

NASA Small Self-Contained Payload Program
Get Away Special
G-056
Phase III Safety Data Package

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November 16, 1995

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0. Preface

0.1 G-056 Acronym List

A/D	Analog-to-Digital
APD	Avalanche Photo-Diode
BATSE	Burst And Transient Source Experiment
BCS	Battery Containment System
BVR	Battery Venting Ring
CGRO	Compton Gamma-Ray Observatory
CO₂	Carbon Dioxide
CPD	Charged Particle Detector
CPU	Central Processing Unit
DC-DC	Direct Current to Direct Current
EDS	Electronic Data System
EMI	Electro-Magnetic Interference
EMP	Experiment Mounting Plate
EPON	(Trade Name)
ETI	Experiment Thermal Isolator
Fe	Iron
FIFO	First-In-First-Out
GAS	Get-Away Special
GAScan	Get-Away Special canister
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
H₂	Hydrogen
HDD	Hard Disk Drive
HVPC	High Voltage Power Converter
Hz	Hertz
IC	Integrated Circuit
IDE	Intelligent Drive Electronics
IEP	Interface Equipment Plate
I/O	Input/Output
JSC	Johnson Space Center
K	Kelvin (degrees)
KOH	Potassium Hydroxide
KSC	Kennedy Space Center
LVPS	Low-Voltage Power Supply
mA	milli-Amperes
MHz	Mega-Hertz
MLI	Multi-Layer Insulation
mm	millimeter
MSFC	Marshall Space Flight Center
N₂	Nitrogen
NaI(Tl)	Sodium Iodide (doped with Thallium)
NASA	National Aeronautics and Space Administration
Ni	Nickel
O₂	Oxygen
OQW	Optical Quartz Window
OTC	Optical Transient Camera
PMT	Photo-Multiplier Tube

PPC	Payload Power Contactor
PRV	Pressure Relief Valve
PSI	Pounds per Square Inch
PTFE	Poly-Tetra-Fluoro-Ethylene (Teflon)
RAM	Random Access Memory
RTV	Room-Temperature Vulcanizing
SCC	Stress Corrosion Cracking
SCSI	Small Computer Standard Interface
SDA	Standard Door Assembly
STS	Space Transportation System
TBE	Tubular Battery Enclosure
UDMD	User Designed Mounting Disc
VAC	Volts Alternating Current
VDC	Volts Direct Current
VTL	Verification Tracking Log

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1. Introduction

1.1 Benign Statement

G-056 utilizes the GAS SDA hardware, however, the experiment configuration provides for a sealed internal environment once the door is opened. The G-056/GAS canister internal environment will be inerted with a dry nitrogen and 10% CO₂ purge and sealed at 1 atmosphere pressure. The G-056 canister internal environment will remain inert throughout the Space Shuttle mission, since the total energy that G-056 possesses is insufficient to breach the sealed nature of the G-056 configuration under worst case dissipation and thermal conditions. In addition, the failed experiment structure will be fully contained under the worst possible STS load environments. G-056 has conducted both a fracture control and penetration analysis to verify structural containment. All materials are non-hazardous and have been found to be compatible with each other as well as the GAS Carrier System and Space Shuttle environments. Surfaces of G-056 components that are exposed to the vacuum environment of space have been assessed for safe use in the Space Shuttle cargo bay. Therefore, G-056 has been classified as a "Class B" (Benign) payload in accordance with JSC Letter TA-91-039.

1.2 Objective

The G-056 experiment is designed to detect gamma-ray bursts from celestial sources and to detect the possible occurrence of optical transients coincident with the gamma-ray bursts. The nature and origin of gamma-ray bursts are still largely a mystery, but current theory suggests that they come from neutron stars in binary systems. Gamma-ray bursts originating from space were first reported in 1973 and since then it has been estimated that between 200 and 500 bursts occur each year. The most recent data come from the Burst and Transient Source Experiment (BATSE) on the Compton Gamma-Ray Observatory (CGRO), which has detected over 200 bursts in over one year of operation. Based on models of the binary systems, gamma-rays emitted in a burst near the neutron star may be accompanied by an optical transient. The optical transient, or optical flash, is due to the reprocessing of the gamma-rays which are incident on the companion star, producing visible light which is observable at the Earth. Discovery of an optical flash from a gamma-ray burst source would provide significant data for theoretical studies, as well as providing the position of the burst to arc minute precision, an order of magnitude better than previously achieved. Localization is crucial for the subsequent identification of the source at other wavelengths.

1.3 Concept

In order to accomplish this goal, we use a NaI(Tl) scintillation gamma-ray detector and a standard 35mm film optical camera with a 40° field of view, along with an intelligent data system. To discriminate between gamma-ray bursts and solar flares, a silicon charged particle detector is utilized, providing a veto for solar and charged particle events. Finally, two Avalanche Photo-Diodes (APDs) are mounted on the surface of the G-056 User-Designed Mounting Disc (UDMD) to detect low energy gamma-rays. The data will be stored in mass storage devices and time tagged for comparison with other experiments, such as BATSE on CGRO and detectors on other spacecraft. A Global Positioning System (GPS) board will be flown to obtain the accurate burst arrival time and Space Shuttle location required for this comparison.

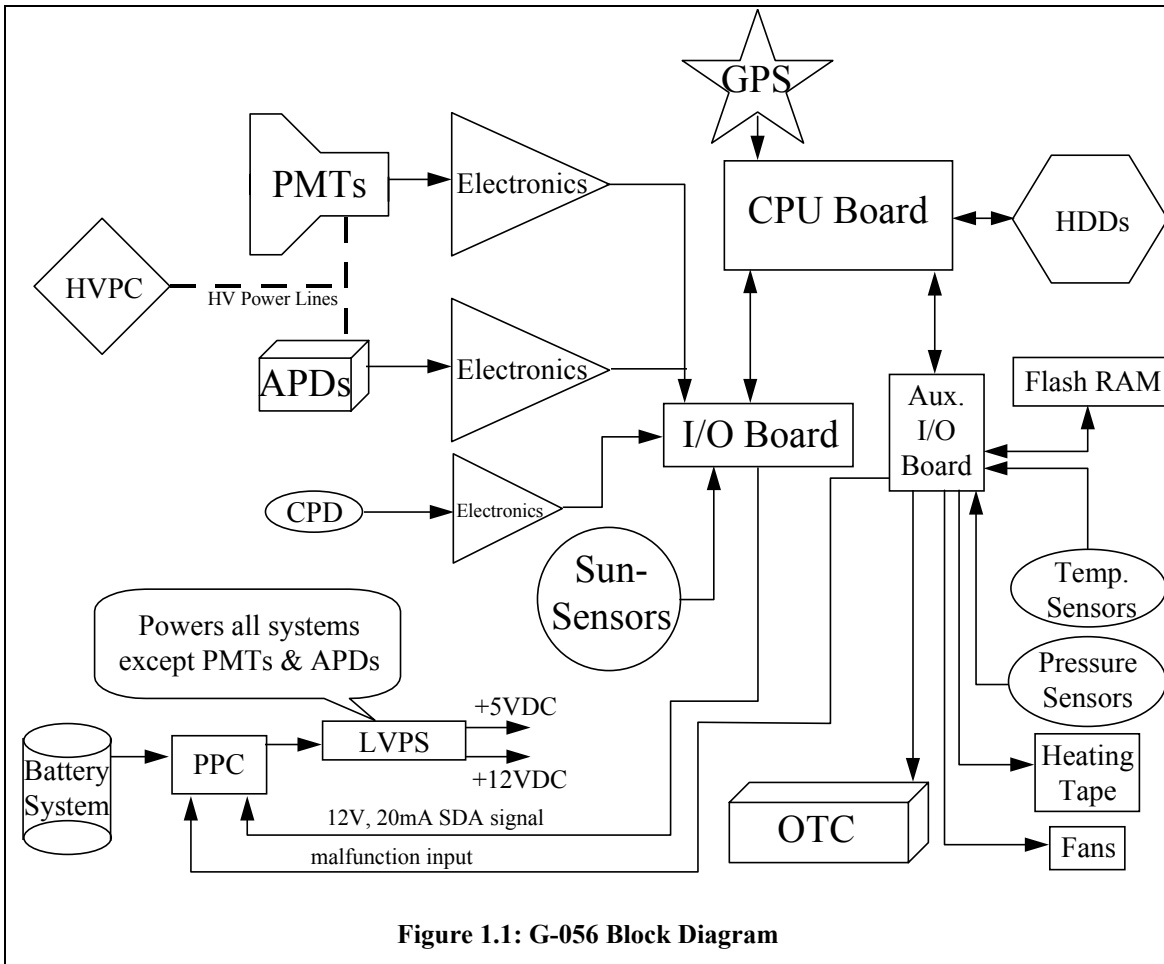


Figure 1.1: G-056 Block Diagram

Figure 1.1 shows a functional block diagram of G-056. The experiment consists of functional blocks including the Photomultiplier Tubes (PMTs), the Charged-Particle Detector (CPD), the Avalanche Photo-Diodes (APDs), the electronics for these three items, the Optical Transient Camera (OTC), the Sun Sensors, the Central Processing Unit (CPU) Board, the Input/Output (I/O) Board, the Hard Disk Drives (HDDs), the Flash Random Access Memory (RAM), the Global Positioning System (GPS) Unit, the Temperature Sensors, the Pressure Sensors, the Battery System, the Low Voltage Power Supply (LVPS), the High Voltage Power Converter (HVPC), the Heating Tape, the Fans, and the PPC interface (see Section 2.2.1 for PPC interface details).

1.4 Operational Scenario

As early as possible in the mission, Relay A will be switched to the Hot position, which will supply main power to the experiment. This enables the payload to perform diagnostic checks. Immediately following this operation, Relay B will be switched to the Hot position, which will enable the opening of the SDA and begin the experiment. Relay B will be switched to latent as late as possible in the mission, turning the payload off and closing the SDA. If the payload's Central Processing Unit (CPU) detects a temperature in the payload which is too low for mission success (as determined by its programming), it will close the SDA. This operation will happen at most ten (10) times and is for mission success only. At least five minutes after Relay B is switched to latent, Relay A will be switched to latent, removing power from the experiment.

2. Description

2.1 Support Structure

The G-056 structure is comprised as follows: (refer to Figure 2.1 and Figure 2.2). A User Designed Mounting Disc (UDMD) mounts to the NASA SDA Experiment Mounting Plate (EMP) through the Experiment Thermal Isolator (ETI), thus structurally securing the ETI to the EMP while maintaining thermal isolation. During takeoff and landing, the NASA SDA covers the UDMD. Attached to the underside of the UDMD is the Battery Containment System (BCS), which supports, seals, and contains the batteries, and whose components include the Battery Venting Ring (BVR) and Tubular Battery Enclosures (TBEs). The BCS also secures the experiment support superstructure as described in Section 2.1.4.2 below. The superstructure holds most of the electronics and the detection hardware. The BCS receives lateral support through a set of three (3) bumpers, as described in Section 2.1.5 below, and is supported vertically by a series of battery support rods, as outlined in Section 2.1.4.2.2 below. The area of G-056 below the UDMD is both sealed and contained, with the UDMD acting effectively as a replacement for the standard NASA end cap.

