capability (EMC)

A satellite that uses the SHELS umbilical connectors must meet all Electro-Magnetic Interference (EMI)/EMC conditions as specified in the Orbiter core ICD-2-19001.

5.1.18 Satellite Radio Frequency (RF) Systems

Payload organizations that incorporate non-ionizing RF systems as part of the payload design are required to provide detailed information regarding these systems to GSFC. An integrated safety assessment will be performed to verify compliance with integrated SHELS requirements, and Orbiter cargo bay requirements. Satellite RF transmission is considered to be a hazardous operation when integrated to the SHELS carrier in the Space Shuttle's Payload Bay, and various inhibit schemes are required. Requirements for inhibits are dependent on RF level and Orbiter configuration.

Payloads are encouraged to review and assess general compliance with requirements early in their RF design. General requirements are found in Section 10.7, ICD-2-19001, Shuttle Orbiter/Cargo Bay Standard Interfaces, and Section 202.5 in NSTS 1700.7, Safety Policy and Requirements for Payloads Using the Space Transportation System. GSFC invites early discussion to assess design requirements, required data analysis, and inhibit implementation.

During ground processing at GSFC, payloads will undergo EMI/EMC tests to verify compliance to specific STS mission payload to Orbiter ICD requirements. After the payload has completed these tests at GSFC and is delivered to KSC, performing any radiating tests during ground processing, and/or after Orbiter integration is strongly discouraged.

5.2 Analysis Requirements

5.2.1 Structural Analysis

The customer is required to perform stress analyses in sufficient detail to show that design factors of safety are met and that positive margins of safety exist for both yield and ultimate stress conditions. The margin of safety formula is shown below.

$$MS = \frac{AllowableStress}{(FS) \times (ActualStress)} - 1 \geq 0$$

Stress analyses shall use methods and assumptions consistent with standard aerospace practices. Buckling, crippling, and shear failures shall be considered ultimate failures. Allowable material stresses/properties shall be taken from MIL-HDBK-5.

5.2.2 Structural Modeling Requirements

Customers are required to verify by test, all satellite natural frequencies less than 100Hz. Hitchhiker requires that the structural stiffness of the spacecraft produce fundamental frequencies above 35Hz in each axis for a satellite hard-mounted at the separation plane on a vibration fixture, without an ejection base and Marman band. A design goal of 50Hz is highly recommended because a customer having a satellite with a fundamental frequency less than 50Hz must submit to Hitchhiker a test-verified finite element math model of their spacecraft. All finite element models submitted to Hitchhiker must demonstrate mathematical validity by showing that the model contains six rigid body frequencies of value 0.001Hz or less. The math model should contain as few degrees of freedom as necessary for accurate simulation of frequencies and mode shapes under 50Hz and all frequencies up to 100Hz, but in all cases must be limited to no more than 10,000 degrees of freedom. The customer and Hitchhiker will agree, on a case-by-case basis, on the specific form and content of the finite element math model submitted to Hitchhiker. A finite element math model is not required for satellite with a fundamental frequency above 50Hz, but an analysis (either classical or finite element) is still required to verify natural frequency testing. Table 5-4 summarizes these frequency and modeling requirements. Test verification can be achieved by performing a modal survey or sine sweep test on the payload as discussed in section 5.3.2*, Natural Frequency Verification Testing.*

Table 5-4 Structural Modeling Requirements

Lowest Fundamental Frequency	Required Testing	Analysis Method
$f_N \geq 100$ Hz	none	classical or F.E.M.
50 Hz $< f_N <$ 100 Hz	sine sweep (modal survey acceptable)	classical or F.E.M.
35 Hz $< f_N <$ 50 Hz	modal survey or sine sweep (dependant on modal complexity)	F.E.M.
$f_N \leq 35$ Hz (1) Note: NOT RECOMMENDED	modal survey or sine sweep (dependant on modal complexity)	F.E.M.

* See Section 5.3.2, *Natural Frequency Verification Testing*

(1) The fundamental frequency of a satellite could couple with the frequencies of the SHELS hardware, thereby creating higher design limit load factors. As a result, these higher loads may preclude SHELS from flight because the SHELS hardware will have to be re-analyzed to the higher design load factors and show positive margins of safety. Optional costs may be incurred to an experimenter if additional analyses are required due to the satellite having a fundamental frequency less than 35 Hz.

5.2.3 Fracture Control

A fracture control program is required for all SHELS satellites. The customer is responsible for providing a Fracture Control Plan, which describes in detail how the requirements of NASA-STD-5003 (Fracture Control Requirements for Payloads using the Space Shuttle) will be satisfied. The fracture control program implemented by the customer shall provide assurance that no catastrophic hazards to the Orbiter or crew will result from the initiation or propagation of flaws, cracks, or crack-like defects in customer structure during its mission lifetime, including fabrication, testing, and service life. Hitchhiker must approve the fracture control plan prior to its implementation, and normally, the plan is submitted as part of the structural verification plan described earlier.

5.2.4 RF Information

Transmitters or systems radiating intentional RF energy from an antenna or other propagating source(s) must submit analysis, and/or testing data to GSFC for an integrated safety assessment. This submittal is required even if the payload is not intending to radiate during Orbiter operations. RF system parameters for satellite transmitters and antennas are generally available through calculations, typically required for RF link budgets. For the RF transmitter, carrier frequency, output power, power output of last amplifier stage, and all system losses are needed. Design specifications for antennas are required and include: antenna type, pattern description, gain over isotropic antenna, and half-power (-3db) beam width. Effective isotropic radiated power (EIRP) is required for overall calculated system performance (transmitter power plus gain/loss added to transmitter by an antenna, minus any cable losses). RF system information is required regardless of the number of inhibits incorporated in the satellite electrical design.

To reduce reoccurring engineering on the part of the satellite designer, early discussions and system assessments by GSFC regarding implementation of RF systems is recommended. This early satellite performance assessment will aid Hitchhiker in evaluating satellite and payload hazards with respect to carrier equipment, other payloads, and the Space Shuttle. During technical interchange meetings, GSFC and satellite organization working groups will review and assess requirements and implementation considerations.

5.2.5 Thermal Analysis

The thermal design and analysis of each satellite is a customer responsibility. The SHELS customer shall determine all internal conduction, convection, and radiation within their satellite. They shall be responsible for the proper design and coupling of high power components. Reduced thermal models of the satellite are to be supplied to Hitchhiker. Temperature limits, as defined below, shall be provided for each node in the reduced thermal math model. The SHELS customer shall also define any special temperature requirements, such as levels and gradients.

<u>Operating Temperature</u> - 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 but not cause a hazard.

Safety Temperature - the temperature, if exceeded, at which the unit could potentially lead to catastrophic damage to the orbiter or injury to the crewmembers (e.g., hydrazine freeze, pressure burst, etc.).

Storage Temperature - the temperature at which the unit may be maintained for extended periods of time in a way that does not permanently affect the performance of the system. (Note: Some servicing activity may be required to restore the specified performance.)

5.3 Standalone Testing Requirements

5.3.1 Structural Test Requirements

The customer is required to perform strength testing of all structural components. The test must demonstrate that no detrimental permanent deformation or ultimate failures occur when loads are imposed on the spacecraft; these loads must be applied such that every primary load-carrying member experiences a stress of at least 1.2 times the limit stress. The limit stress is the highest stress produced either by design acceleration load factors or by refined loads supplied by Hitchhiker. To satisfy this requirement, it is not necessary to impose the precise externally applied load factors in a single test. One may impose artificial loads in a number of different load cases; each load producing the required stresses in only a portion of the structure. The tests must result in the required stresses in all primary load-carrying members. The test load may be applied by pulling/pushing on the structure with discrete forces, by the application of a linear acceleration field (centrifuge), or by subjecting the instrument to a below-resonant-frequency sine dwell or sine burst vibration test.

5.3.2 Natural Frequency Verification Testing

All satellites shall have their lowest fundamental frequency verified by test if the predicted frequency is below 100Hz. Acceptable tests for verifying natural frequencies include modal survey and sine sweep vibration. Hitchhiker may require satellites with complicated mode shapes and natural frequencies less than 50Hz to undergo modal survey testing to recover both structural mode frequencies and mode shapes. The decision of whether to require the modal survey will be based on Hitchhiker's engineering judgment and experience.

5.3.3 Random Vibration Testing

All satellites must be tested for the Space Shuttle vibroacoustic environment. Table 5-5 shows the generalized random vibration specifications for shuttle hardware. New designs must be tested to qualification levels. Previously flown or qualified hardware can be tested to acceptance levels. A prototype satellite may be used for qualification testing. The minimum test duration is one minute in each of the three orthogonal axes. Hitchhiker may waive the random vibration requirement in some instances, such as for previously flown or contained hardware. Refer to NASA-STD-5001 for more information on hardware classifications.

Table 5-5 Generalized Shuttle Component Random Vibration (50 lbs. or less)

Frequency (Hz)	ASD Level (G^2 Hz)	
	Qualification	Acceptance
20	.025	.0125
20-50	+6dB/oct	+6dB/oct
50-600	.15	.075
600-2000	-4.5 dB/oct	-4.5 dB/oct
2000	.025	.0125
Overall	12.9 Grms	9.1 Grms

The test may be modified and the acceleration spectral density level reduced for components weighing more than 50 pounds by using the following formula:

DB reduction = 10LOG(W/50)

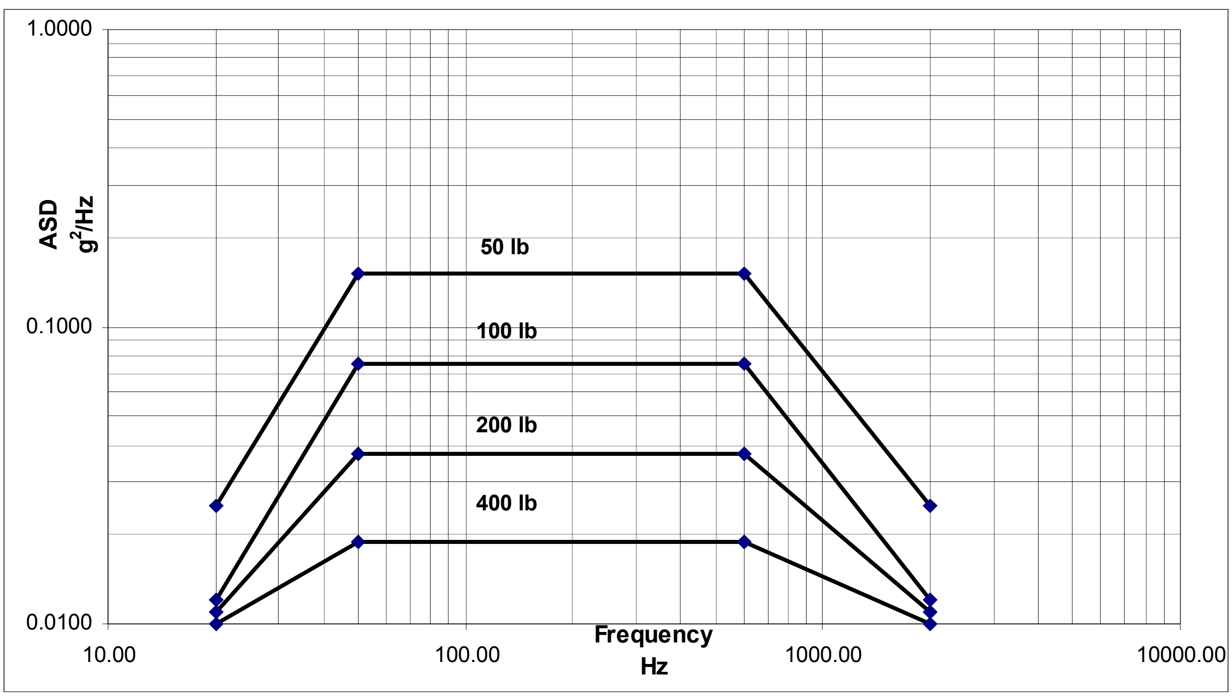
$ASD_{(50\text{-}600Hz)}$ = .15*(50/W) for protoflight

$ASD_{(50\text{-}600Hz)}$ = .75*(50/W) for acceptance

Where W = component weight

The slopes shall be maintained at +6 and -4.5 dB/oct for components weighing up to 125 pounds. Above this weight, the slopes shall be adjusted to maintain as ASD level of 0.01 G^2/Hz at 20 and 2000Hz.

For components weighing over 400 pounds, the test specification shall be maintained at the level for 400 pounds.



5.3.4 Shock Testing

High frequency separation shock levels are difficult to simulate mechanically on a vibration table at the satellite level. The most direct method is to perform a test using the SHELS Engineering Test Unit (ETU) ejection system with a functional Marman band and bolt cutters. The test is performed by integrating the SHELS ETU ejection system (less the ejection spring) to the satellite and then suspending the entire assembly above foam padding. The ETU is then actuated and allowed to drop away on to the foam.

Figure 5-11 shows the maximum flight level shock environment at the payload interface/separation plane. This figure shows the data for three accelerometers located near the Marman band / separation plane interface. The band preload is 3000 pounds. The figure also shows a maximum shock envelope created to encompass the shock environment recorded during the three 3000 pound preload testing. The envelope was defined graphically and encompasses the shock levels at all accelerometer locations. If this data is being used to perform component level shock qualification testing an additional factor of 1.5dB (1.5 test factor) should be added to the maximum shock envelope to account for testing uncertainties.