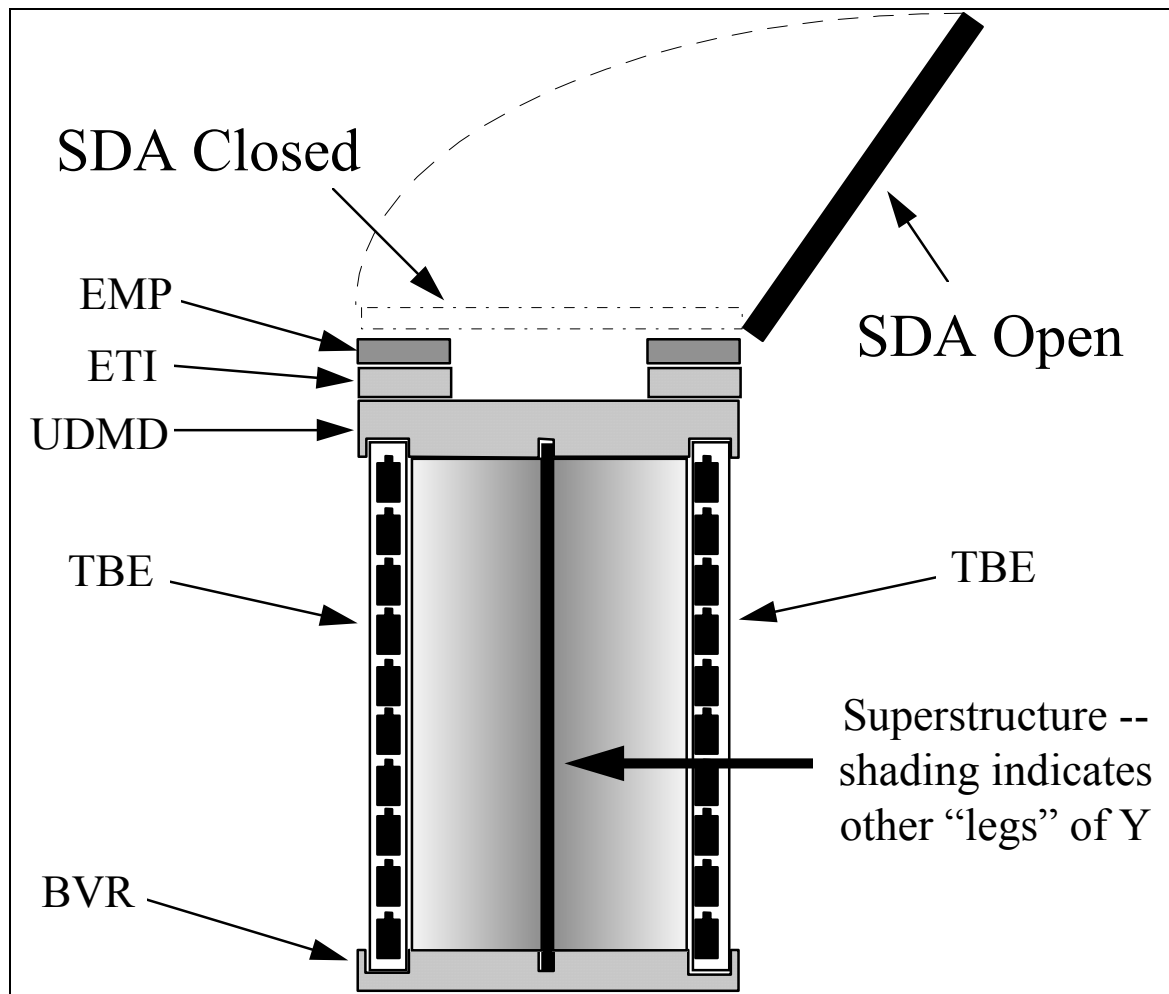


Figure 2.1: G-056 Configuration

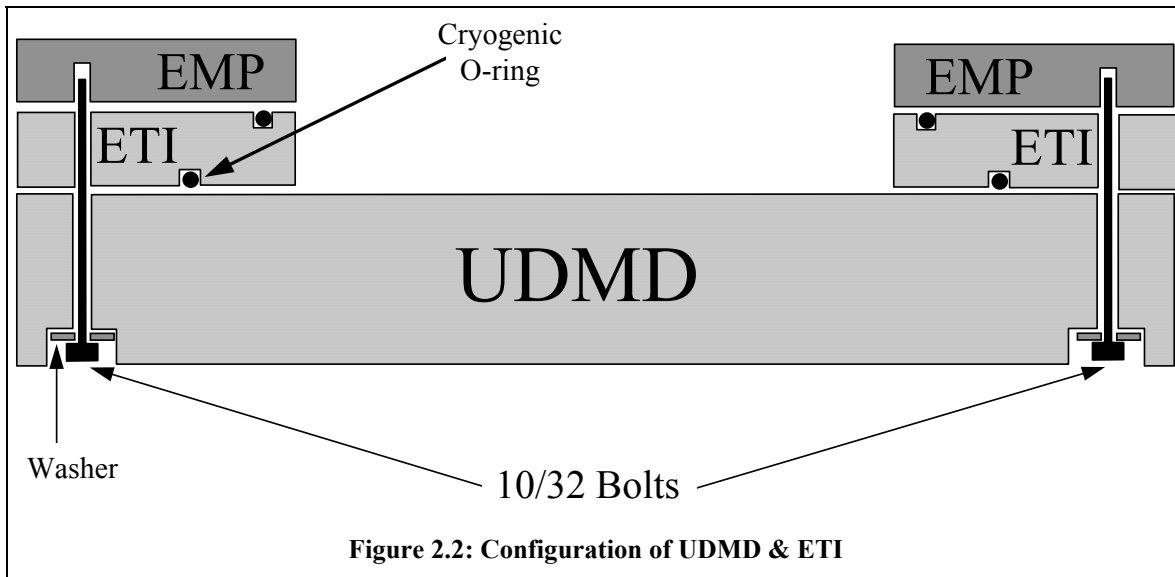


Figure 2.2: Configuration of UDMD & ETI

2.1.1 Experiment Thermal Isolator

The ETI consists of a Polycast acrylic ring 1.25 inches thick, with an outer diameter of 19.75 inches and an inner diameter of 15.4 inches. The ETI has 24 holes running vertically through it, 20 of which are used to allow the UDMD to bolt into the EMP (see Figure 2.3).

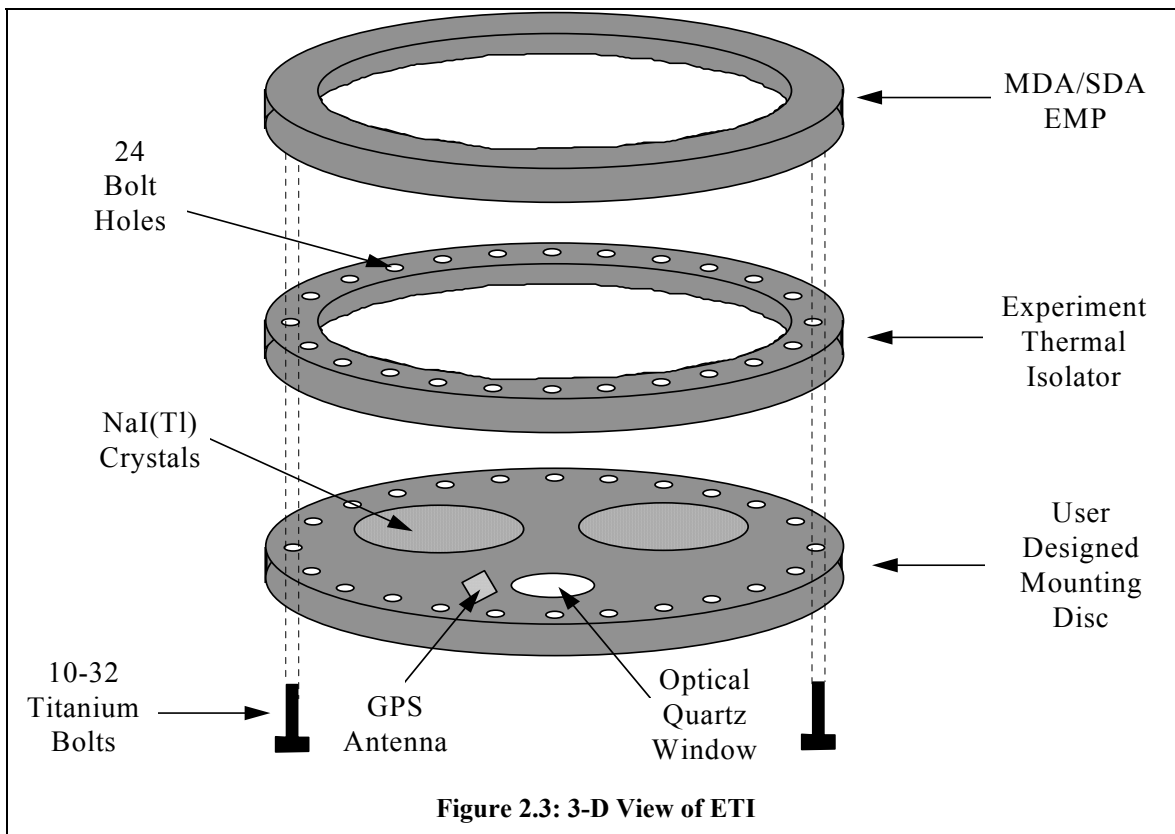
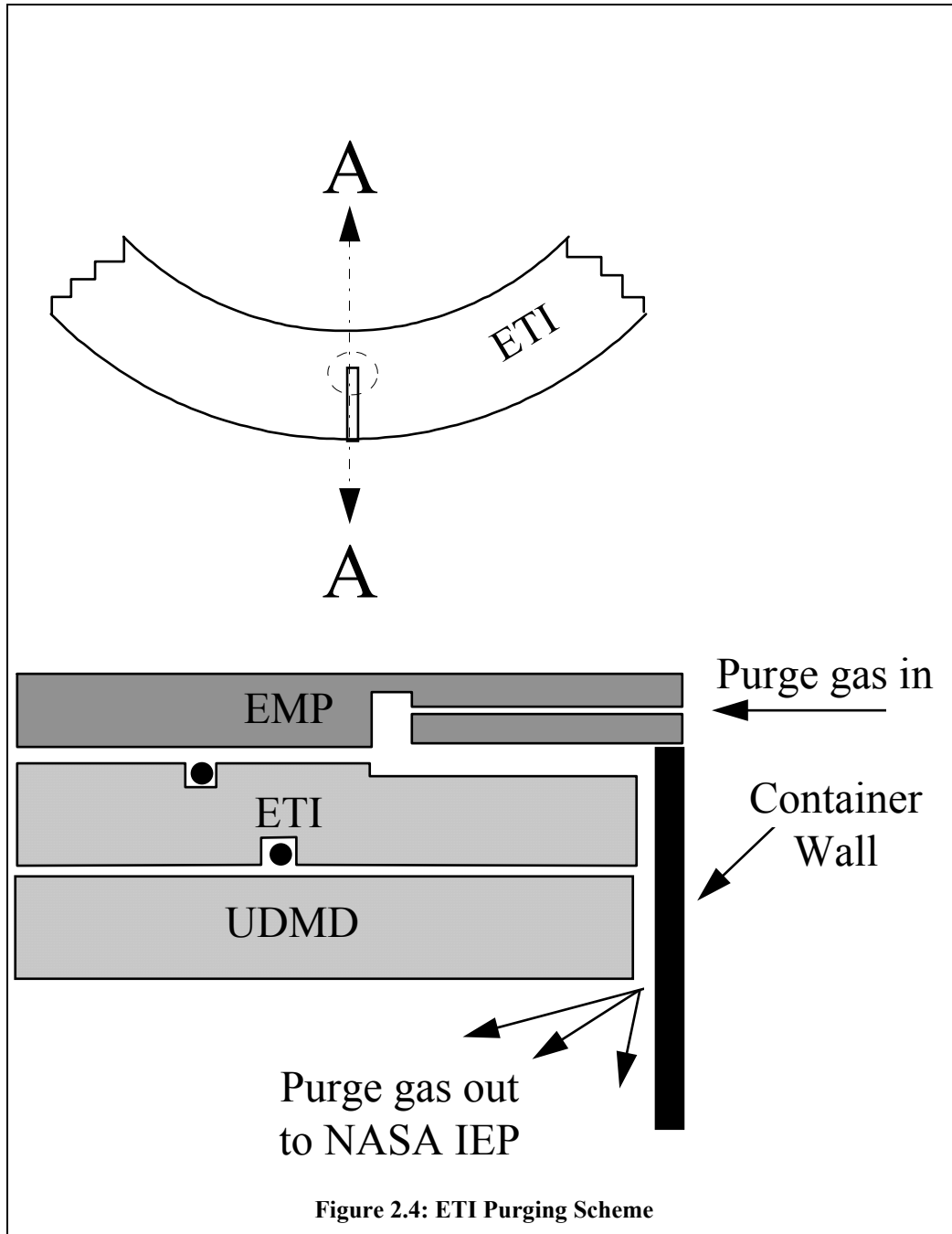
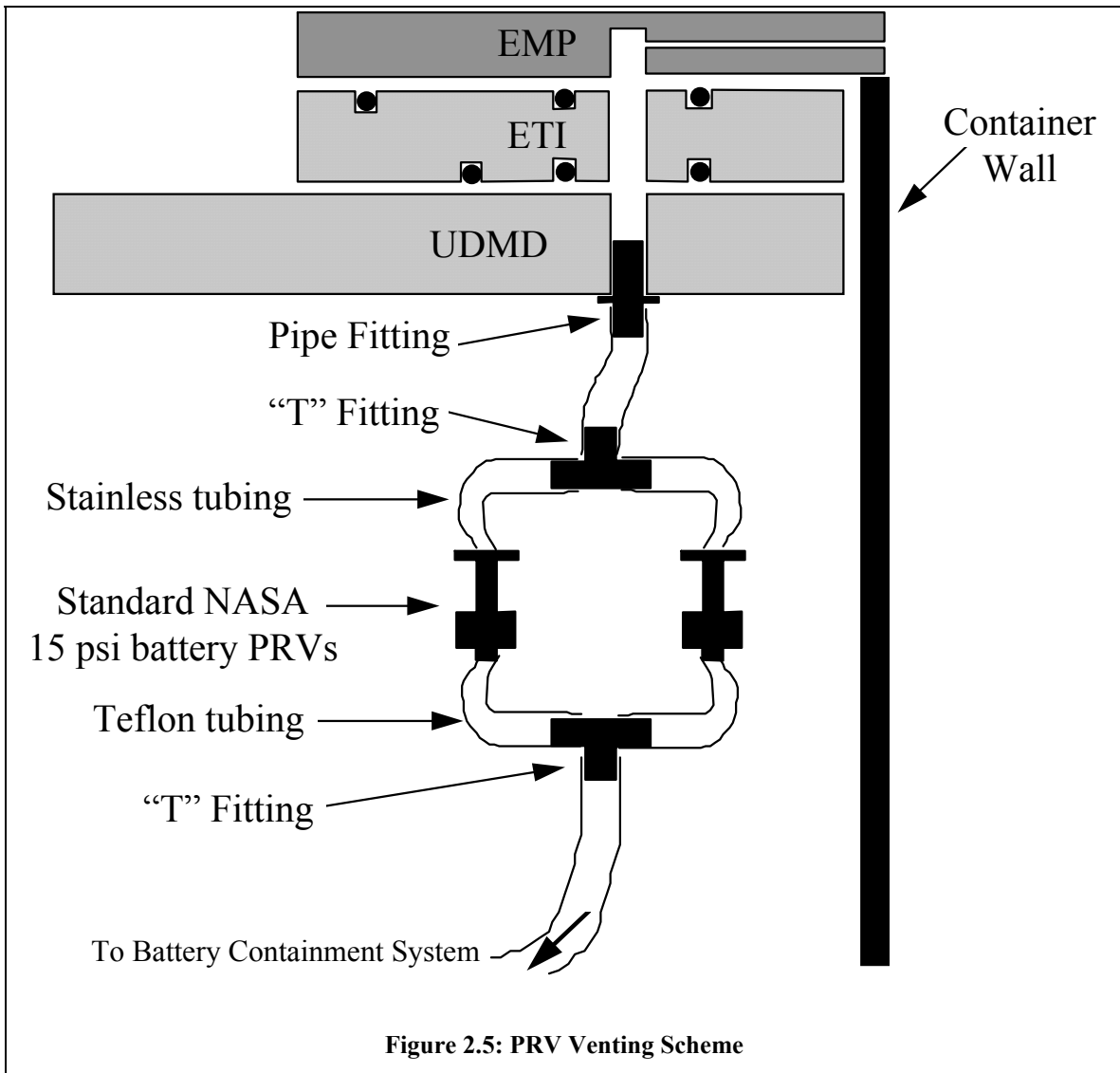


Figure 2.3: 3-D View of ETI

The ETI also contains a horizontal groove along the top surface to allow pre-flight purging of the sealed portion of G-056 (see Figure 2.4). The purge gas will be introduced through the NASA SDA EMP and will exit through the NASA Interface Equipment Plate (IEP).



The ETI also contains one additional hole running vertically through it to allow overboard venting of the PRVs. This hole is sealed with a cryogenic O-ring (see Figure 2.5). For further details of the battery venting scheme, see Section 2.1.4.2.2 below. The top and bottom surfaces of the ETI contain large O-ring grooves around their circumferences which seal the ETI to the EMP and the UDMD, containing the 1 atmosphere of pressure inside the GAScan (see Figure 2.2 and Figure 2.5).



2.1.2 User Designed Mounting Disc

The UDMD consists of a solid 7075-T651 aluminum plate (hard-anodized) with a diameter of 19.75 inches (see Figure 2.6). The “outer portion” of the UDMD, the area with outer diameter of 19.75 inches and inner diameter of 15.4 inches, is 1.25 inches thick. The “inner portion” of the UDMD, the area with outer diameter of 15.4 inches, is 0.5 inches thick in all areas not otherwise specified. It should be emphasized that although these two portions are different thicknesses, they are milled out of one solid piece of aluminum.

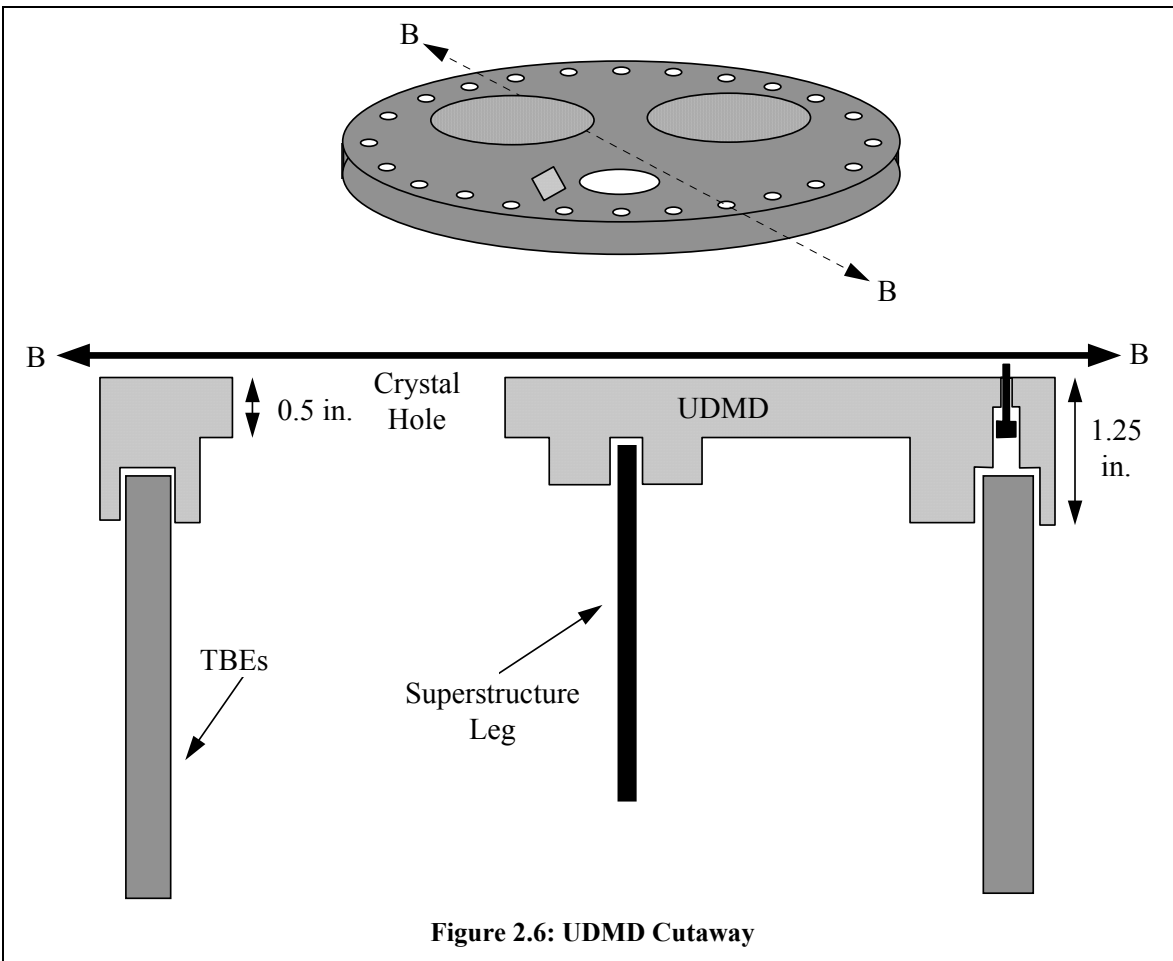


Figure 2.6: UDMD Cutaway

2.1.2.1 Outer Portion

The outer portion of the UDMD is pierced by 24 holes, countersunk to a 1 inch depth with 0.5 inch diameter, which host the 20 10-32 2.15 inch long titanium bolts used to attach the UDMD (and thereby the ETI) to the EMP (see Figure 2.2 above). The outer portion of the UDMD also provides the interface necessary for the PRVs. As explained in Section 2.1.1, there is a hole through the ETI which allows venting the batteries overboard. There is a cryogenic O-ring between the ETI and the EMP, as well as between the ETI and the outer portion of the UDMD (see Figure 2.2). The outer portion of the UDMD also contains a hole in the appropriate place to extend this vent to the bottom side of the outer portion of the UDMD. This hole is threaded to allow the insertion of a pipe fitting (sealed with Teflon tape) which connects to the

stainless steel tubing which vents the PRVs (see Section 2.1.4.2.2). The outer portion of the UDMD is also specially constructed to provide support for the 21 Tubular Battery Enclosures (TBEs) (for a description of the TBEs themselves, see 2.1.4.2.1 below). The bottom side of the outer portion of the UDMD contains 21 non-penetrating slip-fit holes (1.7 inch diameter, 0.5 inch deep) to provide structural support for the TBEs (see Figure 2.6). These holes in the UDMD also contain grooves which allow access to each TBE's battery ground wire (not pictured). The outer portion of the UDMD also contains ten (10) threaded non-penetrating holes to accept the threaded rods which support the BCS (see section 2.1.4.2).

2.1.2.2 Inner Portion

The inner portion of the UDMD is solid except for the following:

1. Two holes which allow light from the NaI(Tl) scintillator crystals to enter the Photo Multiplier Tubes (PMTs). Each hole is circular and is slightly larger than the PMT's metal shield (for additional information, see Figure 2.19 below). The diameter of each hole is approximately 5.1 inches. These holes are sealed by a cryogenic O-ring between the upper side of the UDMD and the bottom of the NaI(Tl) assembly (see Section 2.4.1).
2. One hole to allow the Optical Transient Camera (OTC) to view space through the Optical Quartz Window (OQW), which is located above the remaining 130° sector of the UDMD. It is approximately 2.7 inch diameter and is sealed with a cryogenic O-ring (see Section 2.1.2.4).
3. One wiring hole for the Avalanche Photo-Diodes (APDs) (see Section 2.5). This hole is small (\cong 0.5 inch diameter) and hosts a hermetic connector (4-pin) which is sealed with a Viton gasket.
4. One wiring hole for the Global Positioning System (GPS) antenna (see Section 2.1.2.3). This hole is \cong 0.5 inch diameter and hosts a hermetic connector (coax) which is sealed with a Viton gasket.
5. One wiring hole for the temperature sensors, Sun Sensors (see Section 2.7), and CPD. This hole is \cong 1 inch diameter and hosts a hermetic connector which is sealed with a Viton gasket.

2.1.2.3 Global Positioning System Antenna

Figure 2.7 shows a side view of the mounting of the GPS antenna. As can be seen, the antenna rests on stand-offs which are atop the UDMD and is bolted (4 bolts) through the stand-offs into the UDMD from

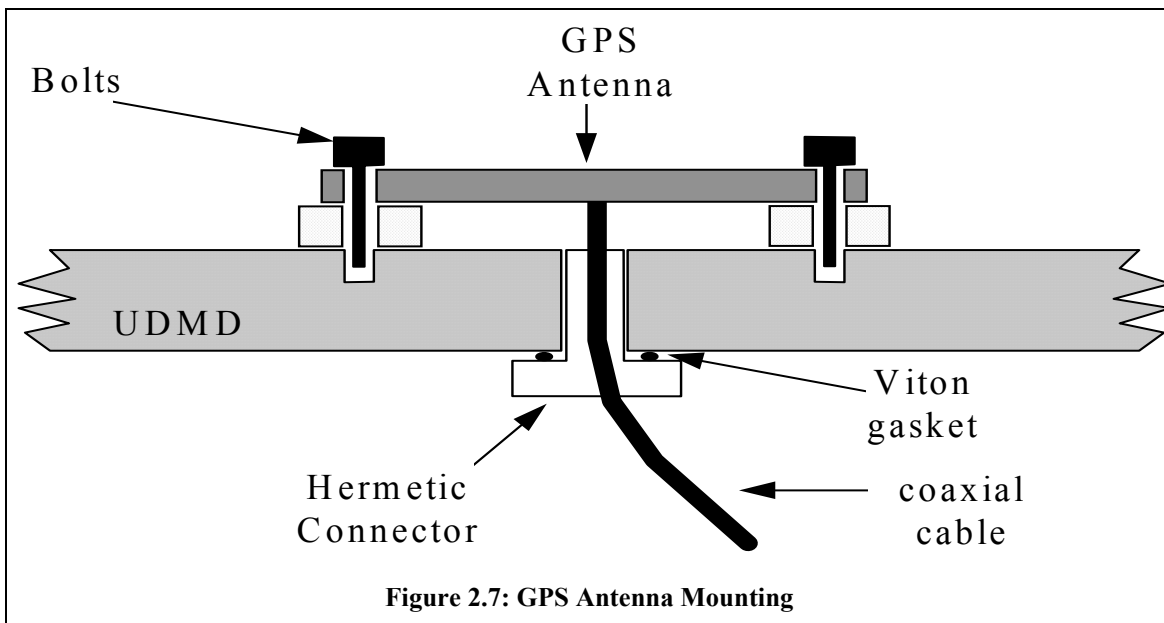
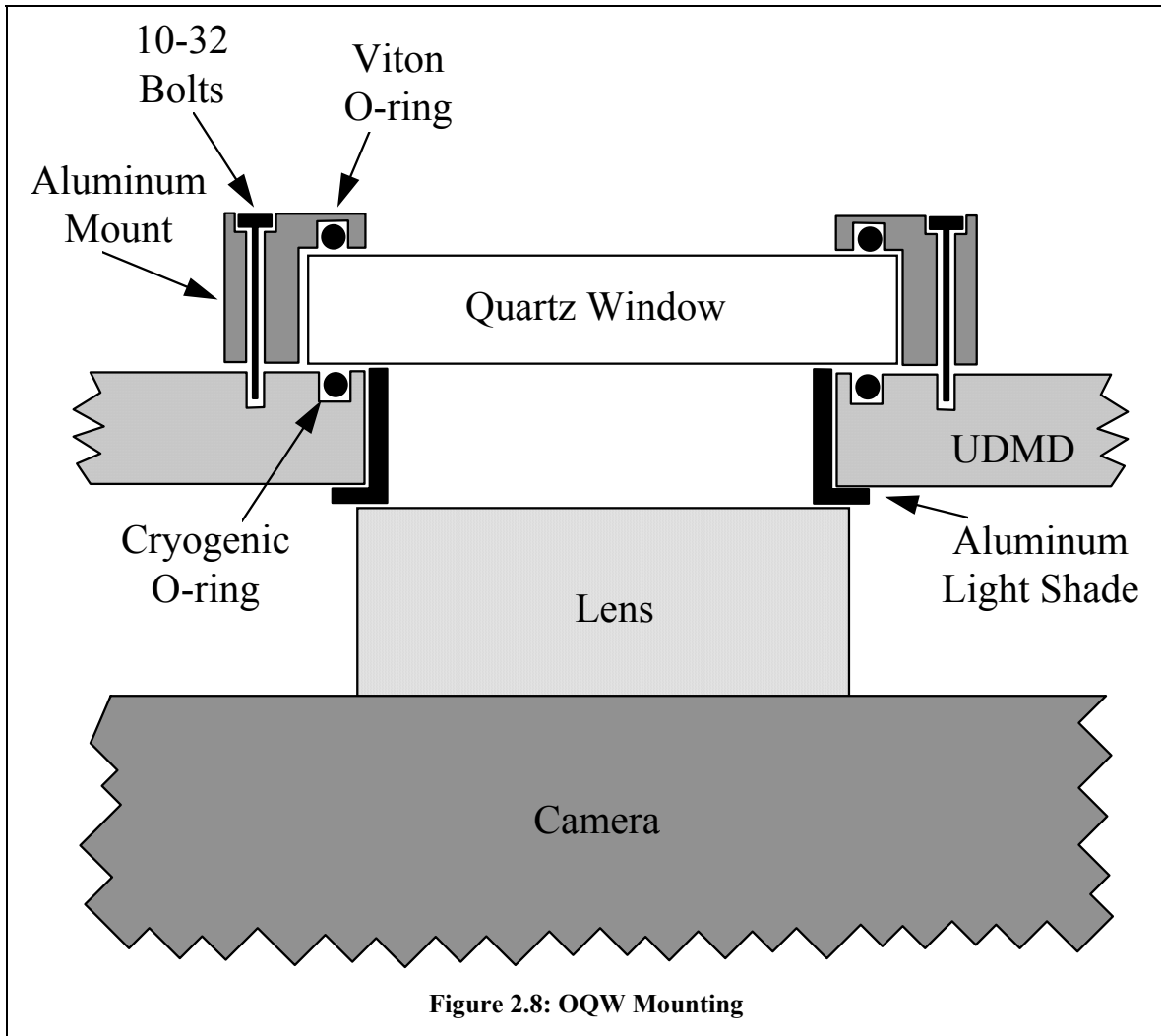


Figure 2.7: GPS Antenna Mounting



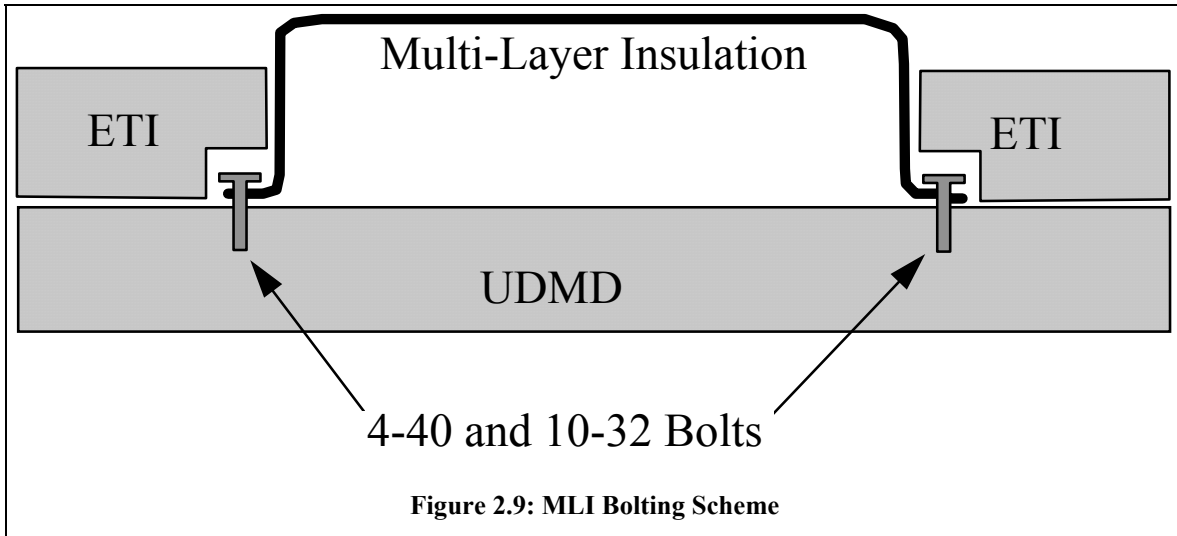
above. The antenna consists of a flat metal active element surrounded by a Lexan cover.