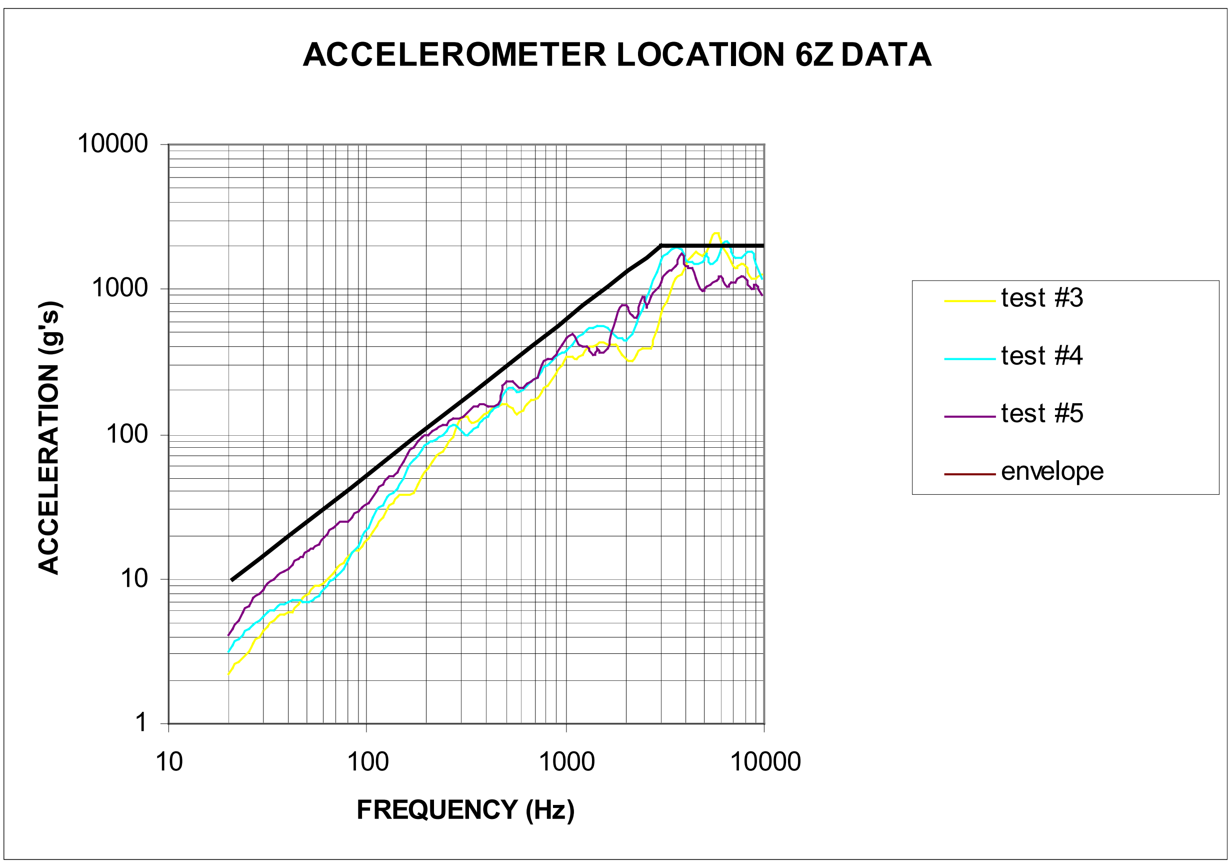


Figure 5-11 SHELS Near Field Shock Levels and Envelope

5.3.5 Typical Test Sequence

The fulfillment of the previous test requirements can often be satisfied by a single visit to a vibration test facility, depending on the mass and stiffness of the payload. A typical test of this type generally includes:

a. Initial sine sweep test to verify the natural frequency,
b. Sine burst test to perform strength testing, and
c. Random vibration test to qualify the payload for vibroacoustic environment.
d. Final sine sweep test to correlate with initial sine sweep test.

This test sequence is typically repeated in three orthogonal axes. Note the sine burst applies a force field in a single axis whereas the design load factors occur in all three axes simultaneously. Therefore, the design load factors must use the root-sum-square method to simultaneously apply the loads in all three axes.

5.3.6 Electrical Verification Testing

It is strongly recommended that the customer perform electrical verification tests on the satellite prior to delivery. This will help prevent failures at I&T that could possibly result in the demanifesting of the payload. The following test should be performed:

a. Continuity and isolation on power, returns, and chassis
b. Component to structure bonding verification
c. EMI/EMC as detailed in Orbiter ICD-2-19001, section 10.7

6 PAYLOAD INTERFACES

6.1 Mechanical

The SHELS mechanical system consists of the ejection system and thermal shroud. Both components are mounted to either the launch structure or an adapter plate for a bridge pallet. The ejection system can accommodate a maximum 400-pound satellite on the launch structure or a maximum 500-pound satellite on a bridge pallet. The satellite center of gravity envelope is a maximum of 24 inches above the ejection system separation plane and within a 0.25-inch radius of the ejection system centerline. The entire system is modeled in Pro-Engineer™.

6.1.1 Launch Structure

The SHELS launch structure is a premium quality, aerospace structural casting with a riveted stress skin panel for increased torsional capability. The casting material is aluminum alloy A356-T6 strength class 10, fabricated with rapid prototype, investment casting techniques. The launch structure provides the structural interface that mounts SHELS to the adapter beam assembly for an Orbiter sidewall flight.

6.1.2 Ejection System

The SHELS ejection system consists of an ejection base, strap and shoe Marman band, center mounted compression spring/push plate assembly, and a torsion spring catcher assembly as shown in Figure 6-1 and Figure 6-2. The thermally isolated ejection base is mounted to the SHELS launch structure or bridge pallet. All hardware necessary for mating and separation, e.g. Marman band assembly, bolt cutters, and torsion spring assemblies, remain with the ejection base upon satellite deployment. The SHELS ejection base is approximately 3.5 inches high and 16.72 inches in diameter at the Marman band flange.

The Marman band consists of two stainless steel tension straps and ten shoes that are loosely riveted to the strap. Trunnions are riveted to the ends of each strap and provide a swiveled attach point for the separation bolts which tension the system. The aluminum shoes have a 20° ramp angle and low friction, hard coatings applied to all surfaces. The separation flange configuration and associated satellite interface requirements are shown in Figure 6-3 and Figure 6-4.

When the separation bolts are preloaded, the shoes clamp the system by riding up matching ramps on the ejection base flange and payload interface plate flange. Each of the separation bolts will also have a bolt force sensor to monitor band separation bolt tension during assembly, testing, and under various environmental conditions. Redundant bolt cutters release the Marman band. A nominal separation of the payload from the ejection base will occur if one or two of the bolt cutters function. When the separation bolts are cut, the Marman band snaps off the flange interfaces and is held in a retracted position, away from the satellite by six torsion spring assemblies.

Once the Marman band has snapped off the flanges, a centrally located compression spring is free to push the payload away from the ejection base. A guide shaft guides the push plate during the entire stroke of the spring. The guide shaft provides a low friction, tightly controlled ejection with low tip off imparted to the satellite. Ejection velocity may be tailored to an individual satellite by varying the stroke of the guide shaft and by placing different size compression springs in the adjustable spring housing. The maximum ejection velocity for a 500 pound satellite is 4 ft/sec with a maximum 5 inch stroke. The ejection velocity is adjustable from 1 ft/sec to 4 ft/sec.

The ejection system allows for the mounting of two low force umbilical connectors. These connectors provide power and telemetry to the satellite while it's in the Shuttle cargo bay prior to ejection. The connectors incorporate a set of wave springs on one half of the connector and an adjustable nut on the other half. By adjusting the location of the nut, the friction force of the contacts can be negated, essentially creating a low force separation connector. The two connectors are mounted on adjustable brackets on the ejection base plate next to the compression spring assembly. The adjustable bracket allows for a blind mate of the connector during payload integration.

6.1.2.1 Separation Switches

Users usually elect to employ one (or more) separation switches[3] as inhibits for hazard mitigation when mated to the SHELS ejection system. If such switches are used, the following requirements apply:

1) A means shall be provided to verify the state of each separation switch after final mate of the spacecraft to the SHELS ejection system.
2) The separation switches shall be hermetically sealed, explosion proof, and flight qualified. Flight qualification can be either via flight heritage or comprehensive environmental (i.e., vibration and thermal/vacuum) tests.
3) Random vibration testing shall be done with the spacecraft mated to the SHELS ejection system. If conditions 4a-c (below) are met, the SHELS ejection system can be replaced by a fixture which emulates the ejection system mechanical interface to the extent that the separation switches are depressed to the position achieved when fully mated to the SHELS ejection system.
4) Switch state shall be continuously monitored during vibration test. Multiple switches connected in series for flight to provide multiple inhibits shall have their individual states separately monitored during test. This requirement can be waived if the following conditions are met:
    a. Inhibit (i.e., launch) state of the switch is open-circuit
    b. There is at least 0.17 inches of over-travel (i.e., travel between the state change to inhibit and the fully stowed position of the switch)

[3] Reference Mil-S-8805 for separation switch suggestions.

c. Over-travel has been verified by fit check with the SHELS ejection system

5) The zone(s) on the upper surface of the ejection system push plate defined in GD 2041621 (depicted in Figure 6-5) shall envelop the touch point(s) for the separation switch(es). Figure 6-6 shows the maximum distance the push can move in the absence of the ejection spring. The chosen inhibit must not change state within this distance.

6) Switch positions and force vs. deflection curves shall be provided to SSPPO for tip-off analysis of the satellite separation.

6.1.3 Thermal Shroud

A thermal shroud was developed for SHELS users. The shroud is designed for ease of use, both at GSFC and during integration activities at KSC. Figure 6-7 shows the shroud (sidewall) along with all critical components labeled.

The basic structure consists of four aluminum honeycomb panels and a machined mounting brackets. For sidewall mounted payloads the rear panel fastens directly to the launch structure. The side panels fasten to the rear panel and also to the adapter beam using the finger and gusset brackets. The front panel fastens to the side panels and is also attached to the launch structure using the long and short gusset brackets. Finally, the shroud corners furthest from the adapter beam are supported using adjustable struts connected to rigid brackets. For bridge-mounted payloads all sidewall attach point and hardware are removed and replaced with six brackets that attach the shroud to the bridge. The shroud has beta cloth multi-layer insulation (MLI) on the external surfaces and white paint on the interior surfaces facing the experiment.

The shroud contains 24, six-inch square openings which allows access to a satellite. Figure 6-8 shows the locations of these openings. The openings will be covered with beta cloth MLI, and a closeout plate will be installed on the top rear opening of each side panel prior to flight to comply with kick load requirements. The bottom three horizontal rows are at the same elevation in each of the panels. Additionally, the entire front panel is removable during any phase of integration. The rear and side panels are not removable after integration to the launch structure/adapter beam or to the bridge.