2.1.2.4 Optical Quartz Window (OQW)

Above the hole for camera (OTC) viewing is the OQW and its mount. The OQW has a diameter of approximately 2.7 inches and a thickness of 0.25 inches and is made of fused silica. The OQW is mounted above the UDMD as shown in Figure 2.8. The OQW is held in place by an aluminum mounting ring. The ring is made of 6061-T6 aluminum and is bolted to the UDMD as shown. A total of 4 titanium bolts are used to hold the mounting structure in place. The OQW, as shown, is sealed by a cryogenic O-ring. Additionally, a silicone O-ring protects the OQW from abrasion against the mounting ring, and a 6061-T6 (anodized) aluminum light shade “ring” prevents stray light from the UDMD from entering the camera lens.

2.1.2.5 Multi-Layer Insulation (MLI)

The inner portion of the UDMD also contains non-penetrating, threaded holes on its upper surface, which receive the 4-40 and 10-32 stainless steel bolts which secure the Multi-Layer Insulation (MLI) (see Figure 2.9). The MLI consists of alternating layers of Beta cloth and aluminized Mylar in an attempt to recreate the



insulating properties of a GAS insulating end cap. The MLI has holes where needed (above OQW, APDs, GPS, and Sun Sensors), and is bolted down to the UDMD around these holes.

2.1.2.6 Superstructure Support

The inner portion of the UDMD is also specially designed to support the superstructure, as discussed in Section 2.1.3 below.

2.1.3 Superstructure

The superstructure consists of three 6061-T6 3/16 inch thick aluminum sheets butted together to form the Y shaped cross section shown in Figure 2.10.

The superstructure contacts the inner portion of the UDMD through a 0.125 inch thick piece of neoprene (which vibrationally isolates the superstructure from the UDMD) where the UDMD is 0.5 inches thick. On either side of each leg of the “Y”, the UDMD is 1.25 inches thick¹, thus providing lateral support for the superstructure (Figure 2.6). Additionally, the superstructure is secured vertically between the UDMD and the BCS (as discussed in Section 2.1.4.2.2). Some components are attached directly to the superstructure, while others are connected to shelves which are attached to this superstructure.

¹ The UDMD is milled out of one solid piece of aluminum that is 1.25 inches thick -- an area 0.5 inches wide on either side of each Y leg was simply left at 1.25 inches rather than milled down to 0.5 inches like the rest of the inner portion of the UDMD.

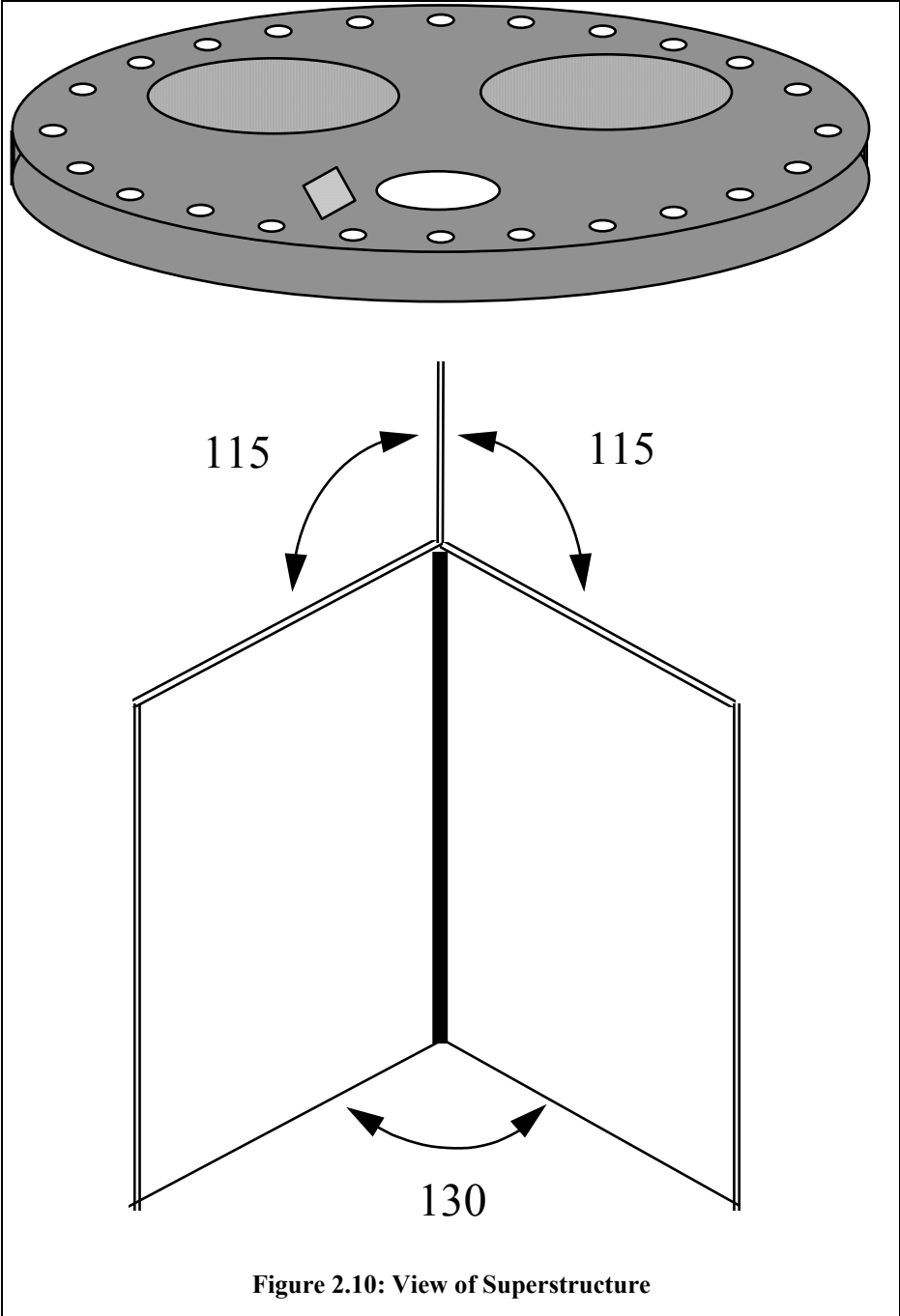
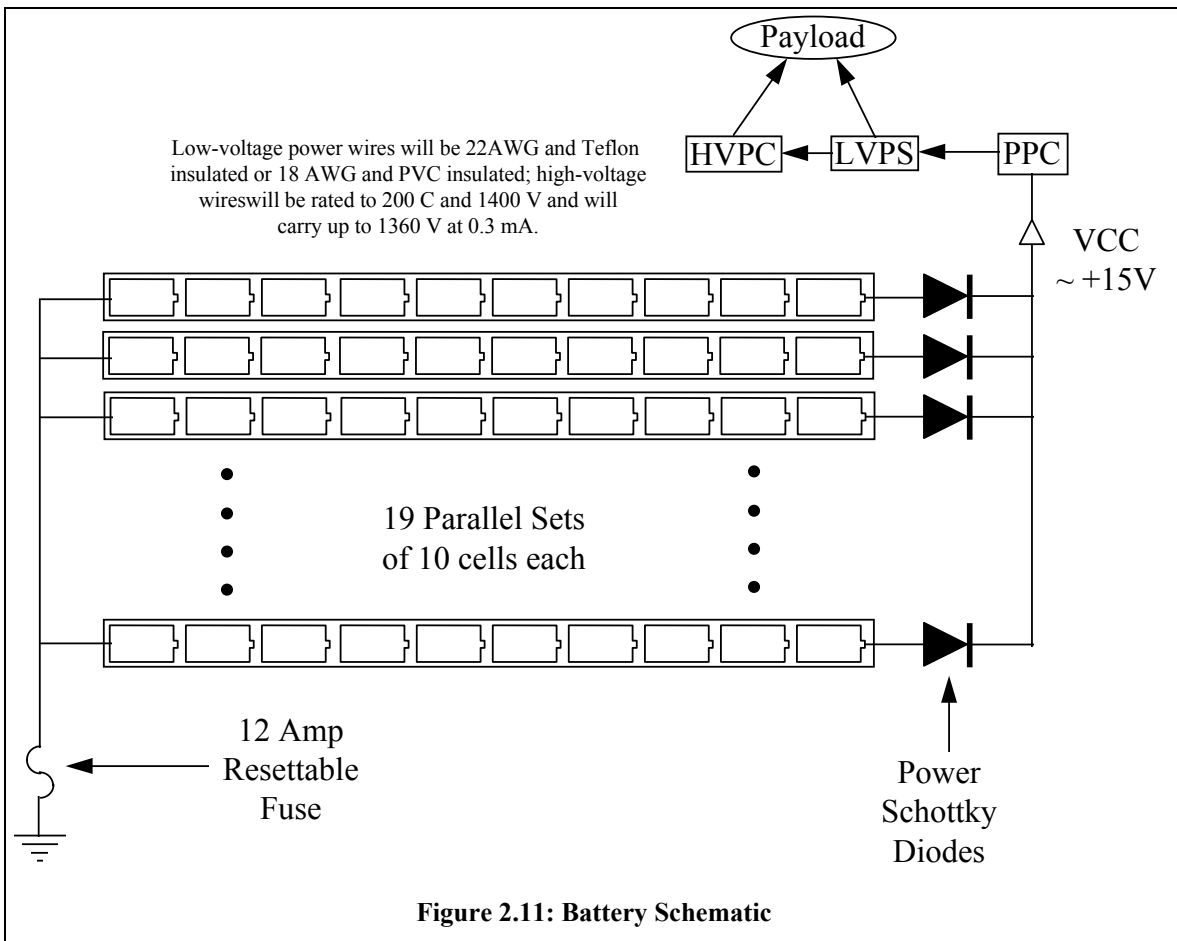


Figure 2.10: View of Superstructure

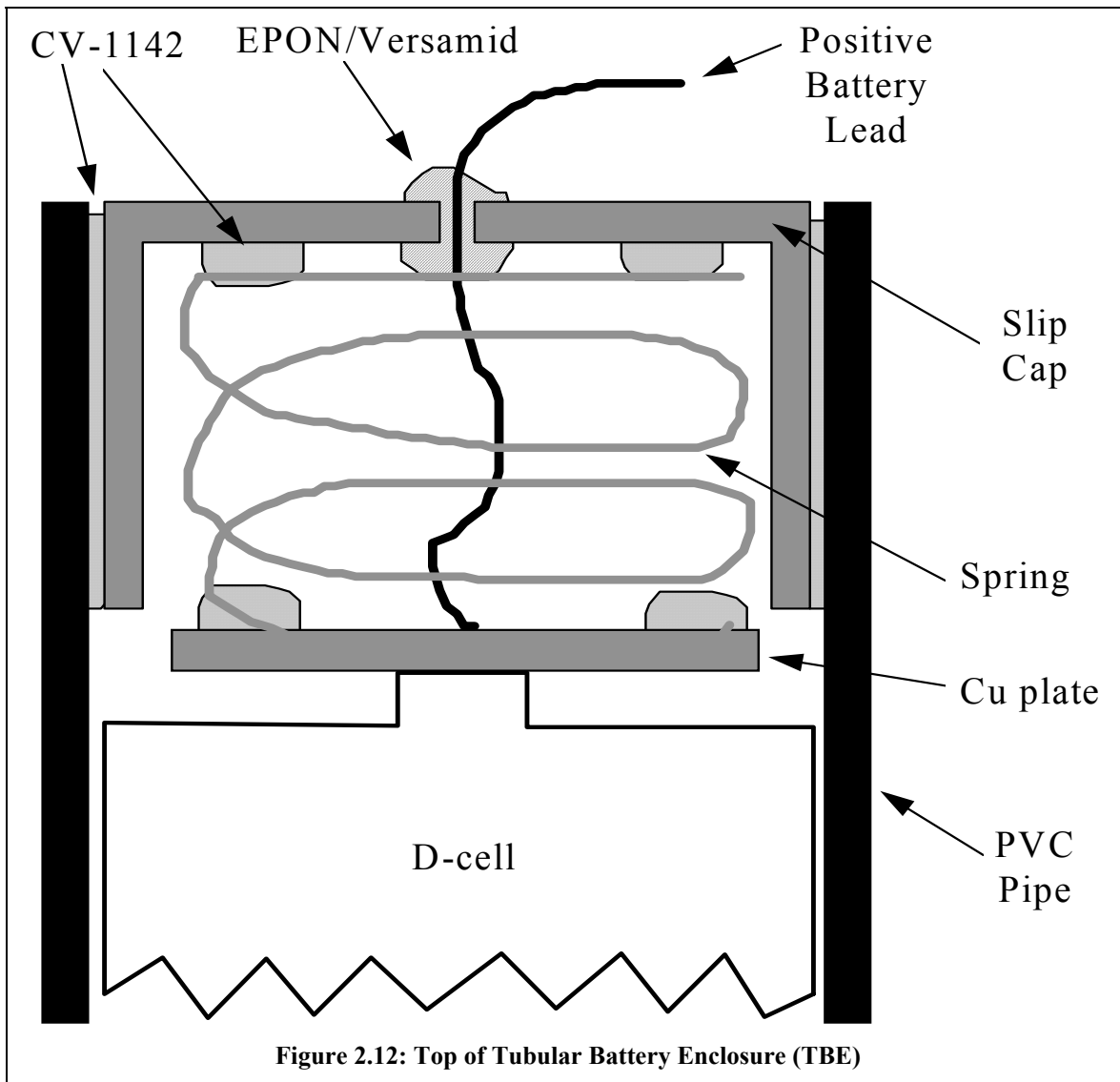
2.1.4 Batteries

2.1.4.1 Type and Fusing

One battery subsystem provides all major power needs for the payload (except as indicated in Sections 2.1.4.2.3 and 2.1.4.2.4 below). This power is provided by commercially available Duracell D-cells. Each cell is rated at 1.5 VDC and 14.25 Amp hours. The power supply for G-056 consists of 190 cells. The cells are arranged in 19 parallel groups of 10 cells connected in series (see Figure 2.11). Each group of 10 cells is herein referred to as a battery of cells or simply a battery. Each D-cell is herein referred to simply as a cell. Each battery provides a nominal 15 VDC (1.5×10), which slopes down to about 8 VDC by end of battery life. Each battery is protected by a Schottky diode to prevent circulating currents between batteries.



A resettable fuse is used to protect the main power wires and the batteries themselves. All primary power wires are Teflon insulated with a thermal rating of 200 °C or are PVC insulated with a thermal rating of 105 °C and are sized to withstand at least 12 Amps. If a single battery shorts, the peak current will be 8 to 12 Amps, so the batteries must be fused against currents this large. The maximum anticipated current the payload will require is 3 Amps, so the fuse used must hold this current. Therefore, the resettable fuse employed will (derating 50%) hold 6 Amps and will trip at 12 Amps. This fuse is placed as close as possible to the negative (ground) leg of the battery system.



2.1.4.2 Battery Containment System (BCS)

The 19 batteries are enclosed in the Battery Containment System (BCS). The BCS consists of 21 Tubular Battery Enclosures (TBEs) (2 of which contain no batteries) and the Battery Venting Ring (BVR).

2.1.4.2.1 Tubular Battery Enclosures (TBEs)

Each TBE contains 10 cells (one battery) arranged just as in a flashlight. A TBE consists of a section of PVC pipe (1.30 inch inner diameter, 1.41 inch outer diameter, approximately 24 inches long) with a 0.75 inch PVC slip-cap inserted to one end and sealed with CV-1142 sealant with the flat side of the slip-cap facing away from the pipe (see Figure 2.12). A spring (1.75 inches long uncompressed, 0.953 inch outer diameter, 0.790 inch inner diameter, spring constant 26.84 lb/in) is attached to the inside of the slip-cap with CV-1142. A solid copper plate (0.95 inch diameter, 1/16 inches thick) is attached to the free end of the spring with CV-1142 and serves as the positive battery contact. A power wire is soldered to the top of the plate (either directly or with the use of a solder tab) and runs through a small (≤ 0.125 inch) hole in the center of the slip-cap which is then sealed with EPON/Versamid. This wire then serves as the positive lead of the battery enclosed by the TBE.

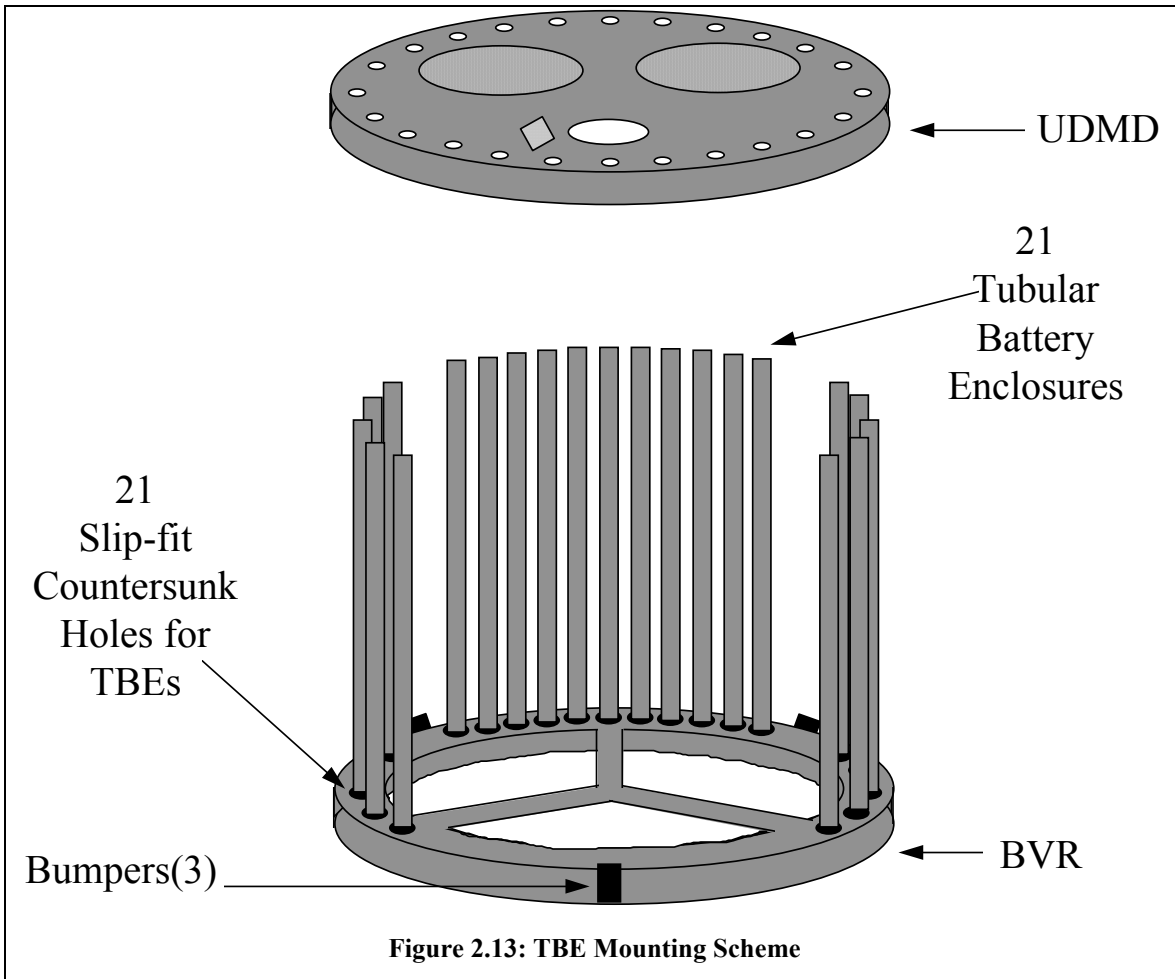


Figure 2.13: TBE Mounting Scheme

The 21 TBEs (two of which do not contain batteries) are oriented vertically just inside the circumference of the GAScan, in the two 115° sections formed by the Y-shaped superstructure. The TBEs are supported by the slip-fit holes in the outer portion of the UDMD (see Section 2.1.2.1) as well as by the BVR (see Section 2.1.4.2.2 below). The positive side of the TBE is sealed as described in the previous paragraph and the negative side of the TBE is sealed and vented by the BVR. A thin ($\cong 0.03$ inch) piece of neoprene also sits between the TBE and the UDMD to vibrationally isolate the TBEs.

2.1.4.2.2 Battery Venting Ring (BVR)

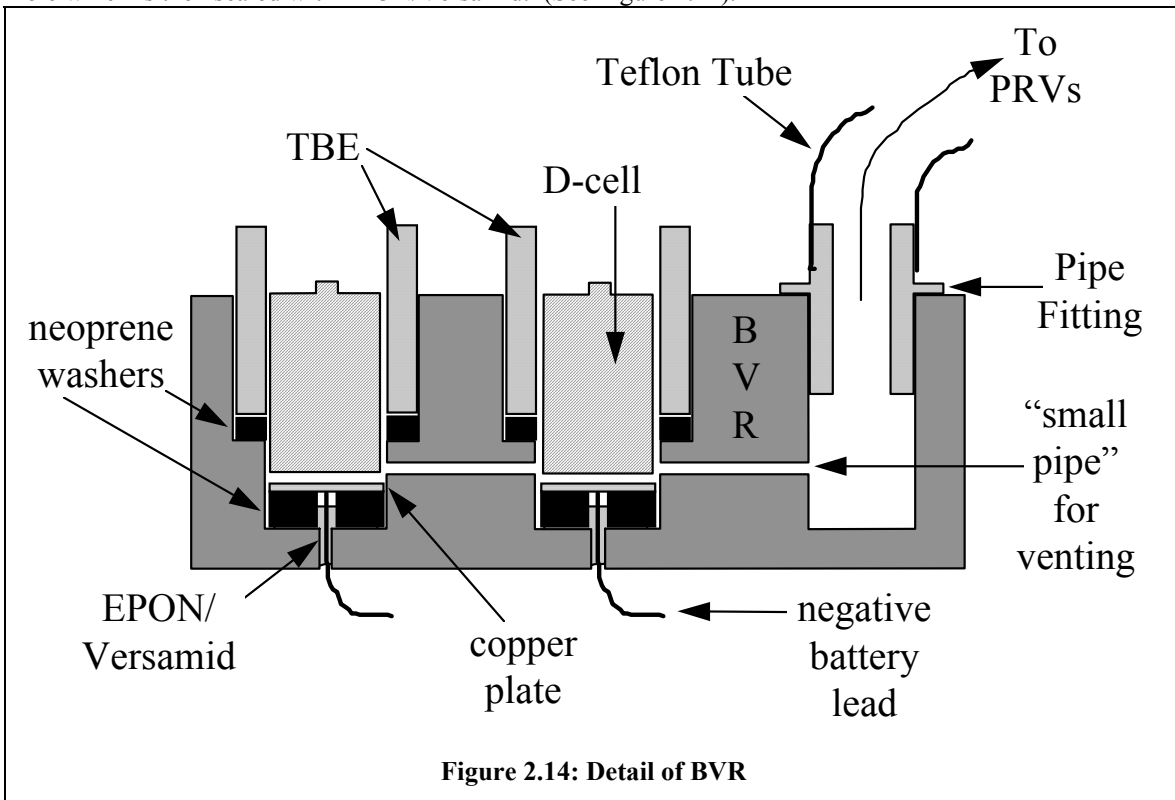
The BVR serves several purposes:

- It provides structural containment of the TBEs.
- It provides overboard venting for the batteries enclosed in the TBEs.
- It supports the lateral support bumpers (see Section 2.1.4.2.4).
- Along with the UDMD, it provides vertical support for the superstructure.

The BVR consists of a 1.25 inch thick plate of Polycast acrylic (milled out in places — see Figure 2.13) which sits near the bottom of the G-056 envelope. The ring has an outer diameter of 19.75 inches. Along the circumference of the BVR, there are 21 countersunk, non-penetrating, slip-fit, 0.625 inch deep holes into which the TBEs are inserted (see Figure 2.13). A neoprene washer (1.4 inch outer diameter, 1.28 inch inner

diameter, 0.125 inch thick) is attached to the bottom of each hole with CV-1142. This washer provides the seal for the TBEs (as described below).

Within this hole is another countersunk non-penetrating hole of diameter 1.25 inches and of additional depth 0.375 inches. At the bottom of this hole, a neoprene washer (1.24 inch outer diameter, 0.25 inch inner diameter, 0.125 inch thick) is affixed with CV-1142. Atop this washer is attached (with CV-1142) a small copper plate (1.24 inch diameter, 0.063 inch thick) which serves as the negative battery contact. To the bottom side of the plate is soldered (either directly or with a solder tab) a power wire which serves as the negative battery lead. This wire exits the hole on the underside of the BVR through a small (≤ 0.125 inch) hole which is then sealed with EPON/Versamid. (See Figure 2.14).

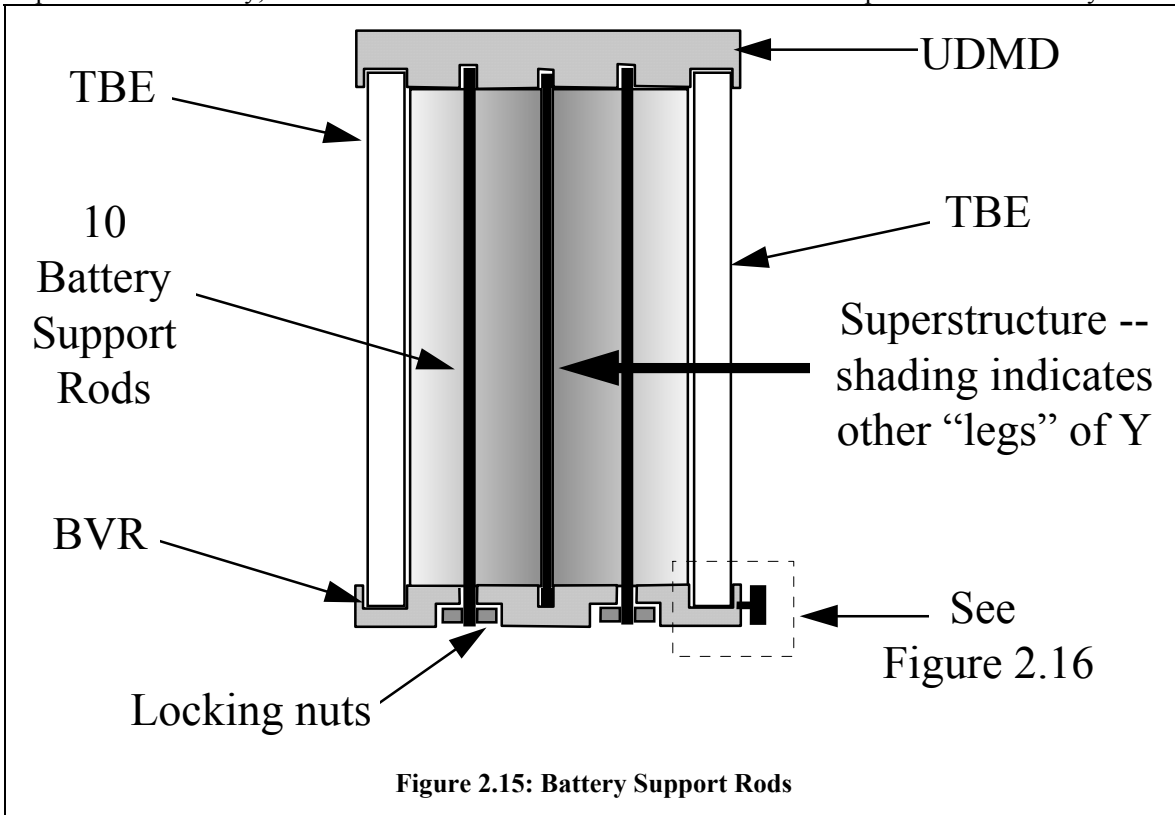


A series of ten (10) aluminum Battery Support Rods (0.375 inch diameter, threaded 1/4-20 for one inch on both ends) are threaded into the UDMD as described in Section 2.1.2.1 (see Figure 2.15). The BVR has matching cleared holes which slide over the threaded rods and the BVR is then secured to the rods (with the TBEs in place) with ten nylon insert locking nuts. The nuts provide the upward pressure to secure the TBEs as well as to provide a positive seal for the TBEs, while the superstructure prevents the BVR from slipping upwards along the threaded rods. Additionally, the lateral motion of the BVR is constrained by the bumpers (see Section 2.1.5).

Overboard venting of the batteries is accommodated as follows (see Figure 2.14). Between each pair of adjacent countersunk non-penetrating TBE holes is a small pipe (≥ 0.125 inch diameter) that has been bored through the BVR. These small pipes allow "air" exchange between and among all TBEs. A similar small pipe connects one of the countersunk holes to another hole which is threaded to accept a Teflon pipe fitting, thus connecting all sealed TBEs to this fitting. One end of a length of flexible Teflon tubing is mated to this fitting, the other end of which is mated to a Teflon T fitting. The ends of this T are in turn mated to two pieces of tubing which are mated to the NASA supplied Pressure Relief Valves (PRVs). The other side of the PRVs are then mated to two pieces of stainless steel tubing which mate to another T fitting. To this T fitting is mated a length of steel tubing which mates onto a pipe fitting in a threaded hole in the UDMD (see

Figure 2.5 above). All tubing, pipe fittings, and PRVs will be positively secured to experiment support structures using Nylon cable-type ties and clamps.