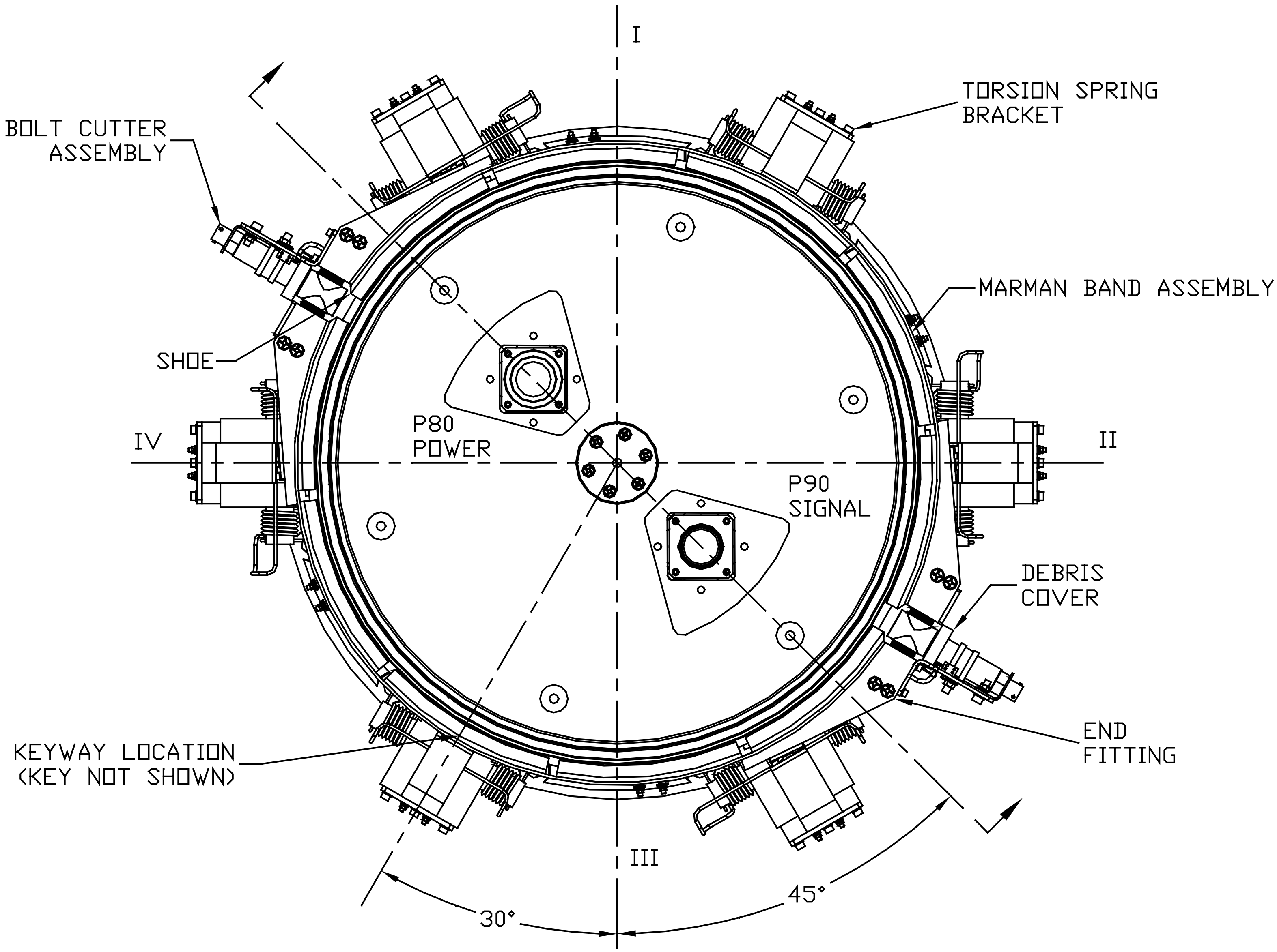


Figure 6-1 SHELS Ejection System - View looking down

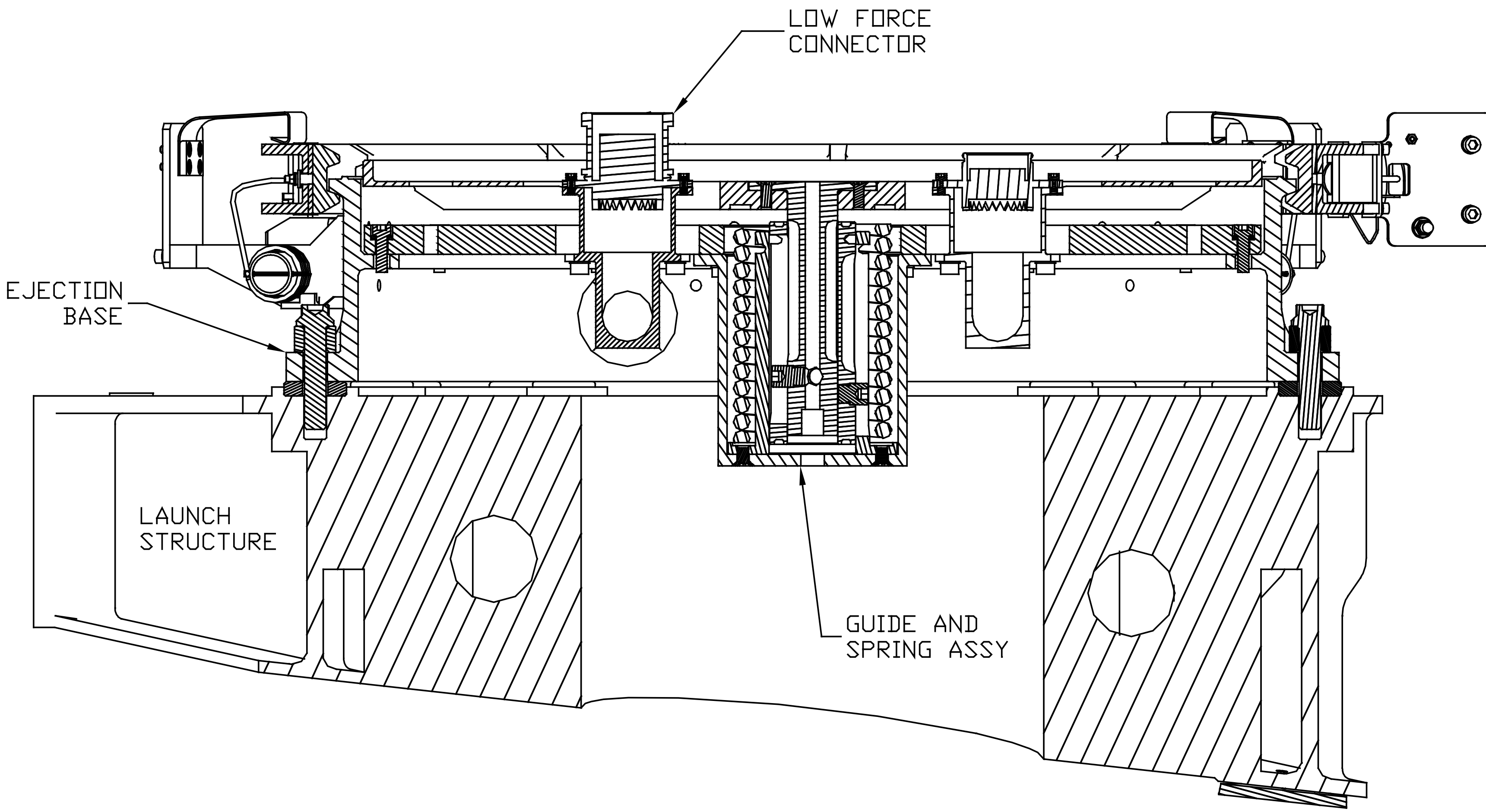


Figure 6-2 SHELS Ejection System - cross section through connector

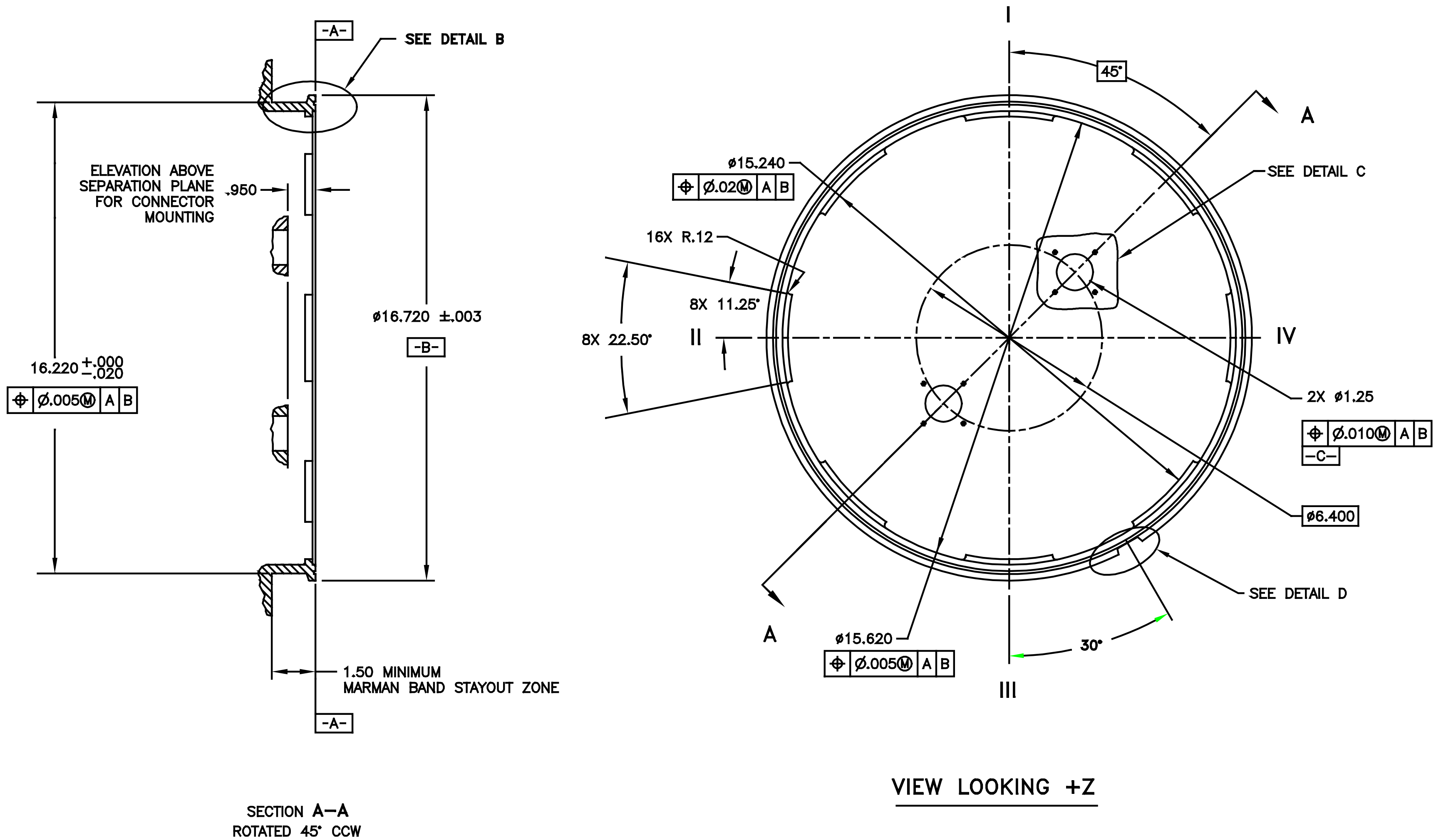


Figure 6-3 SHELS Spacecraft Interface Details

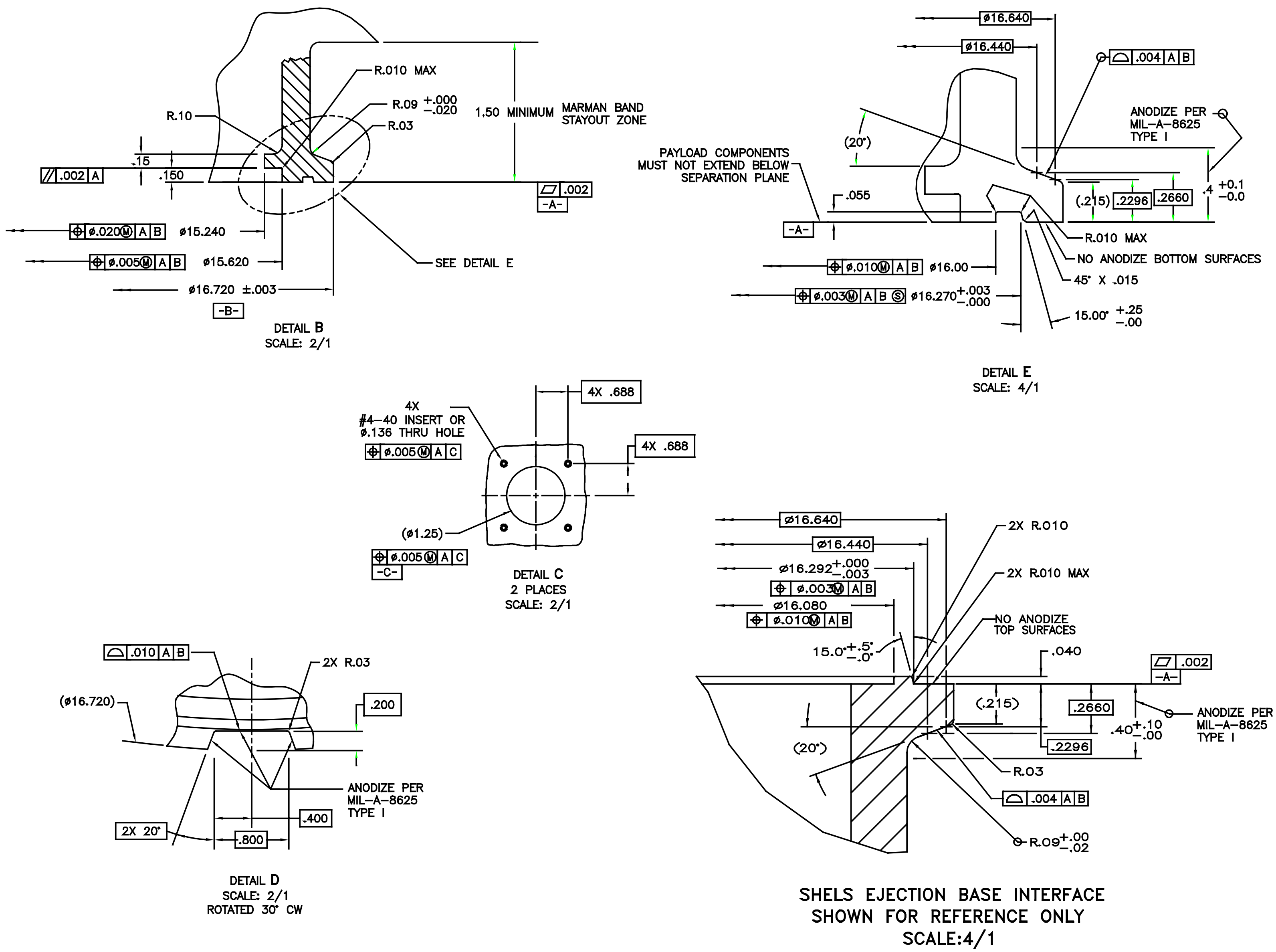


Figure 6-4 Interface Details

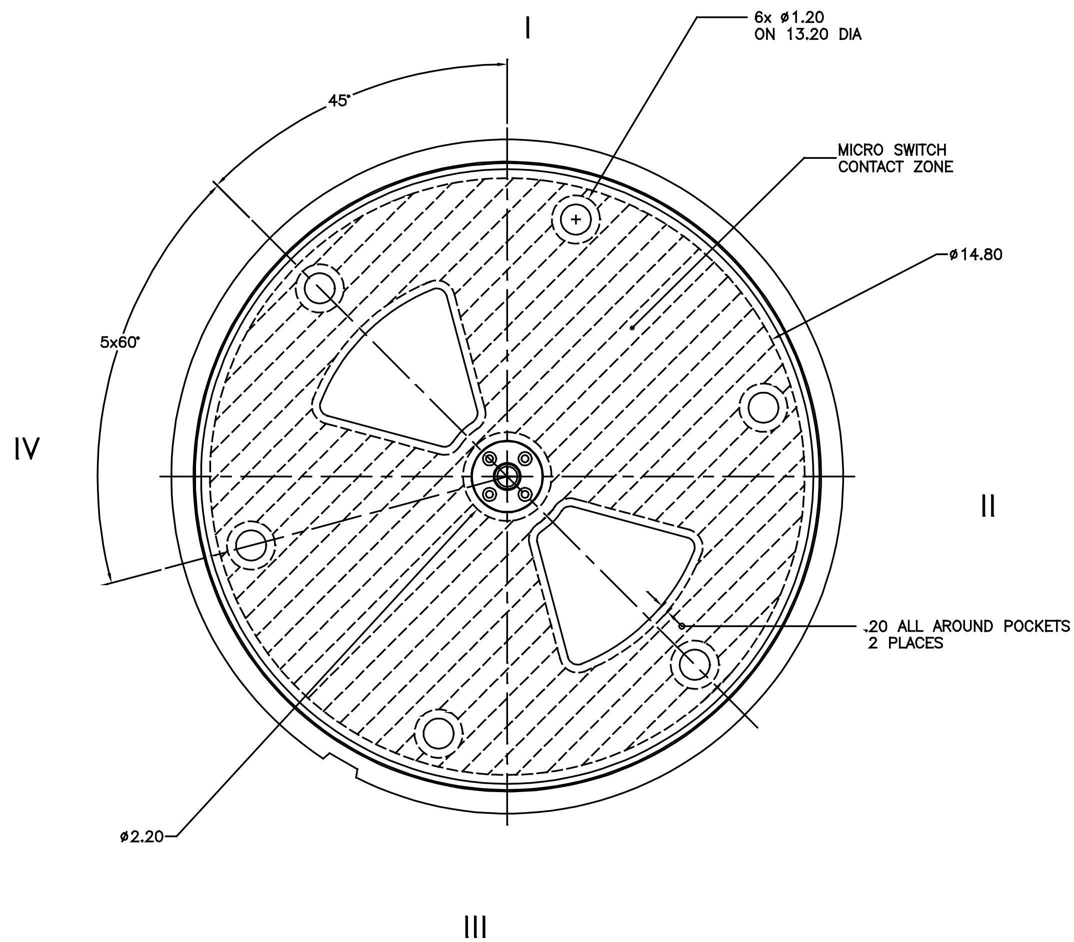


Figure 6-5 Acceptable Separation Switch Contact Zone

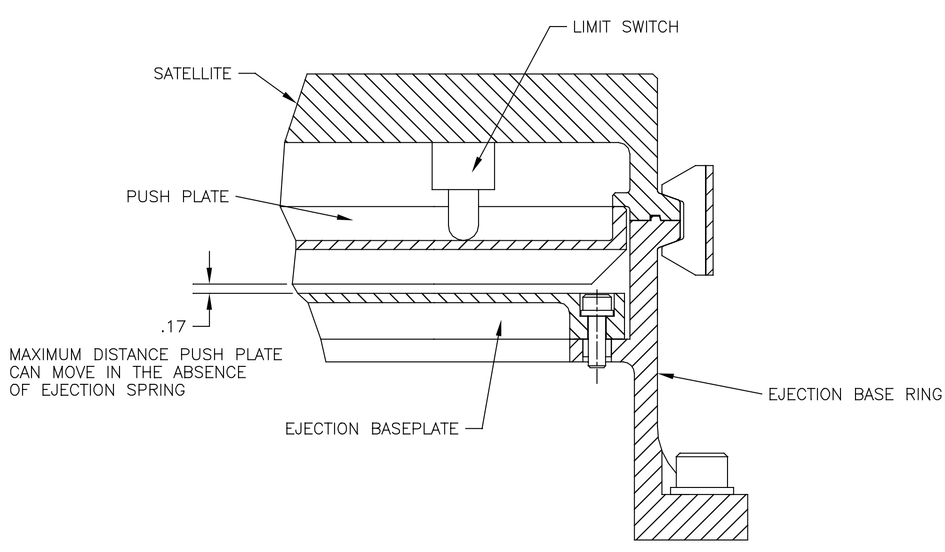


Figure 6-6 Maximum Push Plate Movement

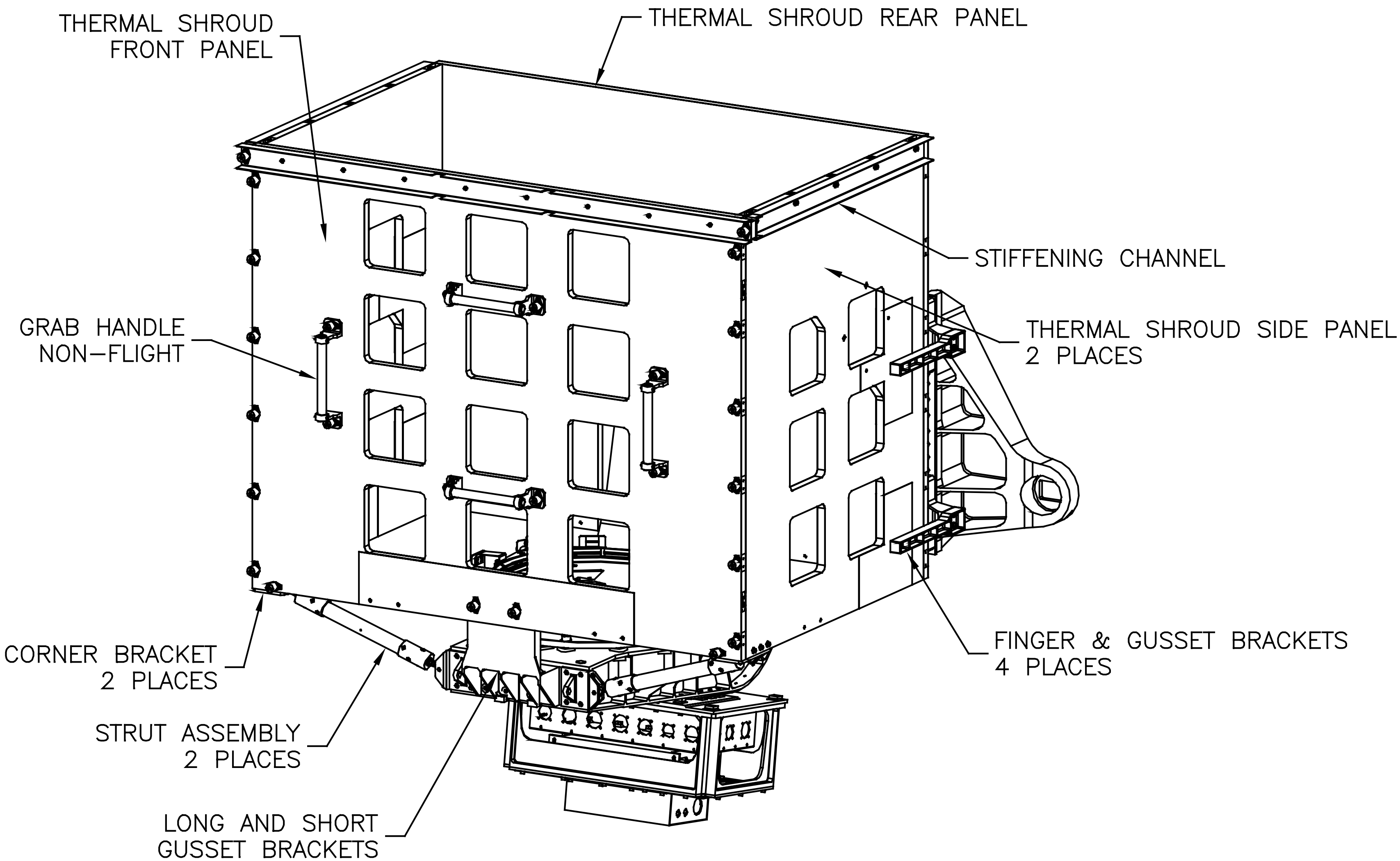


Figure 6-7 Thermal Shroud Mounted in Sidewall Configuration

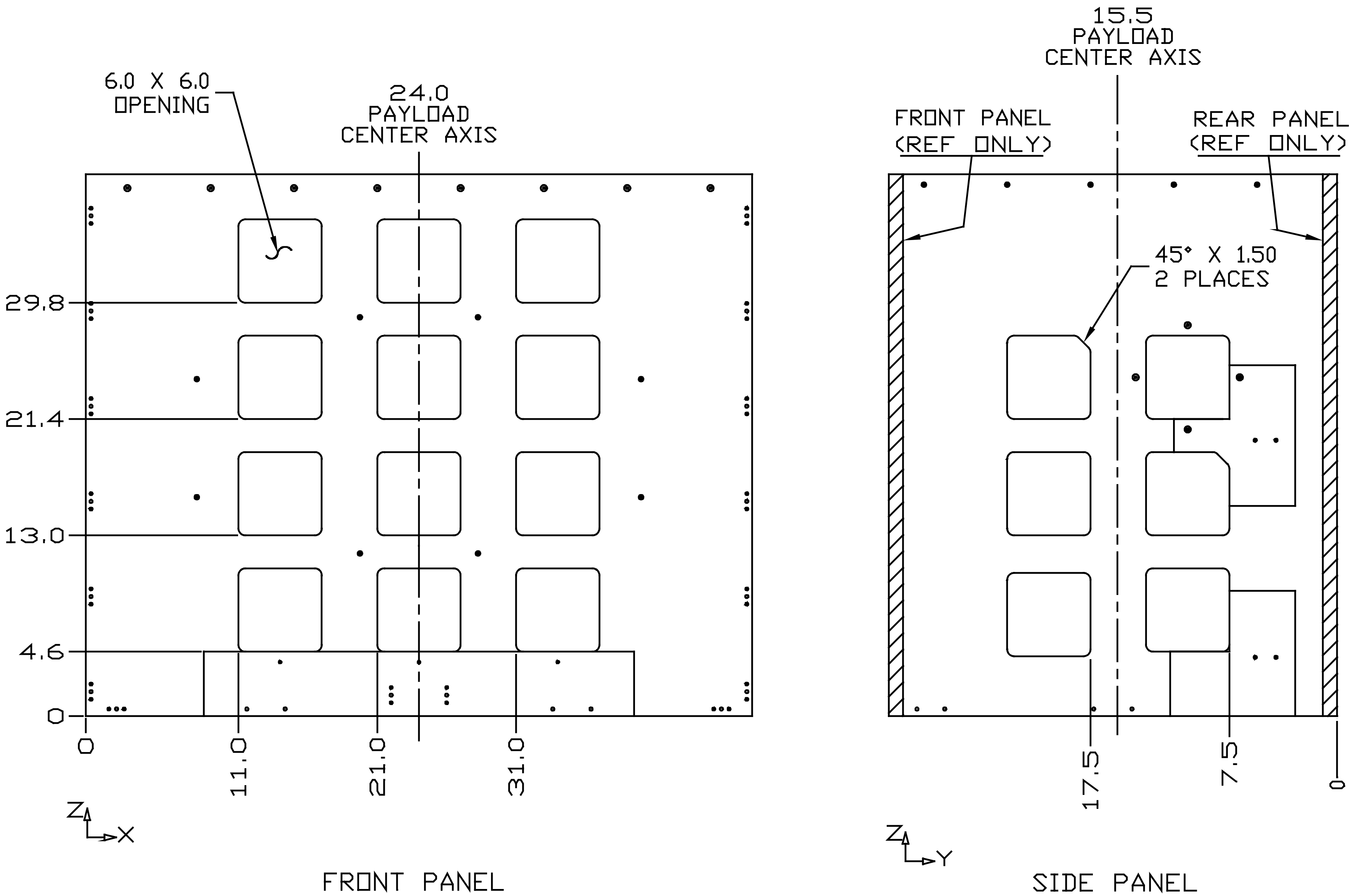


Figure 6-8 SHELS Thermal Shroud Payload Access Locations

6.2 Electrical

6.2.1 Electrical System Overview

Figure 6-9 illustrates the relationship between a satellite and the various electronics required for sidewall adapter beam or MPESS pallet configuration. This configuration uses the Payload General and Support Computer (PGSC), operated by the crew, for telemetry and limited command processing of the carrier hardware. The electrical carrier hardware includes the following: HH Ejection System Electronics (HESE), HH Remote Interface Unit (HRIU), and Multipurpose Interface Box (MPIB). The Standard Switch Panel (SSP) will be utilized for power switching and satellite deployment control. If the SHELS customer has opted to implement the umbilical interface, then satellite command and telemetry processing will also be performed through the carrier electronics.

If manifested on a multi payload Hitchhiker mission, a Hitchhiker avionics may replace the HRIU. This is shown as optional connections in Figure 6-9. This configuration uses the HH Avionics (Standard or Advanced) for ground command and telemetry processing, and power distribution for the carrier hardware. If the SHELS customer has opted to implement the umbilical interface, then satellite command and telemetry processing will also be performed through the HH Avionics from the Payload Operations Control Center (POCC) located at GSFC, or other negotiated location.

6.2.1.1 Payload And General Support Computer (PGSC)

The PGSC is an Orbiter provided laptop computer, which is used to support SHELS payload on-orbit operations. The SHELS avionics umbilical provides an RS-422 serial data interface to the satellite at a 1200 Kbaud rate.