The BVR also provides vertical support for the superstructure. The BVR contains a Y-shaped “slot” (milled down to 0.5 inch in the slot) in which the superstructure sits (see Figure 2.15), just as it does in the UDMD (see Section 2.1.3). A 0.125 inch thick piece of neoprene lays in the slot to vibrationally isolate the superstructure from the BVR. In this configuration, the “slots” in the UDMD and the BVR constrain the superstructure laterally, while the UDMD and BVR themselves constrain the superstructure vertically.



2.1.4.2.3 Clock Backup Cell

The payload includes two 6.20 V Duracell Zinc/Silver Oxide cells in series for maintaining the real-time on-board clock and memory backup functions. These cells are 1/2 AA size and have a 180 mAh capacity, and are not vented overboard. These cells are located in one of the electronics packages mounted to the superstructure, and are isolated from primary experiment power.

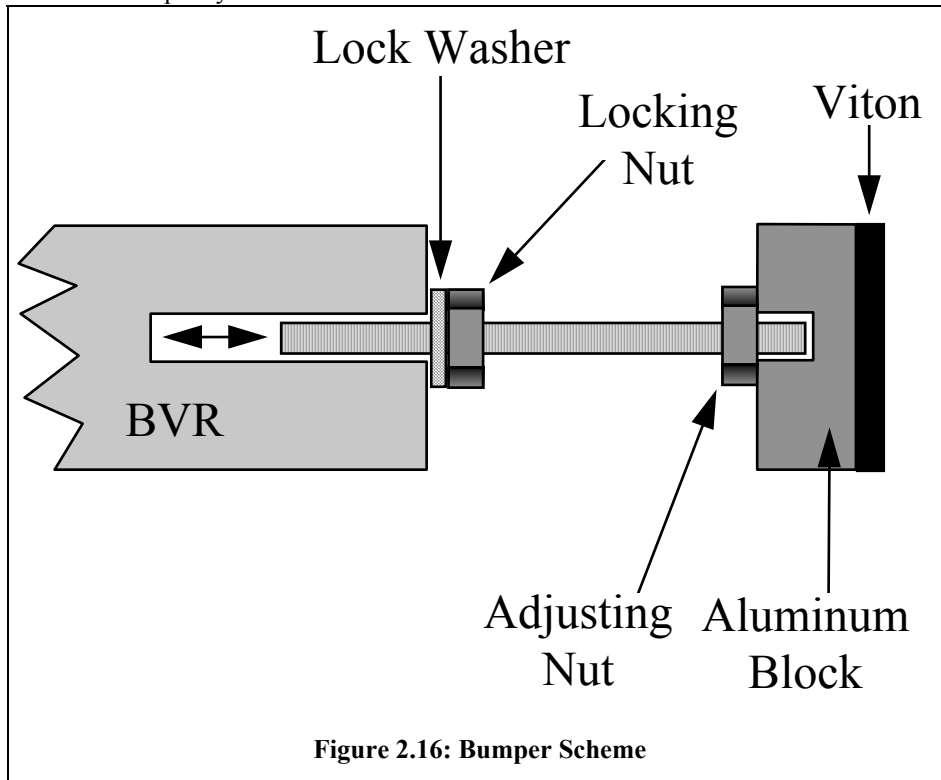
2.1.4.2.4 GPS Backup Cell

The Global Positioning System (GPS) board contains a stack of two (2) button-type Duracell Zinc/Silver Oxide cells in series for backup power. The cells have 180 mAh capacity each, a nominal voltage of 1.55 VDC, and are not vented overboard.

2.1.5 Bumpers

The payload utilizes three (3) viton bumpers, equally spaced around the circumference of the GAScan, to provide lateral support. Each bumper has a contact area with the GAS container of 4.0 in². Each viton bumper is affixed (with EPON/Versamid) to a matching-size 6061-T6 aluminum piece which is 0.25 inch thick. Each aluminum piece has a 0.125 inch deep hole on the side which does not have the viton attached. In this hole sits a 1.75 inch long threaded rod which is threaded into the Battery Venting Ring (BVR). By threading this rod into and out of the BVR, the bumper can be adjusted towards and away from the GAScan

wall. A nut and lockwasher on the threaded rod provides a positive locking mechanism. See Figure 2.16 for a diagram of the bumper system.



2.2 Electrical Power System

An overall schematic diagram of the electrical power system is included as Figure 2.11.

2.2.1 Payload Power Contactor

The 19 batteries are connected in parallel and the +15 VDC nominal line is switched through the Payload Power Contactor (PPC) relays. By means of temperature sensors located throughout the payload and on the UDMD, the CPU will monitor experiment temperature, shutting the experiment down through the PPC malfunction inputs if the temperature exceeds the limits specified in its programming (a range of -40 °C to 50 °C). Such a shutdown would occur for mission success only. The payload also supplies a 12 VDC, 20 mA signal to Pin B of the J400 to power the SDA (see Figure 1.1).

2.2.2 Power Conversion

The power switched by the PPC is fed directly into a DC-DC converter (Low Voltage Power Supply - LVPS) with input voltage range 8-35 VDC, two outputs at 12 VDC and 0.7 Amps, and one output at 5 VDC and 5.1 Amps. The LVPS directly powers all experimental subsystems except for the APDs and the PMTs. Power to most subsystems is switched by the CPU with a set of relays on the Auxiliary I/O Board. The LVPS is mounted directly to the superstructure. Table 2-1 shows a breakdown of experiment subsystems and the maximum power they can consume.

A High Voltage Power Converter (HVPC) supplies high voltage (-100 to -1360 VDC) to the APDs and the PMTs. Expected currents are approximately 0.1 mA per device. The HVPC is powered by the LVPS. The HVPC is also mounted directly to the superstructure. All wires carrying high voltage will be rated to 200°C and 1400 V, and will carry up to 1360 V and 0.3 mA.

Table 2-1: Maximum Consumed Power

Hard Disk Drives	25 W
Central Processing Unit	2 W
Input/Output Board	1 W
PMT Electronics	1 W
APD Electronics	1 W
CPD Electronics	0.6 W
Heating Tape	10 W
Fans	2.4 W
GPS Receiver	2 W
Total (before converter)	45 W
20% converter inefficiency	9 W
Net Power Dissipation	54 W

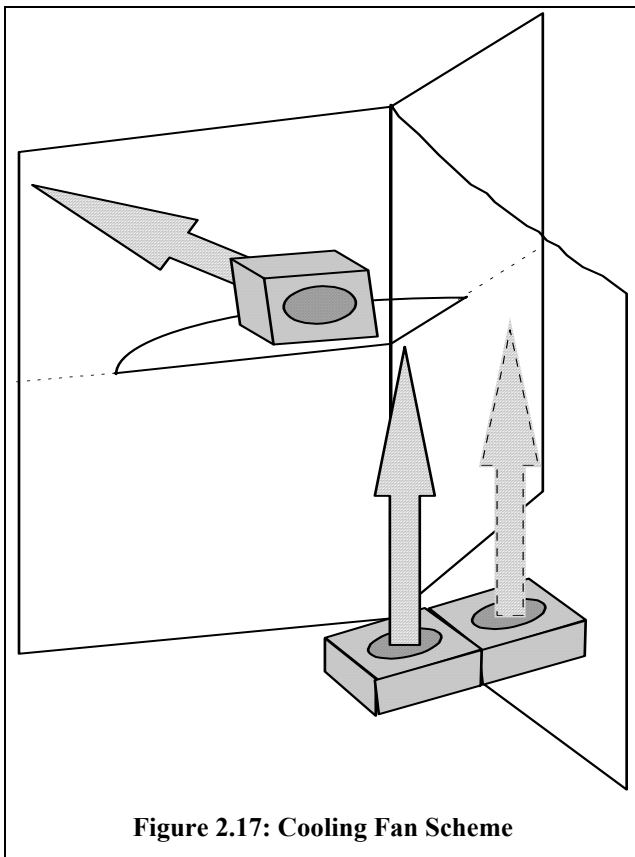


Figure 2.17: Cooling Fan Scheme

2.2.3 Heating and Cooling

G-056 utilizes heating tape to keep certain components warm during cold orbital phases. Such tape is benign and for mission success only. There is less than 10 meters of such tape.

G-056 also utilizes three small 0.8 Watt fans of dimension 8 cm by 8 cm by 2.5 cm to force convective cooling of various components for mission success only. Two fans are mounted directly to the superstructure and one is mounted to a small shelf, as seen in Figure 2.17.

2.2.4 Experiment Grounding

The payload is grounded to the EMP through two (2) of the 10-32 titanium bolts. This grounding path has an effective resistance within 2% of that of the same length of 18 gauge copper wire.

2.3 Materials

The G-056 materials list has been selected in accordance with JSC 09604. Structural

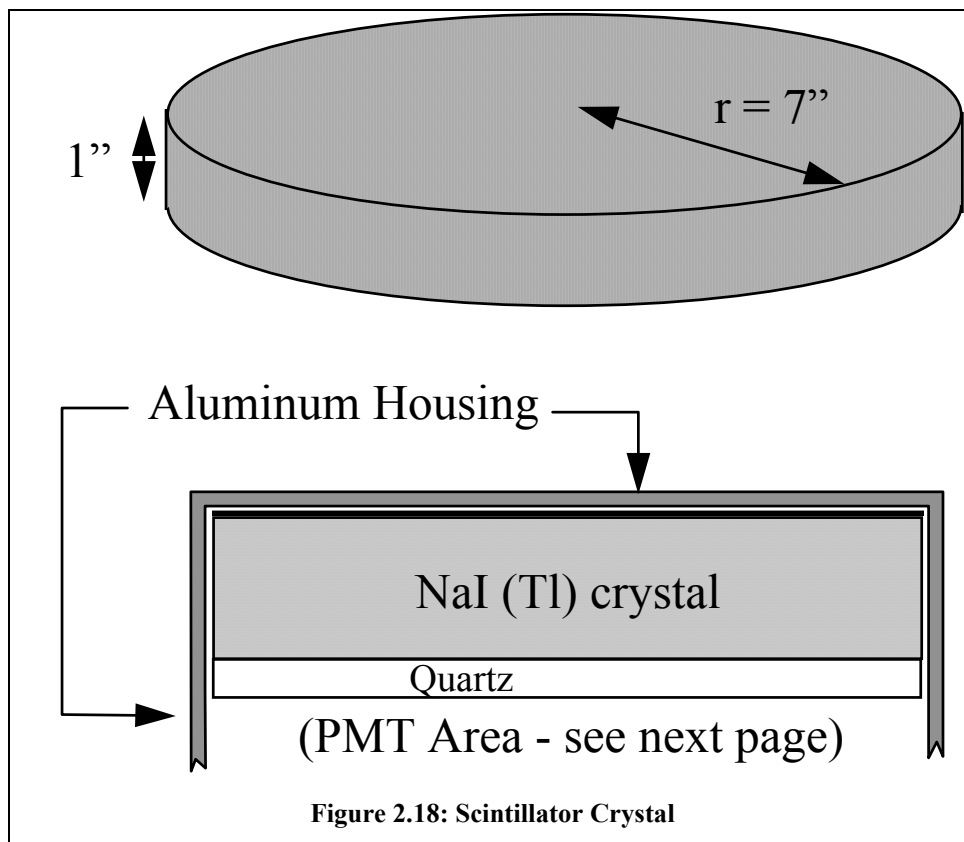
materials have been selected in accordance with MSFC-SPEC-522 to comply with Stress Corrosion Cracking (SCC) requirements. Structural fasteners have been selected in accordance with S-313-100 (GSFC Fastener Integrity Requirements). The materials used in G-056 have been assessed by NASA GSFC Materials Branch/Code 313 for compatibility with the GAS carrier system materials (seals, valves, electronics, and structures). The materials have also been assessed for compatibility within and among experiment subsystems. Materials exposed to the vacuum environment of space have been assessed for use in the Space Shuttle payload bay. All materials have been reviewed and approved for flight by the GSFC Materials Branch/Code 313.

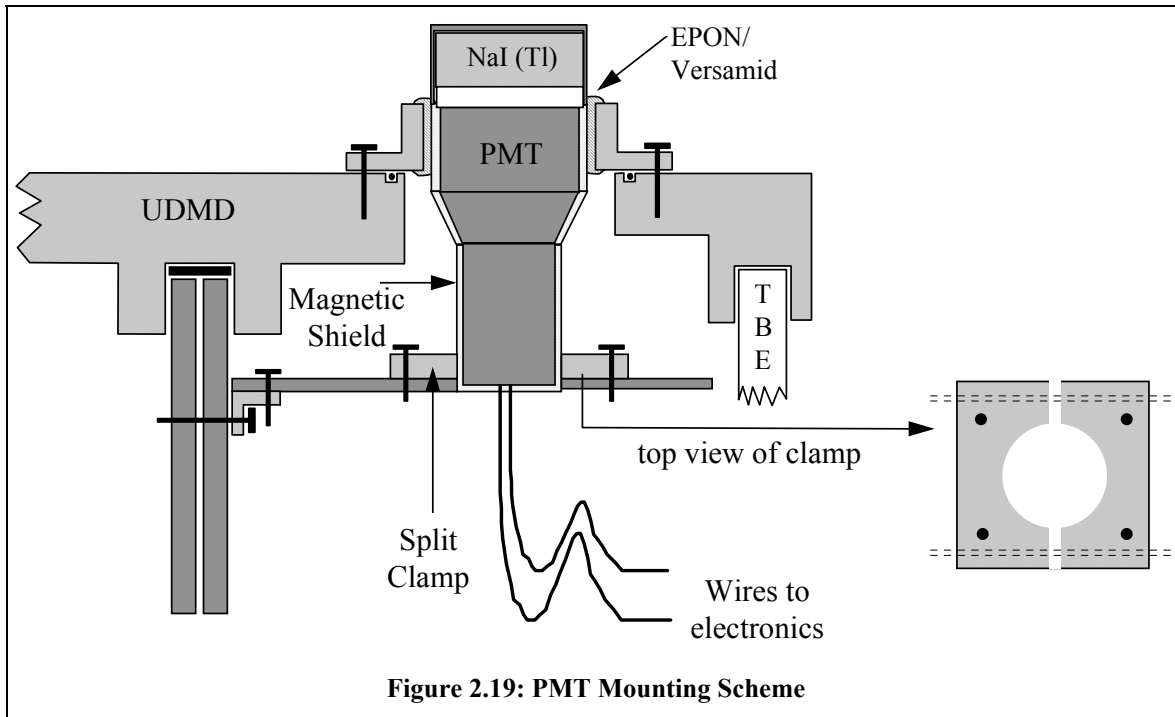
2.4 Gamma-Ray Burst Detector

The gamma-ray burst detector subsystem consists of two identical units. Each unit is made up of two basic components, the first of which is a NaI(Tl) scintillator.

2.4.1 NaI (Tl) Scintillator

The scintillator is a cylindrical component. (It is a cylinder of 5 inch radius and 1 inch height.) This is bounded on the top, sides, and part of the bottom by a barium sulfate based paint coated 6061-T6 aluminum housing and on the bottom by a 0.236 inch thick quartz optical window (see Figure 2.18). The aluminum is in place to prevent light that is created by the scintillation process from being absorbed by the surroundings. The optical window allows this light to be transmitted to PMT. The scintillator is integrally assembled to the PMT shield (see below) by the manufacturer.





2.4.2 Photo-Multiplier Tube (PMT)

The second major component is a head-on type photo-multiplier tube (PMT). The tube is encased in a magnetic shield made of high permeability permalloy (Ni 78%, Fe and others 22%) and this case is integrally assembled by the manufacturer to the crystal housing described earlier. The PMT is connected to processing electronics and an analog-to-digital (A/D) converter, and operates at an anode to cathode voltage of up to 1360 VDC and at a maximum anode current of 0.1 mA. The magnetic shield is secured by a 6061-T6 aluminum compression clamp, which is in turn bolted (using titanium bolts) to a 6061-T6 aluminum shelf which attaches to the superstructure, as depicted in Figure 2.19. This attachment mechanism secures both the PMT (which is secured to the inside of the shield by the manufacturer) and the shield itself.

2.5 Avalanche Photo-Diode (APD)

In addition to the Gamma-Ray Detectors discussed in Section 2.4, G-056 includes two (2) Avalanche Photo-Diodes (APDs) in order to detect X-rays coincident with gamma-ray bursts. The APDs are solid-state, silicon-based detectors with surface area of 1 cm² each. They are mounted near the center of the space-facing side of the UDMD with a small split-clamp. Like the PMTs, they are connected to processing electronics and an A/D converter. The APDs operate at an anode-to-cathode voltage of approximately 1360 VDC and consume minimal current.

2.6 Global Positioning Satellite Unit

G-056 contains a global positioning satellite receiver to provide accurate position and time data in-flight. This is a variant of a standard 6-channel GPS sensor, modified to suit the high velocity Space Shuttle environment. The system consists of an antenna (4 inch square, 0.75 inches thick) mounted atop the G-056 UDMD and a primary GPS board. The antenna is linked via coaxial cable to the primary GPS sensor board, mounted on the superstructure. The GPS signal frequency is 1575±1 MHz and the GPS board is shielded to prevent EMI. The board itself is almost identical to the standard 6-channel configuration with a few hardware and many software modifications. The GPS subsystem nominally consumes 2.00 Watts of power, at +5 VDC.

2.7 Optical Transient Camera (OTC)

The OTC consists of a standard 35 mm film camera with a standard lens and a 250 exposure data back. The camera rests on a thin ($\cong 0.125$ inch) piece of neoprene which rests on an aluminum shelf which is attached to the superstructure. The camera is secured with 6061-T6 aluminum clamps which bolt onto the aluminum shelf (see Figure 2.20). Additionally, the camera is secured on the side opposite the pictured aluminum clamps by a small bracket and screw which bolts into the tripod mounting hole (not pictured).

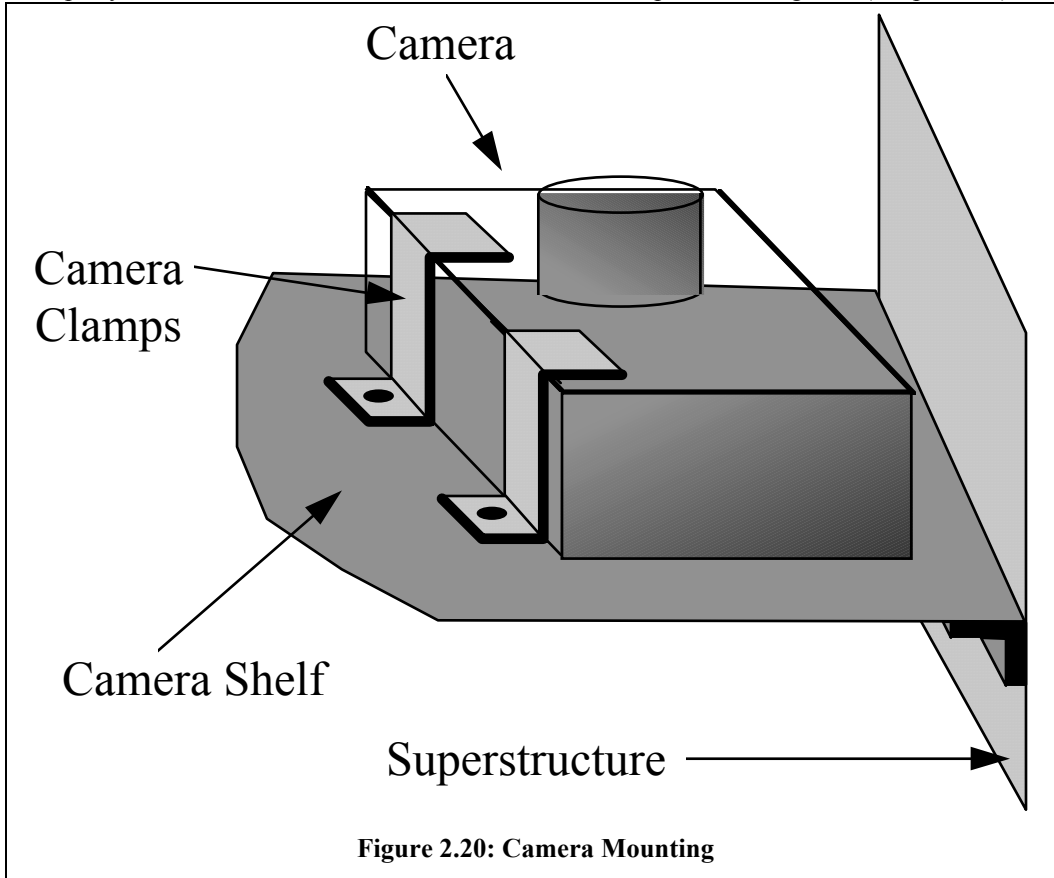


Figure 2.20: Camera Mounting

When the CPU detects a gamma-ray burst, it triggers the OTC to take several exposures ($\cong 1$ minute each). The film used is a standard 35mm film with a resolution of approximately 340 lines/mm. The OTC views space through the OQW (see Section 2.1.2.4).

The payload also utilizes two (2) Sun Sensors, which are mounted on top of the UDMD next to the Optical Quartz Window. These Sun Sensors, which utilize small silicon photodiodes, alert the CPU when the Sun is in the OTC's field of view. The CPU will close the OTC's shutter (or prevent it from opening) whenever a Sun Sensor detects light intensity greater than a threshold level for mission success purposes.

2.8 Charged Particle Detector (CPD)

As a veto for charged particle events which might otherwise appear to the Gamma-Ray Detectors to be gamma-ray bursts, G-056 includes a Charged Particle Detector (CPD). The CPD is a solid-state, silicon-based detector with an active area of 1 cm². It is mounted atop the space-facing side of the UDMD with EPON/Versamid. The CPD is connected to simple processing electronics. The CPD operates at a bias voltage of approximately 150 VDC and consumes minimal current.

2.9 Electronic Data System

The control and data storage system is distributed in several packages throughout the GAScan. These packages are shielded for EMI as feasible. Ribbon, twisted pair, and coaxial cable provide data links between the electronic boards. For a functional block diagram of the electronic data system, see Figure 1.1.

The primary circuit board consists of the Central Processing Unit (CPU). Nearby the CPU Board is the I/O Board, which receives data from the PMTs, APDs, CPD, and Sun Sensors. An Auxiliary I/O Board monitors the Temperature Sensors, Pressure Sensors, contains Flash RAM for non-volatile housekeeping data storage, contains relays for switching power to individual components for mission success only, and triggers the OTC. There is a separate electronics processing board for each of the PMTs, APDs, and the CPD, as well as a separate board which houses Static RAM for data buffering. The payload also contains the primary GPS board (interfaced to the CPU via an RS-422 interface) and five (5) Hard Disk Drives (HDDs) (interfaced to the CPU via a SCSI interface).

3. System Safety Assessment and Verification

3.1 Safety Assessment

Three (3) areas of concern with regard to flight have been identified for this payload. They are associated with: structural failure, battery hazards, and electromagnetic interference. This payload is classified as “Class B” in accordance with the policy set forth in JSC Letter TA-91-029.

3.1.1 Energy Containment Analysis Summary

This experiment includes stored energy in the batteries that is dissipated through electrical devices and the experiment coolers (three small 0.8 Watt fans). The experiment fans are required for mission success only. Hazard Report G-056-1 documents the hazards routinely associated with the failed experiment structure for opening door payloads. The G-056 experiment is contained within a sealed GAS canister that utilizes the NASA GSFC Standard Door Assembly (SDA) hardware. The G-056 experiment support structure is in accordance with GSFC S-313-100, GSFC Fastener Integrity Requirements and are secured with positive retention devices. The hazards routinely associated with batteries are assessed in the power system design as documented in Hazard Report G-056-2. G-056 has been analyzed with respect to Electro-Magnetic Interference (EMI) and Hazard Report G-056-3 documents the hazards associated with EMI. The G-056 canister internal environment will remain inert throughout the Space Shuttle mission..

The worst thermal case for the G-056 experiment would be for all electrical components to “fail on” while in a HOT Space Shuttle attitude. In total, this represents only 54W of power dissipation on a continual basis until battery depletion and requires a failure of all control devices in the experiment. Transient thermal analysis shows that the GAS canister steady state temperature under these worst case conditions would be 87°C (Thermal analysis has also shown that the effects of localized hot spots would be negligible since the maximum power is relatively small and the batteries are thermally isolated. Localized subsystem temperatures, including the battery box, will remain at less than 85°C) and the associated GAS canister pressure would be 1.20 atmospheres. This means the GAS canister would remain sealed because the canister is relieved by 2 and 3 atmosphere pressure relief valves. The thermal analysis has assumed a 63 hour (time of battery depletion) sun point which is not possible for the Space Shuttle. After 6 hours of sun

pointing with 54 W of power dissipation, the canister internal temperature is less than 47°C. After 12 hours, it is less than 54°C, and after 24 hours, less than 65°C. Therefore, the contained experiment design includes controls for hazards to mission success, however, no manifestation of any experiment control failure presents a safety threat to the Space Shuttle or crew.

3.1.2 Stress Analysis Summary

The structural members of the payload have been verified for flight worthiness as documented in the Structural Analysis. Fracture control practices are compliant to GSFC 731-0005-83B. Analysis has verified that the first natural frequency of the payload is higher than 35 Hz. Appropriate limit loads incorporating an ultimate factor of safety of 2.0 were used for the design of G-056 hardware, and show positive margins. Structural fasteners have been selected in accordance with S-313-100 (GSFC Fastener Integrity Requirements). The materials used were suitable for the applications, and conform to MSFC-SPEC-522B (Table I) and MSFC-HDBK-527. The documentation associated with structures (analyses, testing and materials) has been submitted, reviewed, and approved by NASA/GSFC.

3.1.3 Structural Containment Analysis Summary

This experiment is contained completely by a user-supplied lid, referred to as the UDMD. An analysis was performed to ensure that the UDMD would comply with GSFC 731-0005-83B. The analysis uses the Thompson and Punch equations to determine the maximum travel distances needed for “worst-case” projectiles to penetrate the UDMD. The safety factors calculated are tabulated below, and are all in excess of 2.0. This, along with the arguments presented in the Report, indicates that no penetration of any parts through the UDMD is possible, and that G-056 is contained as required by GSFC-731-0005-83B.

Table 3-1: Safety Factors for Penetration Through UDMD

Projectile	Thompson Equation			Punch Equation		
	Distance Needed	Maximum Possible Distance	Safety Factor	Distance Needed	Maximum Possible Distance	Safety Factor
Case 1	69.2 in	26.5 in	2.61	79.2	26.5 in	2.99
Case 2	290.0 in	26.5 in	10.9	159.8	26.5 in	6.03

Table 3-2: Safety Factors for Penetration Through Scintillators

Projectile	Thompson Equation			Punch Equation		
	Distance Needed	Maximum Possible Distance	Safety Factor	Distance Needed	Maximum Possible Distance	Safety Factor
Case 1	307.7 in	26.5 in	11.6	70.4	26.5 in	2.66
Case 2	1287.2 in	26.5 in	48.6	142.1	26.5 in	5.36

3.2 Hazard Assessment

Hazard assessments in accordance with NSTS 1700.7B within the context of the integrated G-056/GAS Carrier system are included for the following items: structural, electrical, and EMI. Credible hazards have been identified for the structural, electrical, and EMI subsystems and associated hazard reports have been generated.

3.2.1 Structure (Hazard Report G-056-1)

The following potential hazard causes have been identified related to a “Failure of Experiment Support Structure”:

1. The structural design of the superstructure or the BCS might be inadequate to withstand the STS launch and landing environments.
2. The structural materials selected for use in the G-056 payload may not be appropriate.
3. Any defects or flaws that might be present in the experiment structure could propagate to failure.

The following controls have been imposed to prevent the above potential hazards:

1.
 - (a) The experiment support structure has been designed such that the fundamental frequency of the experiment about any axis is at least 35 Hertz.
 - (b) The experiment support structure has been designed to an ultimate Factor of Safety of 2.0 over the appropriate limit loads with positive margins of safety.
2. The structural materials selected for use in G-056 have been selected in accordance with the stress corrosion requirements of MSFC-SPEC-522B, Table I.
3. The experiment support structure was designed in accordance with GSFC 731-0005-83, Rev. B., General Fracture Control Plan for Payloads Using the STS. All elements of the payload are either of low released-mass, contained, or fail-safe, and therefore are non-fracture critical.

3.2.2 Electrical (Hazard Report G-056-2)

The following potential hazard causes have been identified related to a “Rupture of 190 Duracell D-size Cells”:

1. A short circuit in the payload might produce an overcurrent.
2. Hydrogen and oxygen might evolve in the presence of an ignition source.
3. Electrolyte might leak from the cells.
4. Cell reversal might occur due to circulating currents.

The following controls have been imposed to prevent the above potential hazards:

1.
 - (a) In accordance with JSC 20793, the negative ground leg of each string is fused to protect the battery from an overcurrent condition.
 - (b) The Battery Containment System (BCS) is non-conductive, as it is made of PVC, Polycast acrylic, CV-1142, and EPON/Versamid.
2.
 - (a) Cells are contained in a sealed Battery Containment System (BCS), which has been proof pressure tested to 22.5 psi.
 - (b) The BCS is redundantly vented overboard using 15.0 psig valves.
 - (c) The BCS is purged with a nitrogen/carbon dioxide mixture.