A PGSC, with GSFC developed flight software (FSW) is used to perform limited SHELS on-orbit operations, and monitor housekeeping telemetry. Satellite commands and telemetry may be used to perform certain non-critical operations to assess satellite health prior to deployment. In addition, PGSC hardware is provided for SHELS ground testing. Mission specific FSW is developed in accordance to a requirements document to include experiment requirements. This document captures satellite command and telemetry definition, which is coded prior to satellite delivery to GSFC.

6.2.1.2 Bus Interface Adapter (BIA)

The BIA is used in conjunction with the PGSC in the Orbiter crew cabin. It serves as a modem, which is controlled by the PGSC FSW to send/receive commands and telemetry packets to/from the SHELS avionics.

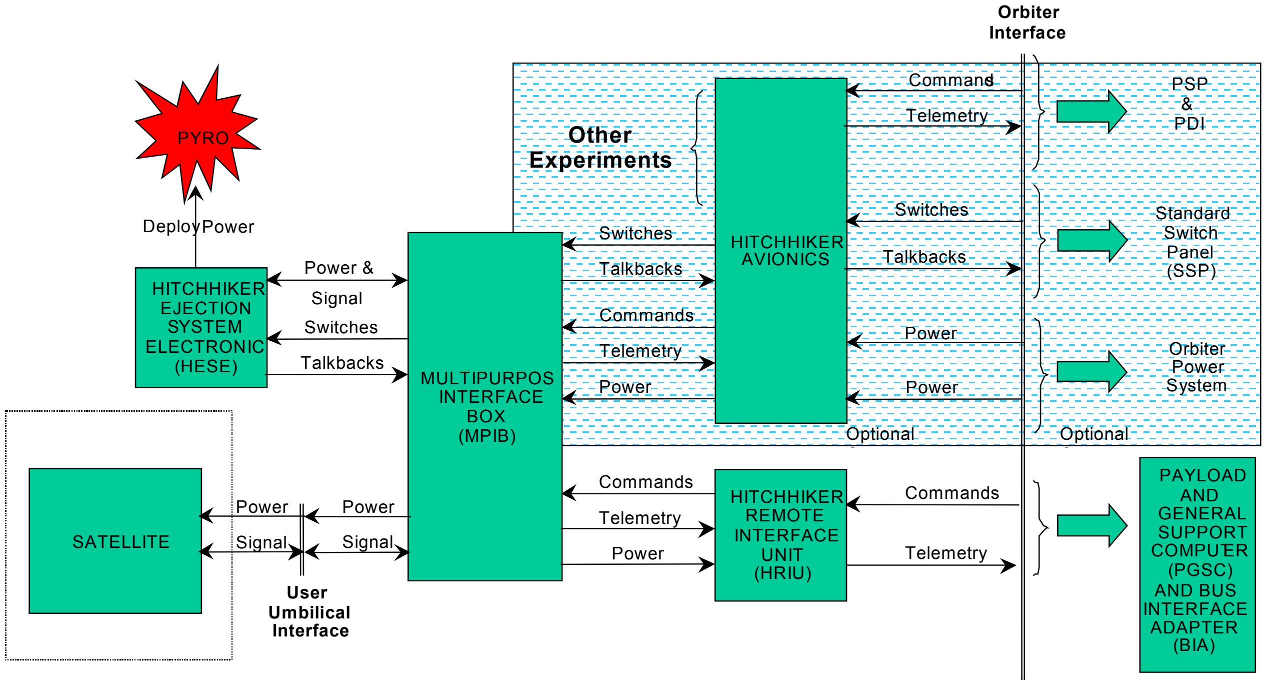


Figure 6-9 SHELS Electrical Configuration

6.2.2 Umbilical Connector Interfaces

Figure 6-10 and Figure 6-11 show the Hitchhiker to satellite specific interfaces. The umbilical interface from the Hitchhiker electronics to the satellite consists of two, 41-contact low force connectors; one defined for power, the other for signal, with any unused contacts defined as auxiliary usage with pin-outs as shown in Figure 6-12 and Figure 6-13. Additionally, for satellite ground processing and operations an auxiliary interface to the satellite is provided. The standard auxiliary interface goes from the umbilical interface through the hitchhiker electronics to a 41-contact connector shown in Figure 6-14. There is also an optional auxiliary interface, which allows access to the satellite without using the other Hitchhiker electronics boxes. The optional auxiliary interface also uses two 41-contact connectors, shown in Figure 6-15 and Figure 6-16. The power umbilical, P80/J80, and the signal umbilical, P90/J90, are defined in Figure 6-17. Both connectors are located near the ejection system/satellite separation plane. The auxiliary interface location is not shown pictorially, however it is located towards the top of the rear thermal shroud panel, which is relatively easy to access. The GSE cabling required by an experimenter to access their satellite shall be of sufficient length such that once connected, all operations may be performed outside of the Shuttle cargo bay. Hitchhiker will provide this length as the mission configuration details become known.

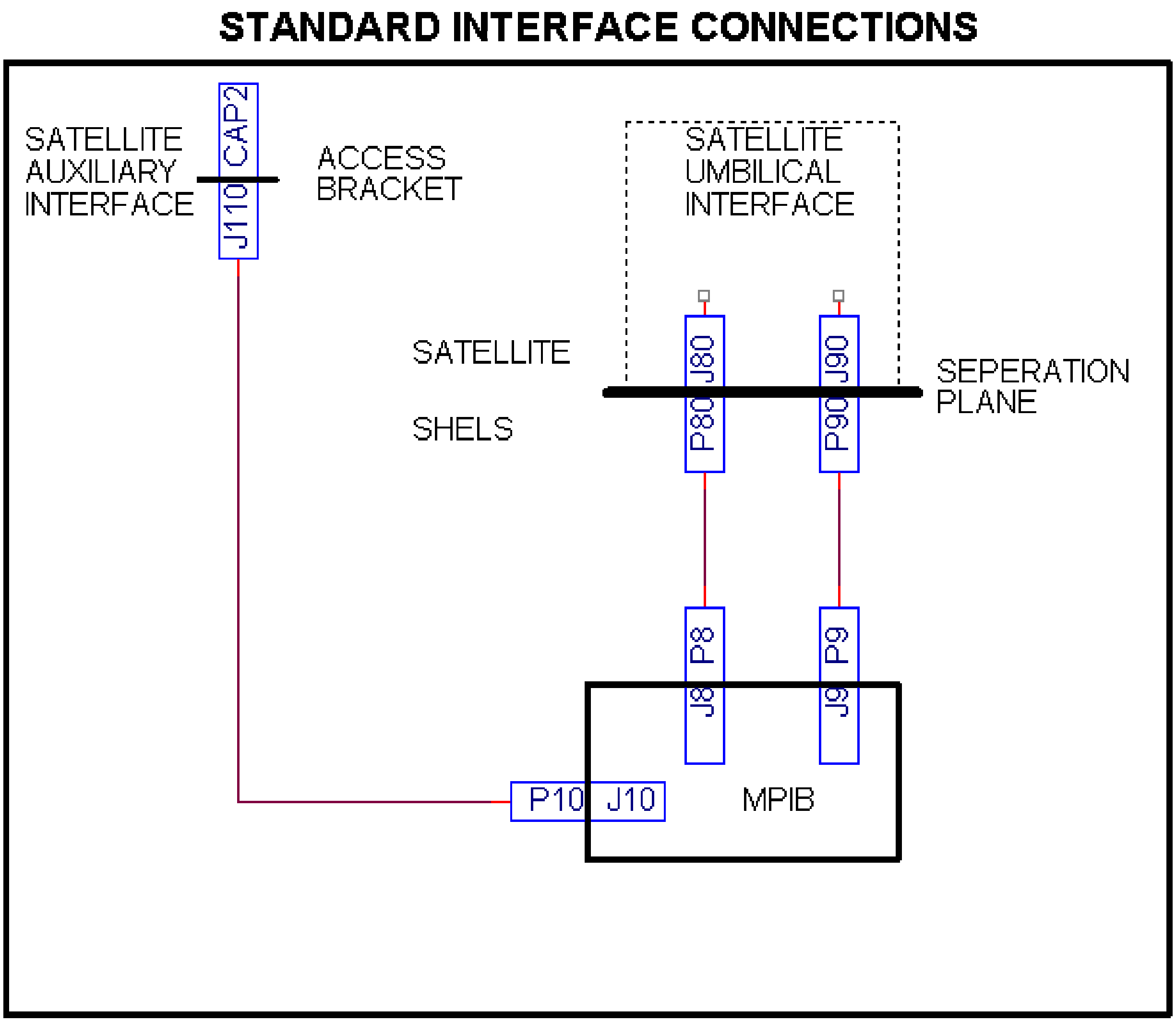


Figure 6-10 Standard Customer Interfaces with SHELS

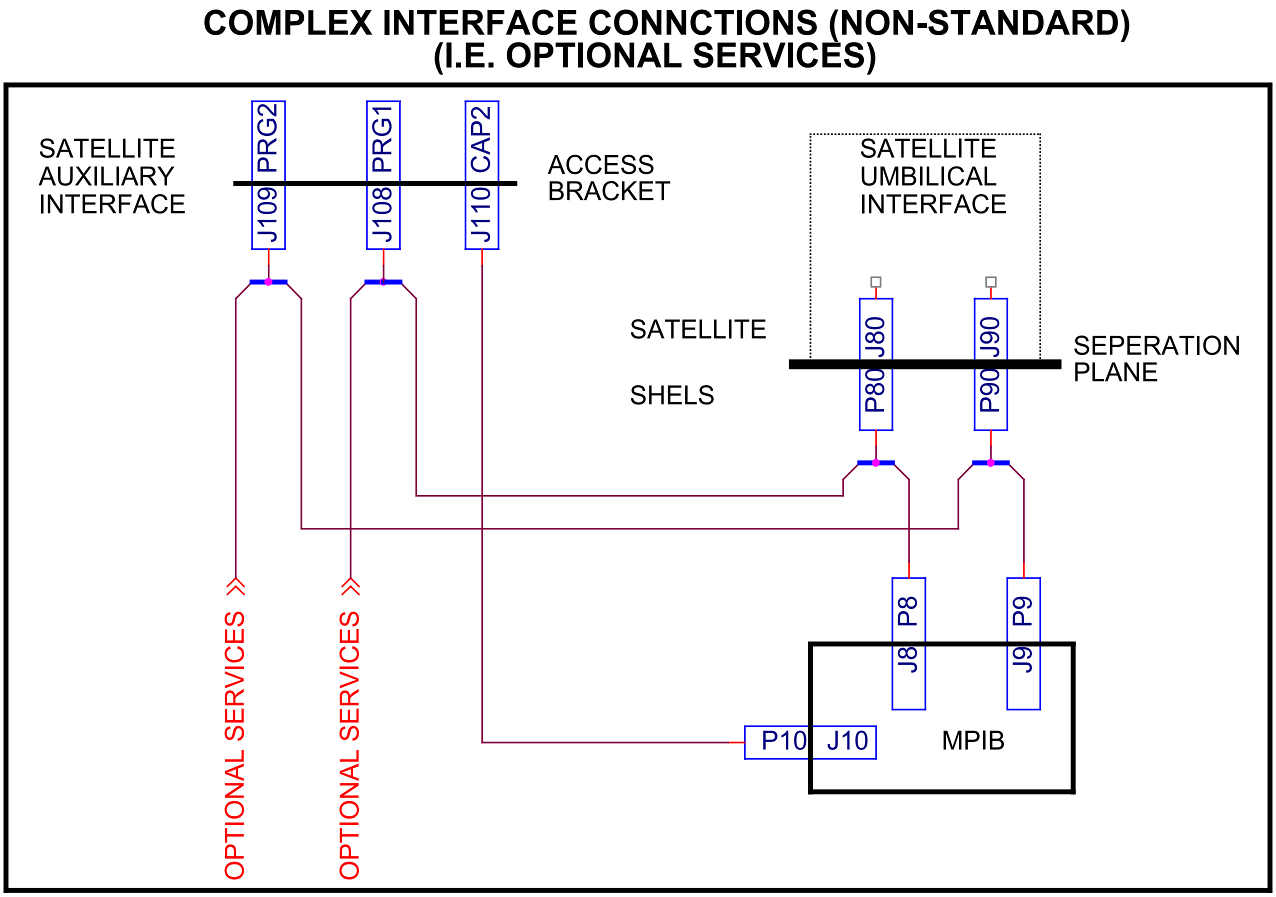
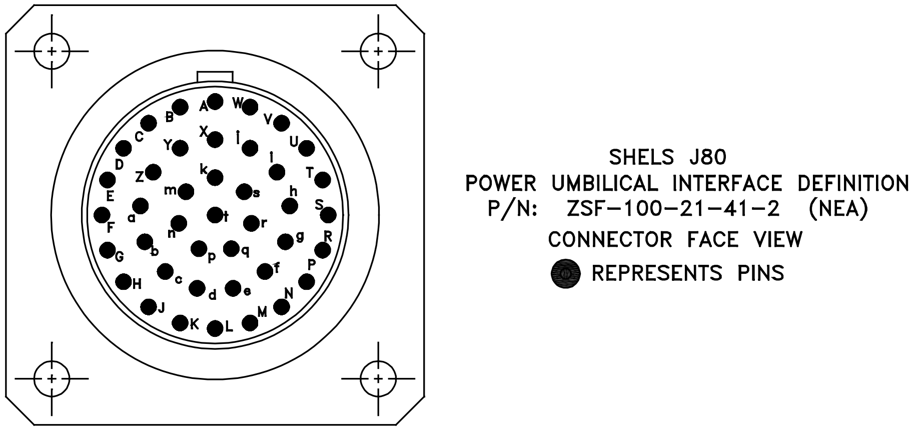
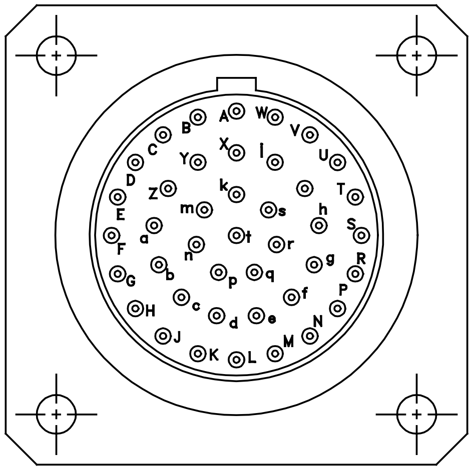


Figure 6-11 Complex Customer Interfaces with SHELS



CONTACT	DESCRIPTION	COMMENT
A	+28V Power A	Current limit to ≤ 2.5A
B	+28V Return	Current limit to ≤ 2.5A
C	+28V Power B	Current limit to ≤ 2.5A
D	+28V Return	Current limit to ≤ 2.5A
E	+28V Power C	Current limit to ≤ 2.5A
F	+28V Return	Current limit to ≤ 2.5A
G	+28V Power D	Current limit to ≤ 2.5A
H	+28V Return	Current limit to ≤ 2.5A
J	Satellite Auxiliary 1	User Defined; Ground Processing
K	Satellite Auxiliary 2	User Defined; Ground Processing
L	Satellite Auxiliary 3	User Defined; Ground Processing
M	Satellite Auxiliary 4	User Defined; Ground Processing
N	Satellite Auxiliary 5	User Defined; Ground Processing
P	Satellite Auxiliary 6	User Defined; Ground Processing
R	Satellite Auxiliary 7	User Defined; Ground Processing
S	Satellite Auxiliary 8	User Defined; Ground Processing
T	Satellite Auxiliary 9	User Defined; Ground Processing
U	Satellite Auxiliary 10	User Defined; Ground Processing
V	Satellite Auxiliary 11	User Defined; Ground Processing
W	Non-Standard Access #1	Optional Service
X	Non-Standard Access #2	Optional Service
Y	Non-Standard Access #3	Optional Service
Z	Non-Standard Access #4	Optional Service
a	Non-Standard Access #5	Optional Service
b	Non-Standard Access #6	Optional Service
c	Non-Standard Access #7	Optional Service
d	Non-Standard Access #8	Optional Service
e	Non-Standard Access #9	Optional Service
f	Non-Standard Access #10	Optional Service
g	Non-Standard Access #11	Optional Service
h	Non-Standard Access #12	Optional Service
i	Non-Standard Access #13	Optional Service
j	Non-Standard Access #14	Optional Service
k	Non-Standard Access #15	Optional Service
m	Non-Standard Access #16	Optional Service
n	Non-Standard Access #17	Optional Service
p	Non-Standard Access #18	Optional Service
q	Non-Standard Access #19	Optional Service
r	Non-Standard Access #20	Optional Service
s	Non-Standard Access #21	Optional Service
t	Non-Standard Access #22	Optional Service

Figure 6-12 SATELLITE Power Umbilical Connector Interface Definition (J80)



SHELS J90
SIGNAL UMBILICAL INTERFACE DEFINITION
P/N: ZSF-200-21-41-2
CONNECTOR FACE VIEW
◎ REPRESENTS SOCKETS

CONTACT	DESCRIPTION	COMMENT
A	Satellite Analog 1	Level 0-5V
B	Satellite Analog 2	Level 0-5V
C	Satellite Analog 3	Level 0-5V
D	Satellite Analog Shield	Chassis
E	Satellite Asynchronous RD +	1200 bps
F	Satellite Asynchronous RD -	
G	Satellite Asynchronous RD Shield	Chassis
H	Satellite Asynchronous SD +	1200bps
J	Satellite Asynchronous SD -	
K	Satellite Asynchronous SD Shield	Chassis
L	Satellite MET Minute Pulse	
M	Satellite MET Minute Pulse Shield	Chassis
N	Satellite Bi-level 1	0 or ~ 24V
P	Satellite Bi-level 2	0 or ~ 24V
R	Satellite Bi-level 3	0 or ~ 24V
S	Satellite Auxiliary 12	User Defined; Ground Processing
T	Satellite Auxiliary 13	User Defined; Ground Processing
U	Satellite Auxiliary 14	User Defined; Ground Processing
V	Satellite Auxiliary 15	User Defined; Ground Processing
W	NASA Reserved	Optional Service
X	NASA Reserved	Optional Service
Y	NASA Reserved	Optional Service
Z	NASA Reserved	Optional Service
a	NASA Reserved	Optional Service
b	NASA Reserved	Optional Service
c	NASA Reserved	Optional Service
d	NASA Reserved	Optional Service
e	NASA Reserved	Optional Service
f	NASA Reserved	Optional Service
g	NASA Reserved	Optional Service
h	NASA Reserved	Optional Service
i	NASA Reserved	Optional Service
j	NASA Reserved	Optional Service
k	NASA Reserved	Optional Service
m	NASA Reserved	Optional Service
n	NASA Reserved	Optional Service
p	NASA Reserved	Optional Service
q	NASA Reserved	Optional Service
r	NASA Reserved	Optional Service
s	NASA Reserved	Optional Service
t	NASA Reserved	Optional Service

Figure 6-13 SATELLITE Signal Umbilical Connector Interface Definition (J90)

SHELS J10 connector uses MIL-C-38999 Series IV, 21-41 insert arrangement

CONTACT	DESCRIPTION	COMMENT
A	Satellite Auxiliary 1	User Defined; Ground Processing
B	Satellite Auxiliary 2	User Defined; Ground Processing
C	Satellite Auxiliary 3	User Defined; Ground Processing
D	Satellite Auxiliary 4	User Defined; Ground Processing
E	Satellite Auxiliary 5	User Defined; Ground Processing
F	Satellite Auxiliary 6	User Defined; Ground Processing
G	Satellite Auxiliary 7	User Defined; Ground Processing
H	Satellite Auxiliary 8	User Defined; Ground Processing
J	Satellite Auxiliary 9	User Defined; Ground Processing
K	Satellite Auxiliary 10	User Defined; Ground Processing
L	Satellite Auxiliary 11	User Defined; Ground Processing
M	Satellite GSE Power A	Current limit to ≤ 2.5A
N	Satellite GSE Return	Current limit to ≤ 2.5A
P	Satellite GSE Power B	Current limit to ≤ 2.5A
R	Satellite GSE Return	Current limit to ≤ 2.5A
S	Satellite GSE Power C	Current limit to ≤ 2.5A
T	Satellite GSE Return	Current limit to ≤ 2.5A
U	Satellite GSE Power D	Current limit to ≤ 2.5A
V	Satellite GSE Return	Current limit to ≤ 2.5A
W	Satellite Analog Telemetry 1	
X	Satellite Analog Telemetry 2	
Y	Satellite Analog Telemetry 3	
Z	Satellite Analog Telemetry Shield	
a	Satellite Asynchronous RD+	
b	Satellite Asynchronous RD-	
c	Satellite Asynchronous RD Shield	
d	Satellite Asynchronous SD+	
e	Satellite Asynchronous SD-	
f	Satellite Asynchronous SD Shield	
g	MET Minute Pulse	
h	MET Minute Pulse Shield	
i	Bi-level 1	
j	Bi-level 2	
k	Bi-level 3	
m	Satellite Auxiliary 12	User Defined; Ground Processing
n	Satellite Auxiliary 13	User Defined; Ground Processing
p	Satellite Auxiliary 14	User Defined; Ground Processing
q	Satellite Auxiliary 15	User Defined; Ground Processing
r	Not Wired	No Connection in MPIB
s	Not Wired	No Connection in MPIB
t	Not Wired	No Connection in MPIB

Figure 6-14 SHELS Satellite Auxiliary Interface Definition (J10)

SHELS J108 connector uses MIL-C-38999 Series IV, 21-41 insert arrangement

CONTACT	DESCRIPTION	COMMENT
A	Not Wired	Overlaps Satellite Connector I/F
B	Not Wired	Overlaps Satellite Connector I/F
C	Not Wired	Overlaps Satellite Connector I/F
D	Not Wired	Overlaps Satellite Connector I/F
E	Not Wired	Overlaps Satellite Connector I/F
F	Not Wired	Overlaps Satellite Connector I/F
G	Not Wired	Overlaps Satellite Connector I/F
H	Not Wired	Overlaps Satellite Connector I/F
J	Not Wired	Overlaps Satellite Connector I/F
K	Not Wired	Overlaps Satellite Connector I/F
L	Not Wired	Overlaps Satellite Connector I/F
M	Not Wired	Overlaps Satellite Connector I/F
N	Not Wired	Overlaps Satellite Connector I/F
P	Not Wired	Overlaps Satellite Connector I/F
R	Not Wired	Overlaps Satellite Connector I/F
S	Not Wired	Overlaps Satellite Connector I/F
T	Not Wired	Overlaps Satellite Connector I/F
U	Not Wired	Overlaps Satellite Connector I/F
V	Not Wired	Overlaps Satellite Connector I/F
W	Non-Standard Access #1	Optional Service
X	Non-Standard Access #2	Optional Service
Y	Non-Standard Access #3	Optional Service
Z	Non-Standard Access #4	Optional Service
a	Non-Standard Access #5	Optional Service
b	Non-Standard Access #6	Optional Service
c	Non-Standard Access #7	Optional Service
d	Non-Standard Access #8	Optional Service
e	Non-Standard Access #9	Optional Service
f	Non-Standard Access #10	Optional Service
g	Non-Standard Access #11	Optional Service
h	Non-Standard Access #12	Optional Service
i	Non-Standard Access #13	Optional Service
j	Non-Standard Access #14	Optional Service
k	Non-Standard Access #15	Optional Service
m	Non-Standard Access #16	Optional Service
n	Non-Standard Access #17	Optional Service
p	Non-Standard Access #18	Optional Service
q	Non-Standard Access #19	Optional Service
r	Non-Standard Access #20	Optional Service
s	Non-Standard Access #21	Optional Service
t	Non-Standard Access #22	Optional Service

Figure 6-15 SATELLITE Power Umbilical Connector Interface Definition (J108)

SHELS J109 connector uses MIL-C-38999 Series IV, 21-41 insert arrangement

CONTACT	DESCRIPTION	COMMENT
A	Not Wired	Overlaps Satellite Connector I/F
B	Not Wired	Overlaps Satellite Connector I/F
C	Not Wired	Overlaps Satellite Connector I/F
D	Not Wired	Overlaps Satellite Connector I/F
E	Not Wired	Overlaps Satellite Connector I/F
F	Not Wired	Overlaps Satellite Connector I/F
G	Not Wired	Overlaps Satellite Connector I/F
H	Not Wired	Overlaps Satellite Connector I/F
J	Not Wired	Overlaps Satellite Connector I/F
K	Not Wired	Overlaps Satellite Connector I/F
L	Not Wired	Overlaps Satellite Connector I/F
M	Not Wired	Overlaps Satellite Connector I/F
N	Not Wired	Overlaps Satellite Connector I/F
P	Not Wired	Overlaps Satellite Connector I/F
R	Not Wired	Overlaps Satellite Connector I/F
S	Not Wired	Overlaps Satellite Connector I/F
T	Not Wired	Overlaps Satellite Connector I/F
U	Not Wired	Overlaps Satellite Connector I/F
V	Not Wired	Overlaps Satellite Connector I/F
W	Non-Standard Access #1	Optional Service
X	Non-Standard Access #2	Optional Service
Y	Non-Standard Access #3	Optional Service
Z	Non-Standard Access #4	Optional Service
a	Non-Standard Access #5	Optional Service
b	Non-Standard Access #6	Optional Service
c	Non-Standard Access #7	Optional Service
d	Non-Standard Access #8	Optional Service
e	Non-Standard Access #9	Optional Service
f	Non-Standard Access #10	Optional Service
g	Non-Standard Access #11	Optional Service
h	Non-Standard Access #12	Optional Service
i	Non-Standard Access #13	Optional Service
j	Non-Standard Access #14	Optional Service
k	Non-Standard Access #15	Optional Service
m	Non-Standard Access #16	Optional Service
n	Non-Standard Access #17	Optional Service
p	Non-Standard Access #18	Optional Service
q	Non-Standard Access #19	Optional Service
r	Non-Standard Access #20	Optional Service
s	Non-Standard Access #21	Optional Service
t	Non-Standard Access #22	Optional Service

Figure 6-16 SATELLITE Signal Umbilical Connector Interface Definition (J109)

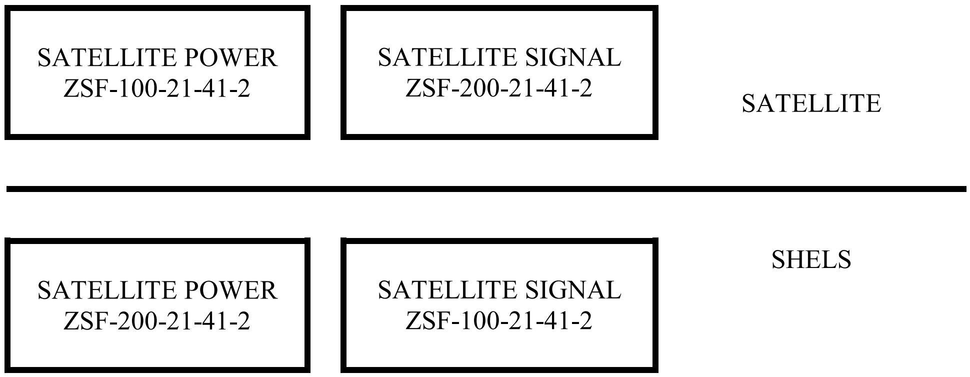


Figure 6-17 SHELS Umbilical Connector Definition

6.2.2.1 Umbilical Power Interface

Umbilical power is delivered to the satellite through MPIB connector J8 and subsequently to the umbilical P80. The power delivered to the satellite may be used for any purpose, if approved through the safety process, but may impose constraints on the analog telemetry. For example, using umbilical power for onboard satellite heaters will require using at least one of the analog telemetry inputs for thermal monitoring. The power delivered to the satellite is limited to 10A with the distribution system illustrated in Figure 6-18. The satellite power bus is diode-isolated from the carrier bus and delivered on four 20 AWG wire pairs fused on the supply side and returned to the system return bus. If combined on the satellite side into a single power bus, fusing will be required on the spacecraft side in accordance with TA-92-038 and TM-102-179.

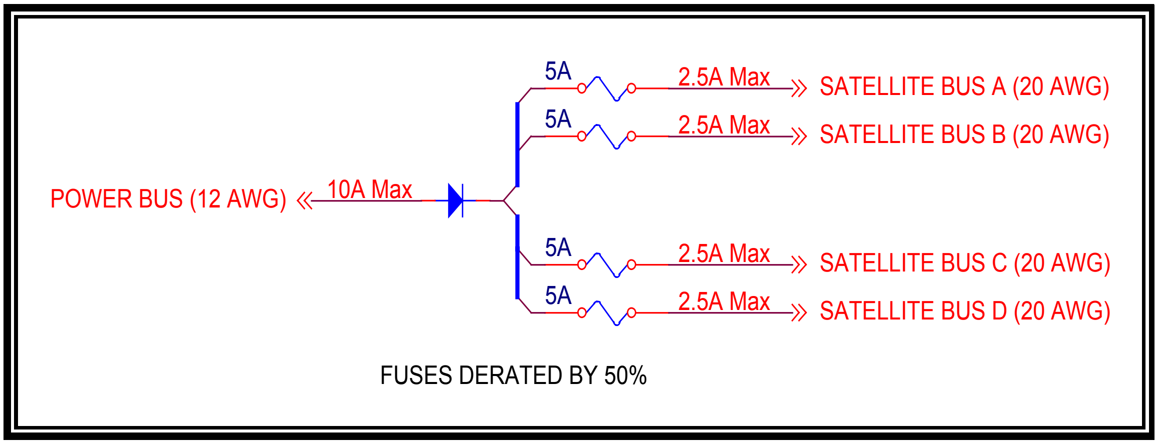


Figure 6-18 MPIB Satellite Power Distribution

6.2.2.2 Umbilical Signal Interface

The umbilical signal interface, which uses opto-isolation circuitry, consists of the following capabilities with interfaces in the identified figures.

- Low Rate Asynchronous Command and Telemetry, 1200bps (ASYNC) (Figure 6-19 and Figure 6-20)
- Mission Elapsed Time Minute Pulse (METMIN) (Figure 6-21)
- Bi-level controls, may be pulses (Figure 6-22)
- Analog 0-5V telemetry (Figure 6-23)

The satellite contact definition is shown in Figure 6-13.

6.2.2.3 Auxiliary Interface

The auxiliary interface is designed to allow the SHELS customer to access the satellite without requiring the HH electrical systems to be active. The intent of this interface is to allow the SHELS customer the ability for offline processing that may mitigate the need for other satellite access connectors, which may include, but not be limited to firmware updates, health and status checkups, and battery top charging with safety approval. Note that the auxiliary power and signal interfaces to the satellite are shared with the carrier flight interfaces, i.e. hardwire OR'ed. Care should be exercised to avoid EGSE damaging the flight signals. The power delivered to the satellite from the customer ground support equipment will require the proper fusing since the fusing inside the MPIB is bypassed during the auxiliary access mode. The auxiliary signal interface is defined in Figure 6-14.

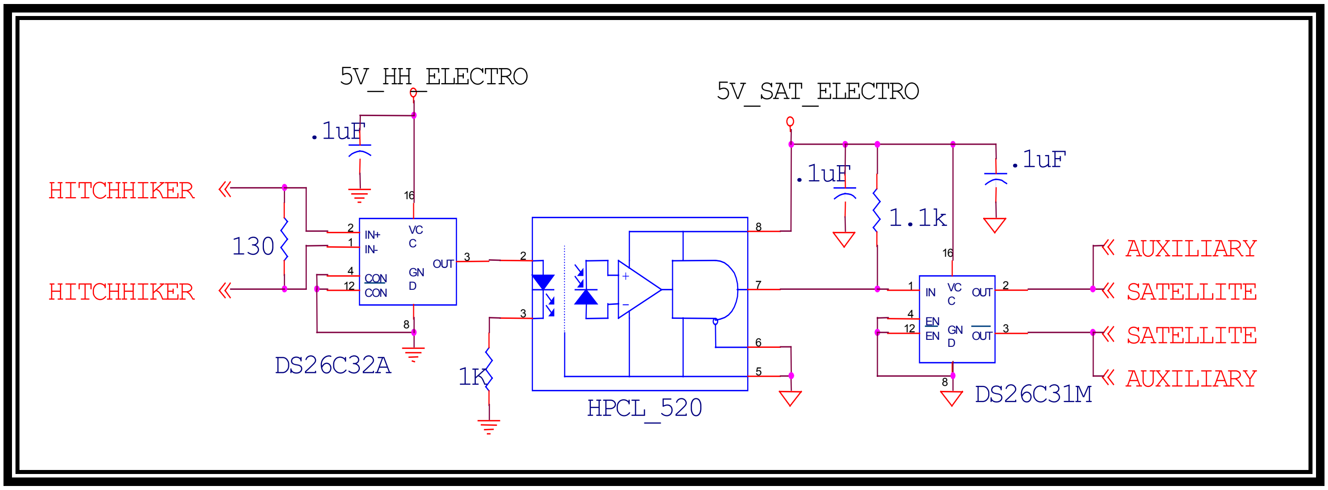


Figure 6-19 MPIB Send Data (SD) Isolation Implementation

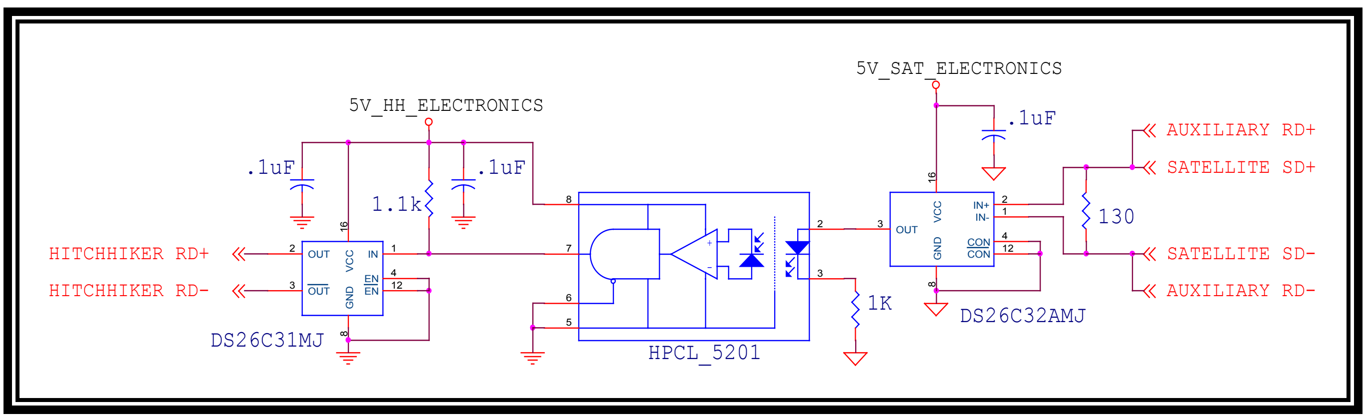


Figure 6-20 MPIB Receive Data (RD) Isolation Implementation

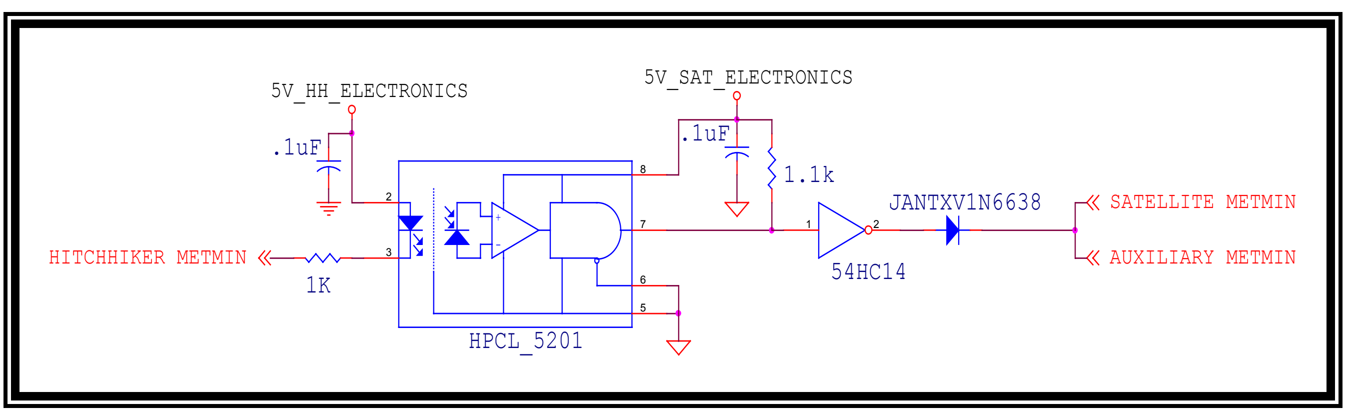


Figure 6-21 MPIB MET Minute Pulse Isolation Implementation

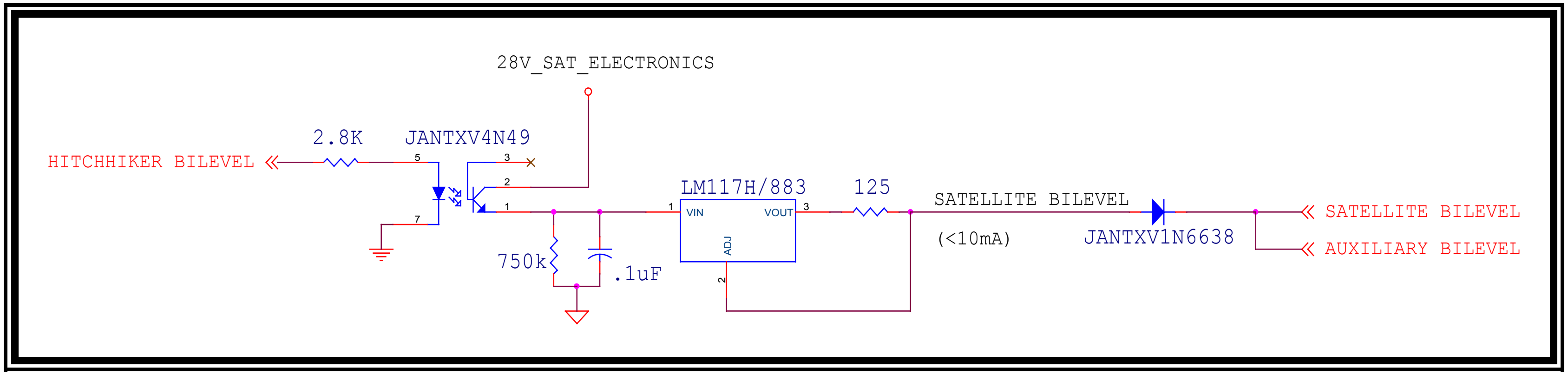


Figure 6-22 MPIB Bi-level Isolation Implementation

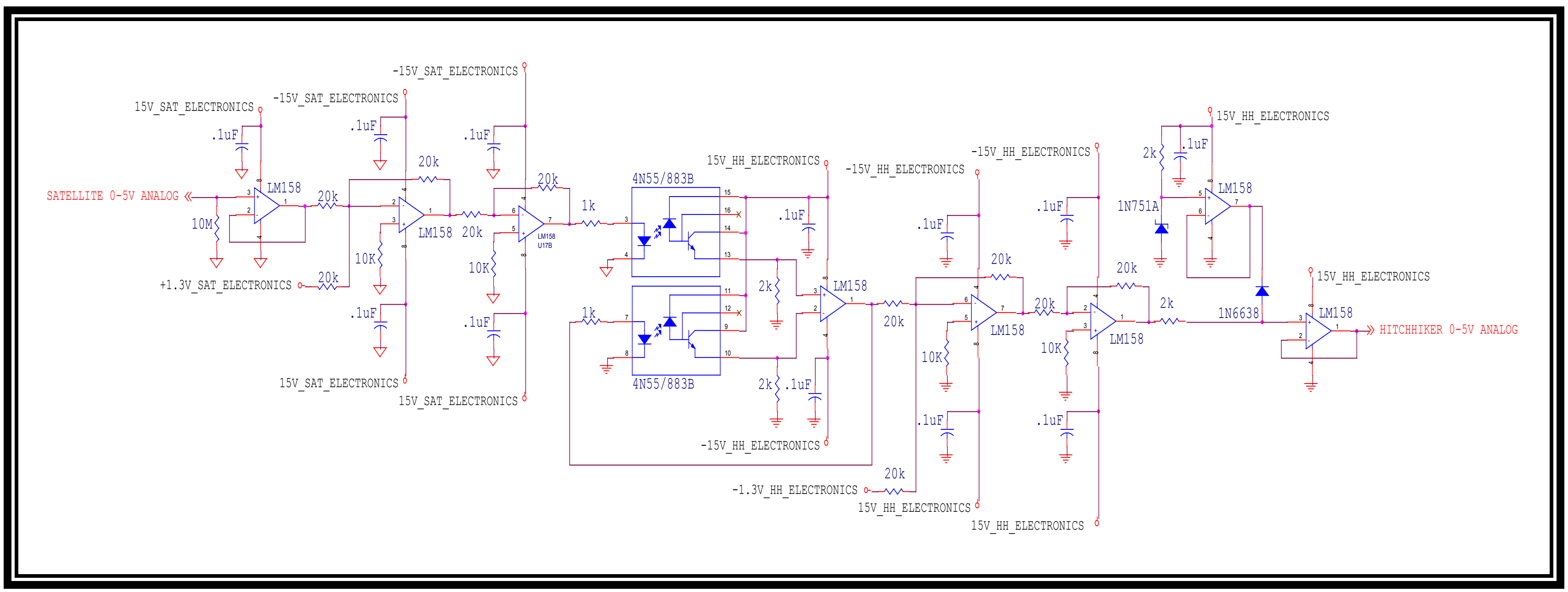


Figure 6-23 MPIB Analog Telemetry Isolation Implementation

7 HARDWARE INTEGRATION

7.1 Fit Check

Prior to delivery of the satellite to GSFC, fit checks of the satellite interface plate with the SHELS ejection system baseplate shall be performed. Hitchhiker shall provide to the customer a SHELS fit check plate (part number GD2041613) for an initial fit check. A final fit check will be conducted using a SHELS ejection system baseplate ETU or flight unit. Included in the final fit check are any electrical inhibit verifications of all limit switches that interface with the ejection plate in an integrated configuration. Hitchhiker shall provide the required hardware, GSE, and engineering support for integrating the SHELS hardware to the satellite at the time of the final fit check.

7.2 Integration at GSFC

After the satellite developer has completed all activities and the satellite is flight qualified, the satellite is shipped to GSFC for integration with SHELS. Figure 7-1 shows the typical flow for generalized ground operations at GSFC. Ground operations for an MPESS configuration are similar, but the GSE (step 8) used to integrate the payload will be different. Environmental controls established during shipment to GSFC are the responsibilities of the satellite developer. Upon arrival to GSFC, satellite receiving and inspection activities will be performed in accordance with GPG-5900.1. The customer SHELS CPR and ICD documents will identify all required GSFC activities, as well as the necessary environmental requirements to be established following satellite delivery.

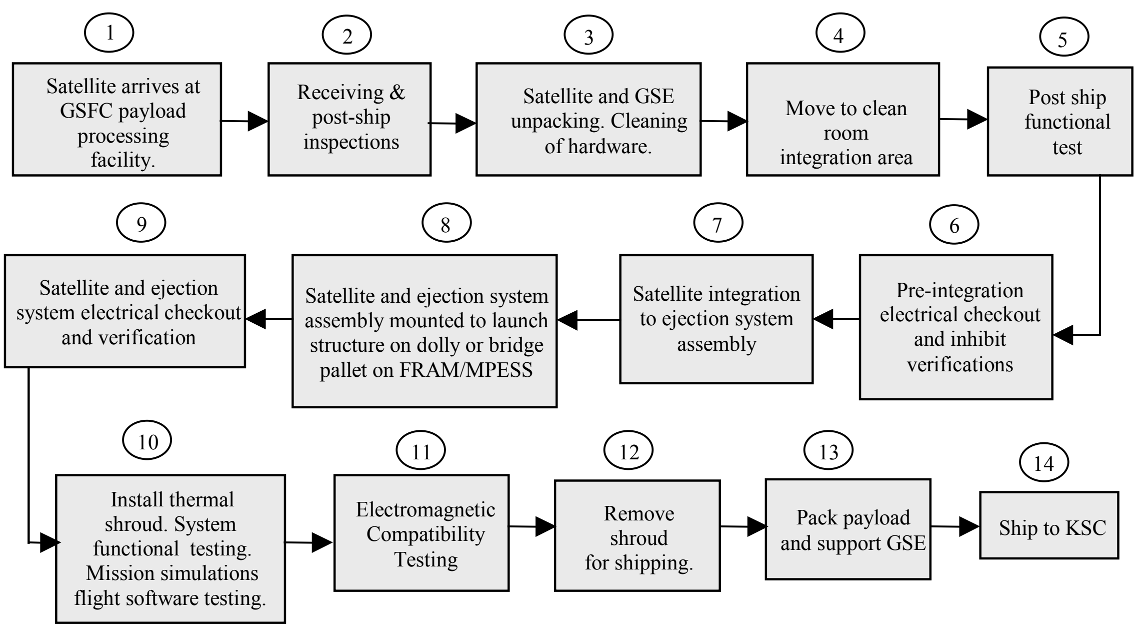


Figure 7-1 Typical SHELS Integration Flow at GSFC

SHELS customers can expect clean room environments ranging from class 10,000 to 100,000. Typical cleanrooms at GSFC provide class 100,000 or better. However, arrangements must be made with Hitchhiker before delivery if the SHELS customer requires an environment cleaner than class 100,000, so that appropriate cleanroom garments and procedures may be planned.

The satellite provider will perform post-shipment functional testing and pre-integration electrical check-outs using standalone GSE to verify the satellite is ready for SHELS integration. The satellite is then integrated to the ejection system assembly by Hitchhiker personnel. This includes installing the Marman band, band catcher brackets, and also removing the ejection plate loading tool. The electrical bonding across the separation plane of the satellite and ejection system assembly can now be checked and shall be 1 ohm or less. After integration, any electrical inhibit verifications will be performed, as well as any satellite external test panel interfaces that utilize separation plane microswitches.

Combined satellite and ejection system assembly electrical check-outs may now be performed. After these tests are completed the thermal shroud is integrated with the payload. The payload is in its flight configuration and will be transported for an integrated payload EMI/EMC test. This test is required for all payloads. The EMI/EMC environment expected during testing is detailed in the Orbiter ICD-2-19001, section 10.7. The integrated payload EMI/EMC test is performed to ensure that they will neither be a source of electromagnetic interference (EMI) nor a susceptibility to EMI when integrated with other electrical systems in the Orbiter. The payload will perform these EMI/EMC tests under expected flight operational conditions and mission deployment scenarios. If the satellite is powered during deployment, the satellite will be required to test these modes of operation.

There are no requirements for an integrated payload to be exposed to vibration or thermal vacuum tests but may be required depending on configuration and safety requirements

The integrated satellite and ejection system assembly are ready to proceed to the next step of hardware integration. The next step is dependent on where the payload is to be located in the Orbiter. If the payload is to be located on the sidewall adapter beam assembly, then the payload gets mounted to the launch structure, which in turn mounts to a GSE dolly (Hitchhiker Super Dolly) for the remaining ground handling operations and eventual transportation to Kennedy Space Center (KSC). If the payload is located on a Hitchhiker MPESS, then it gets mounted to a bridge pallet, which then mounts to an MPESS, along with the required HH avionics systems and harnessing. If the satellite is configured for a FRAM, then most integration activities occur at KSC.

Hitchhiker has the option to integrate the bridge pallet to the MPESS at GSFC or KSC. The preferred integration location is at GSFC. If the integration occurs at GSFC, then the satellite will be transported to KSC on the MPESS. If the bridge pallet is integrated at KSC, then the satellite will be transported on the bridge pallet dolly GSE or any other suitable method that allows the satellite and ejection system assembly to remain integrated. LMC integration will most likely occur at KSC.

Following completion of all GSFC activities, all the SHELS hardware with the integrated satellite are wrapped and shipped to KSC via ground transportation, following ISO 9001 compliant practices and procedures.

7.3 Integration at KSC

During all KSC operations, Hitchhiker shall represent the SHELS user and interface and coordinate directly with KSC personnel.

Security rules and regulations are strictly enforced at KSC. SHELS users will generally require a Hitchhiker escort at all times in order to gain access to KSC facilities. KSC may also require training or certification of training for customer personnel performing certain payload ground processing activities on the base and within the Shuttle cargo bay.

7.3.1 KSC Integration Overview

Ground processing requirements and SHELS customer-requested support are documented in the Launch Site Support Plan (LSSP), Annex 8 to the PIP, the Time-critical Ground Handling Requirements (TGHR), and the Operations and Maintenance Requirements Specifications Document (OMRSD). The Hitchhiker mission manager gathers input to these documents from the SHELS customer via the appropriate Ground Operations Working Group (GOWG) meetings, Technical Interchange Meetings (TIM), the CPR, and Carrier-to-Customer ICD.

All SHELS customer Technical Operating Procedures (TOP) to be performed at KSC shall be prepared in accordance with KHB 1700.7. Non-hazardous Technical Operating Procedures are required for GSFC and KSC Safety review no later than 50 days prior to use at KSC. Hazardous TOPs are required for GSFC and KSC Safety review and approval no later than 75 days prior to use KSC. However, any procedure required to close a KSC ground VTL item will be required to have been reviewed and approved (as necessary) by KSC prior to delivery of the satellite to GSFC for integration and testing.

During launch site processing of the payload, the Shuttle Program will conduct an inspection of the payload for contamination and any sharp edges, corners, surfaces, or protrusions that may damage a crewmember's EVA suit or associated equipment. This inspection will be coordinated with the customer and corrective actions will be taken by the customer or the customer's representatives. Hazards not correctable will be identified and documented.

The Shuttle Program will take required photographs of the payload before and after installation in the Orbiter, including closeout photographs to support ground operations, Flight Data File (FDF) development, flight crew, flight controller training, and for possible in-flight contingencies.

7.3.2 Customer Processing

All the SHELS hardware, including the integrated satellite and GSE will be shipped directly from GSFC to KSC via ground transportation.

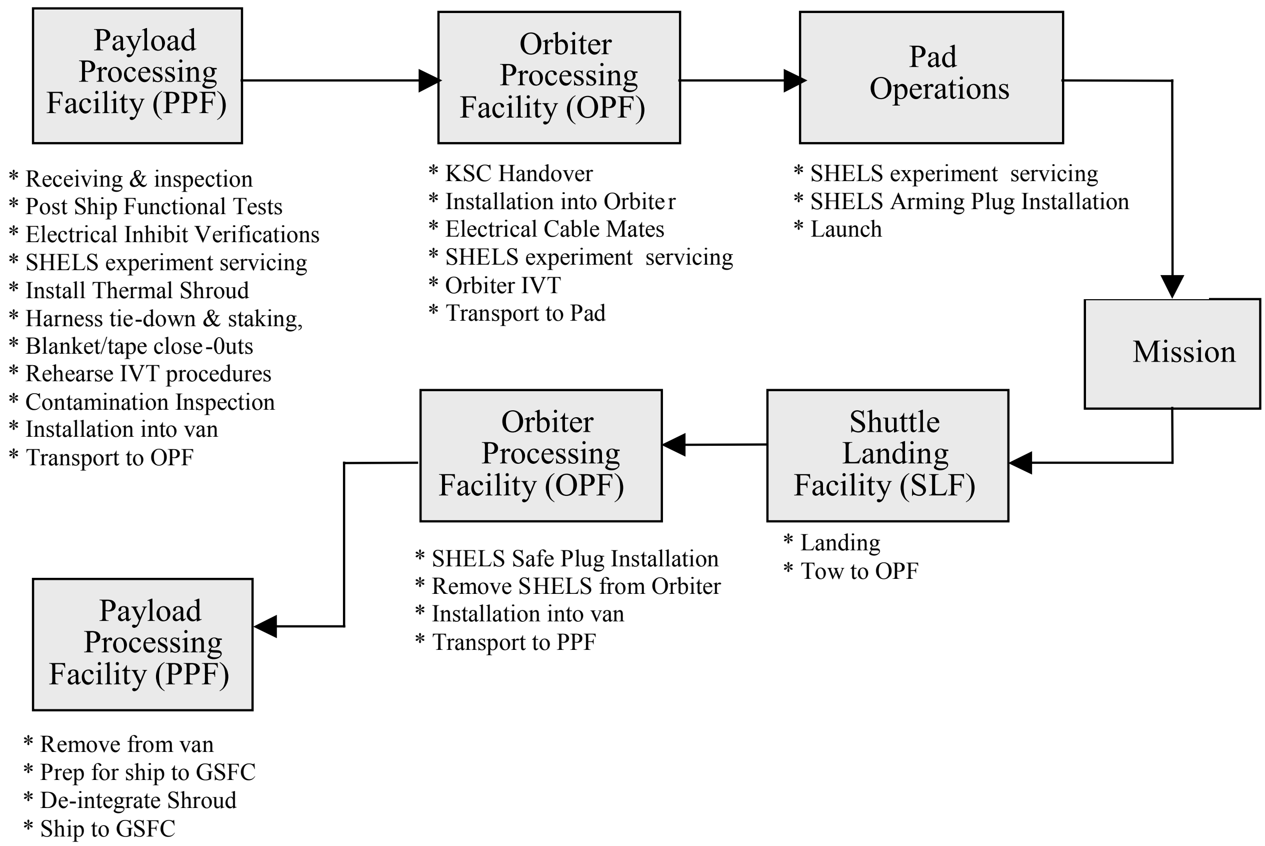


Figure 7-2 shows the flow for generalized ground operations at KSC. Upon arrival at KSC, the hardware will be delivered to a pre-assigned Payload Processing Facility (PPF). Activities to be performed at the PPF include post-shipment hardware inspection, functional checkouts, and preparation for the next phase of integration. The environment of the ground operations facilities at KSC is specified in the Launch Site Accommodations Handbook for Payloads, K-STSM-14.1.

Typically, the customer is responsible for the all payload-unique pre-integration activities and utilizes payload-provided GSE. Only certified GSFC personnel will perform certain payload ground processing activities, such as crane operations and pyrotechnic arming. It is also possible to negotiate launch and landing site technical and personnel support, as well as the use of existing KSC-provided GSE.

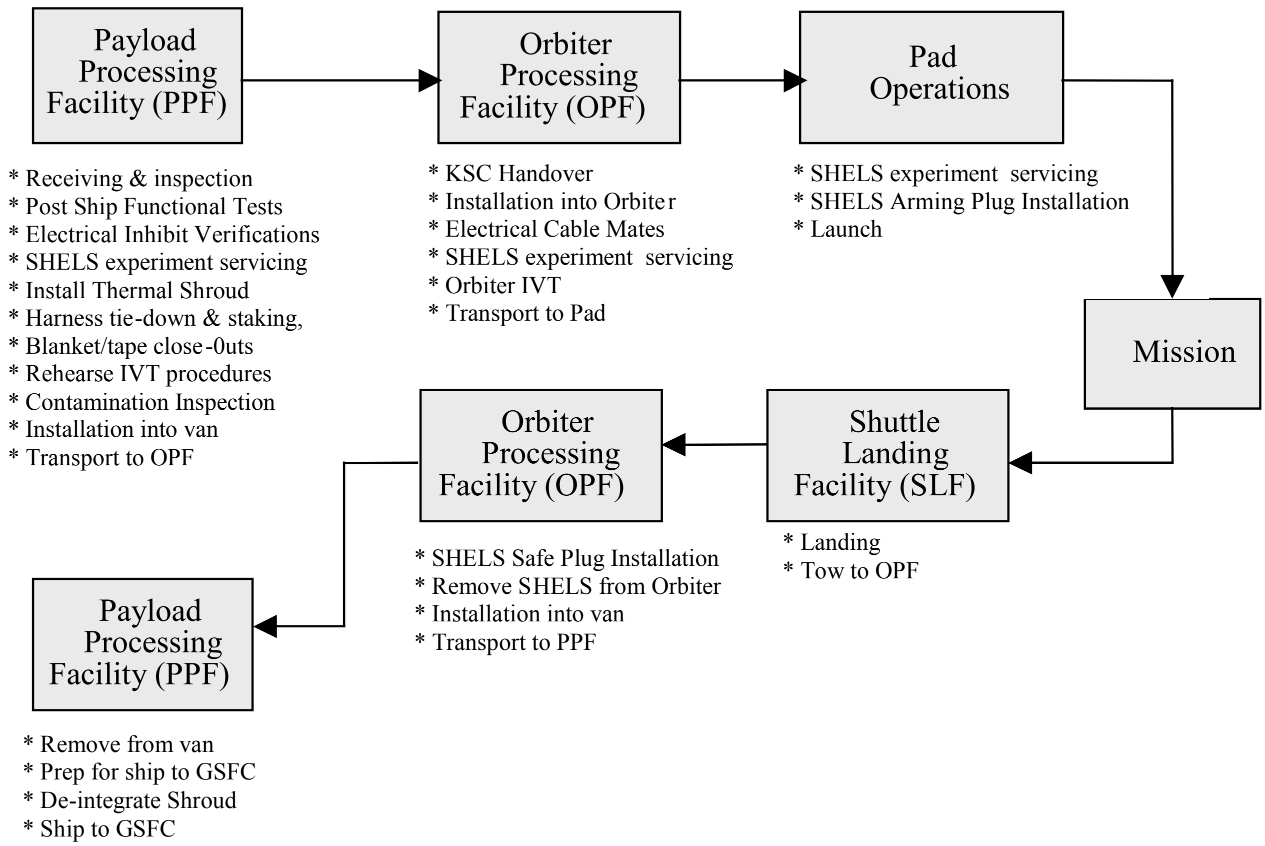


Figure 7-2 Typical SHELS Integration Flow at KSC

7.3.3 Sidewall Adapter Beam Integration Flow

After arrival at KSC, the integrated payload will perform post-ship inspections and functional tests to verify hardware integrity after shipment. The thermal shroud will be installed; final harnessing, thermal blankets, and rehearsal of IVT procedures will be performed. KSC personnel will inspect the payload for compliance to contamination and sharp edge requirements.

After completion of all PPF operations, the payload will be handed over to KSC for Orbiter processing. The payload is transported to the OPF for installation into the Orbiter by a KSC-provided vehicle. Once this activity begins, all operations and testing are scheduled and controlled by KSC personnel and supported by Hitchhiker and the SHELS customer.

Throughout the payload integration process, newly mated or reestablished interfaces must be verified. As agreed to in Annex 8, space will be provided for the customer to monitor payload parameters using customer provided GSE. Once testing is completed, final payload servicing may be performed.

Before the payload bay doors are closed, additional payload-unique servicing may be scheduled on a noninterference basis up until payload bay door closure for OPF rollout. After payload bay door closure, the Orbiter is towed to the Vertical Assembly Building (VAB) for integration with the other Orbiter elements and transported to the pad for launch.

The thermal environment for payloads in the OPF is environmentally controlled. Temperatures range from 65°F to 85°F. Requirements outside of this range are negotiated on a case-by-case basis.

If the SHELS to satellite power or signal umbilical connectors are being used, then the IVT will consist of verifying that the copper paths within the umbilical have been established. This will entail sending commands and receiving telemetry to and from the spacecraft using SHELS customer supplied GSE.

7.3.4 MPESS Integration Flow

The MPESS processing flow will generally follow a different I&T sequence than the sidewall configuration. However, in terms of satellite provider support, most payload processing activities will remain the same as the sidewall configuration.

The MPESS will typically arrive as a fully tested and integrated assembly at the OPF/Pad and will be integrated into the Orbiter by KSC personnel. After all mechanical installations, harnessing and electrical interfaces have been mated the payload-to-Orbiter Interface Verification Test (IVT) will be performed.

7.3.5 LMC/FRAM Integration Flow

The FRAM processing flow may also follow a different I&T sequence than the sidewall and MPESS configurations, but will be mostly transparent to the satellite provider.

SHELS hardware will arrive as several separate assemblies to a KSC designated facility for FRAM/LMC integration. After all mechanical installations, harnessing and electrical interfaces have been mated and verified, the payload-to-Orbiter Interface Verification Test (IVT) will be performed.

7.3.6 Late Payload Operations

Payload unique activities may be performed at the launch pad if absolutely required and if orbiter access permits. Typical activities might include top-charging of customer flight batteries, SHELS pyrotechnic circuit arming plug installation, removal of satellite protective covers, etc. Details of all late payload operations for SHELS customers will be documented in Annex 8 of the PIP. The thermal environment for payloads at the launch pad ranges from 45°F to 85°F. Requirements outside of this range are negotiated on a case-by-case basis.

Reference NSTS 07700, Volume XIV, Appendix 5, for requirements associated with contingencies such as launch delay, scrub turnaround, and launch termination.

7.3.7 Post landing

After completing the mission, the Orbiter will return to the OPF, where SHELS will be removed from the payload bay and transported to the appropriate PPF for de-integration. For every mission, it is anticipated that the only hardware items left to be de-integrated from the Orbiter will be the SHELS hardware since the satellite is going to be deployed during flight. If the satellite is not deployed during the mission, the integrated SHELS assembly will be de-integrated from the Orbiter and returned to GSFC. There the satellite will be de-integrated from the ejection system, and returned to the customer. Details of the return of payload GSE to the customer will be documented in Annex 8 to the PIP.