- (d) The BCS is contained in a sealed GAScan that is purged with a nitrogen/carbon dioxide mixture.
- 3. The BCS (PVC, Polycast acrylic, CV-1142, and EPON/Versamid) is inert to KOH electrolyte.
- 4. Parallel cell strings are diode isolated with Shottky diodes to prevent circulating currents.

The GPS board, which contains four (4) Zinc/Silver Oxide button cells, is isolated from the main power supply to protect against reverse charging current. The on-board clock also utilizes four Zinc/Silver Oxide backup cells, which are also isolated from the main power supply.

3.2.3 EMI (Hazard Report G-056-3)

EMI is a concern with this experiment since the experiment is contained in a GAS canister that utilizes SDA. The experiment was designed to minimize EMI such that the sources are low level and low frequency. An EMI test will be performed to verify that radiated fields are well within the levels set in ICD-2-19001. The concerns associated with the radiation subsystem are associated with the possibility of electromagnetic interference caused by the power supply or control circuitry. To prevent EMI, all circuit boards are shielded with Faraday cages and twisted wire pairs are employed where feasible.

3.3 Hazard Control Verification

The hazard solutions for credible hazards detailed in Section 3.2 have been verified in the following manner:

3.3.1 Structure (Hazard Report G-056-1)

The hazard controls cited in Section 3.2.1 have been verified as follows:

- 1.
 - (a) A vibration analysis of the payload support structure has been performed and reviewed by GSFC.
 - (b) A stress analysis of the payload support structure has been performed, and reviewed and approved by GSFC.
- 2. The GSFC Materials Branch (Code 313) has reviewed and approved the G-056 Materials List.
- 3. A structural containment analysis of G-056 has been performed, and reviewed and approved by GSFC. This analysis verified that in the event of experiment structure failure the payload is contained by the UDMD and the 5.0 cubic foot GAScan (even with SDA open).

3.3.2 Electrical (Hazard Report G-056-2)

The following verification methods have been employed to verify the hazard controls cited in Section 3.2.2.

- 1.
 - (a) Fusing has been evaluated by GSFC design review (see Figure H/R#G-056-2-1)
 - (b) The suitability of PVC, Polycast acrylic, CV-1142, and EPON/Versamid as non-conductive has been evaluated by GSFC design and material reviews.
- 2.
 - (a) A proof pressure test of the BCS has been conducted.
 - (b) A standard PRV refurbishment checkout will be performed.
 - (c) The BCS will be purged with a nitrogen/carbon dioxide mixture by GSFC Field Operations personnel and will be tracked on the Verification Tracking Log (VTL).
 - (d) The GAScan will be purged with a nitrogen/carbon dioxide mixture by GSFC Field Operations personnel and will be tracked on the VTL.

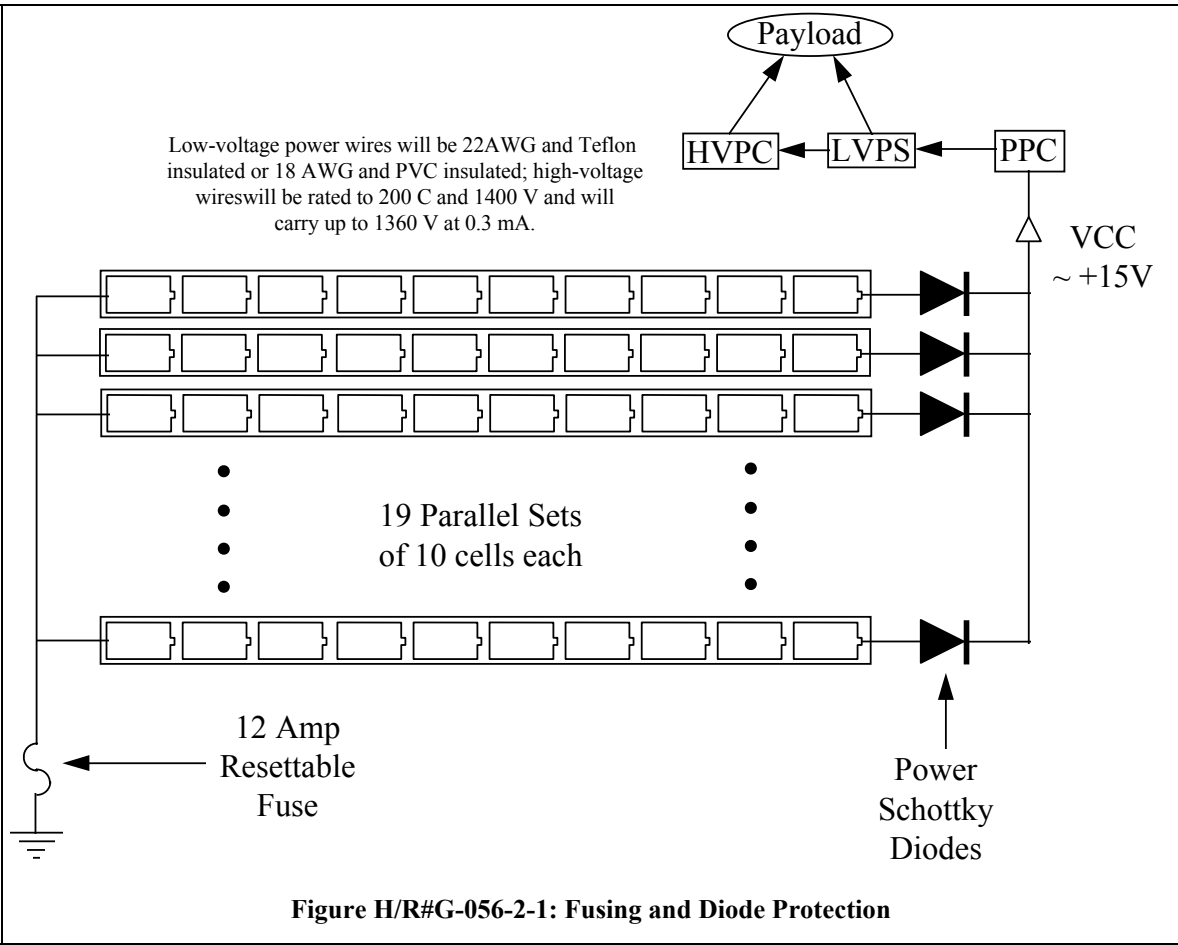
3. The suitability of PVC, Polycast acrylic, CV-1142, and EPON/Versamid as inert to KOH electrolyte has been evaluated by GSFC design review.
4. The protection scheme for circulating currents has been evaluated by GSFC design review (see Figure H/R#G-056-2-1).

3.3.3 EMI (Hazard Report G-056-3)

An EMI test will be done prior to integration and documented on the Verification Tracking Log (VTL) to verify compliance with ICD-2-19001.

PAYLOAD HAZARD REPORT		No. G-056-1
PAYLOAD G-056		PHASE III
SUBSYSTEM Structures	HAZARD GROUP Collision	DATE 1/27/95
HAZARD TITLE Failure of Experiment Support Structure		
APPLICABLE SAFETY REQUIREMENTS		HAZARD CATEGORY
NSTS 1700.7B: 206 Failure Propagation; 208.1 Structural Design		Catastrophic
208.2 Emergency Landing Loads; 208.3 Stress Corrosion		X Critical
DESCRIPTION OF HAZARD During launch/landing operations, the experiment support structure fails resulting release of the experiment.		
HAZARD CAUSES		
<ol style="list-style-type: none"> 1. Inadequate structural design for launch and landing environment. 2. Improper materials selection. 3. Defects or flaws assumed to be present in the experiment structure propagate to failure. 		
HAZARD CONTROLS		
<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> (a) Fundamental frequency of experiment about any axis ≥ 35 Hz. (b) Experiment support structure designed to an ultimate Factor of Safety of 2.0 over appropriate limit loads with positive margins of safety. 2. Materials selected in accordance with stress corrosion requirements of MSFC-SPEC-522B, Table I. 3. The structure was designed in accordance with GSFC 731-0005-83, Rev. B, General Fracture Control Plan for Payloads Using the STS. All payload elements are either low released mass, contained, or fail-safe; therefore non-fracture critical. 		
SAFETY VERIFICATION METHODS		
<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> (a) Vibration Analysis. (b) Structural Analysis. 2. GSFC Materials Branch (Code 313) review. 3. Fracture Control Analysis. 		
STATUS OF VERIFICATION		
<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> (a) Open. (b) Open. 2. Open. 3. Open. 		
PHASE III	GAS P/L Manager	GAS Safety Officer
APPROVAL	GAS Project Manager	STS

PAYLOAD HAZARD REPORT		No. G-056-2
PAYLOAD G-056		PHASE III
SUBSYSTEM Electrical	HAZARD GROUP Explosion/Corrosion	DATE 3/28/95
HAZARD TITLE Rupture of 190 Duracell D-size Cells		
APPLICABLE SAFETY REQUIREMENTS		HAZARD CATEGORY
NSTS 1700.7B: 206 Failure Propagation; 208.5 Sealed Compartments, 213 Electrical Systems; 209 Materials, 219 Flammable Atmospheres		Catastrophic
		X Critical
DESCRIPTION OF HAZARD Rupture of 190 battery cells and the release of battery electrolyte.		
HAZARD CAUSES		
<ol style="list-style-type: none"> 1. Battery overcurrent/short circuit. 2. Evolution of hydrogen and oxygen in the presence of an ignition source. 3. Electrolyte leakage. 4. Cell reversal. 		
HAZARD CONTROLS		
<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> (a) In accordance with JSC 20793, the negative ground leg of each string is fused to protect the battery from an overcurrent condition. The fusing also meets the wire/fuse criteria of TA-92-038. (b) Battery Containment System (BCS) interior (PVC, Polycast acrylic, CV-1142, and EPON/Versamid) is non-conductive. 2. <ol style="list-style-type: none"> (a) Batteries are contained in a sealed BCS (proof pressure tested to 22.5 psi). (b) BCS is redundantly vented overboard using 15.0 psig valves. (c) BCS purged with nitrogen/carbon dioxide mixture. (d) Contained in sealed GAS canister that is purged with nitrogen/carbon dioxide mixture. 3. BCS internal surface (PVC, Polycast acrylic, CV-1142, and EPON/Versamid) is inert to KOH electrolyte. 4. Parallel cell strings are diode isolated. 		
SAFETY VERIFICATION METHODS		
<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> (a) Design Review (see electrical schematic Figure H/R#G-056-2-1). (b) Design Review; Materials review. 2. <ol style="list-style-type: none"> (a) Proof pressure test of BCS. (b) Standard PRV refurbishment checkout. (c) Battery box purged with nitrogen/carbon dioxide by GAS Field Operations personnel. (d) GAS can purged with nitrogen/carbon dioxide by GAS Field Operations personnel. Standard Sealed GAS Canister Assembly/Integration Procedure. 3. Design Review. 4. Design Review (see electrical schematic Figure H/R#G-056-2-1). 		
STATUS OF VERIFICATION		
<ol style="list-style-type: none"> 1. (a) Open. (b) Open. 2. <ol style="list-style-type: none"> (a) Open. (b) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS37-300-11). (c) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS CAN-08-011). (d) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS CAN-08-011). 3. Open. 4. Open. 		
PHASE III APPROVAL	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS



PAYLOAD HAZARD REPORT		No. G-056-3
PAYLOAD G-056		PHASE III
SUBSYSTEM Electrical	HAZARD GROUP Nonionizing Radiation	DATE 1/27/95
HAZARD TITLE Electromagnetic Interference (EMI)		
APPLICABLE SAFETY REQUIREMENTS		HAZARD CATEGORY
NSTS 1700.7B: 212.2 Nonionizing Radiation		<input type="checkbox"/> Catastrophic
		<input checked="" type="checkbox"/> Critical
DESCRIPTION OF HAZARD Emission of electromagnetic radiation interferes with Space Shuttle and/or other payload systems.		
HAZARD CAUSES		
1. Radiated or conducted EMI from G-056 caused by electrical switching and/or equipment operation.		
HAZARD CONTROLS		
1. All sources shielded and grounded in accordance with ICD-2-19001. MIL-STD-462 will also be used as technical reference.		
SAFETY VERIFICATION METHODS		
1. EMI test to verify compliance with ICD-2-19001.		
STATUS OF VERIFICATION		
1. Open.		
PHASE III APPROVAL	GAS P/L Manager	GAS Safety Officer
	GAS Project Manager	STS

4. Ground Safety

The objective of this section is to describe the ground safety aspects of G-056 Ground Support Equipment (GSE) and operations.

4.1 Payload GSE Description

4.1.1 Basic GSE

The GSE includes basic tools such as wrenches, screwdrivers, pliers, personal computers, oscilloscopes, multimeters, pulse generators, low voltage power supplies, an HP-IB interface, hand-held calculators, and possibly custom-designed testing circuitry. UL and CSA (Canadian equivalent) listings are tabulated below. No high voltage will be supplied to the payload during ground operations, although the payload's internal HVPC will generate high voltage inside the sealed GAScan.

Table 4-1: Listings for GSE

Compaq Comtura Laptop Computers	UL 63H0
Fluke 79 Multimeter (hand-held)	UL 950Z
Hewlett-Packard Low Voltage Power Supply	CSA LR 85750C
Hewlett-Packard Multimeter	CSA LR 33773
Hewlett-Packard Oscilloscope	CSA LR 33772
Hewlett-Packard Pulse Generator	CSA LR 53538C
Soldering Station	UL 776Z

4.1.2 Power Requirements

The electrical power required for all experiment GSE can be satisfied by several standard 15 Amp, 110 VAC outlets and internal experiment batteries.

4.2 Ground Operations

4.2.1 Location

All ground support operations will take place in the GAS preparation area.

4.2.2 Description of Operations

After experiment installation, the container will be pressurized for the purpose of leak testing. Pressurization of no more than 4 psig for no more than 20 hours will be permitted by the customer. The customer plans to electronically calibrate the on-board real-time clock and perform other electronic and software diagnostics at KSC. All expected contact with the payload at KSC will be through NASA supplied experiment electronics interfaces (such as the J400), and no physical manipulation of the payload is anticipated. The customer plans to test opening and closing of the SDA no more than three (3) times. The exact testing timeline is given in Table 4.2 below.

Table 4-2: Testing Timeline for G-056 at KSC

Operation Description	Min. Time Needed	Expected Time	Max. Time Needed
Testing of PMTs	0:10	0:20	0:45
Testing of Camera	0:05	0:10	0:30
Testing of APDs	0:10	0:20	0:45
Testing of CPD	0:10	0:25	1:00
Testing of SDA	0:05	0:15	0:30
Testing of Heating Tape	0:15	0:30	1:30
Testing of Experiment Fans	0:10	0:15	0:30
Testing of Hard Drives	0:30	0:45	1:45
Testing of CPU/Software	0:20	1:45	6:00
Testing of Static RAM Buffer	0:10	0:20	1:00
Testing of Sun Sensors	0:10	0:15	0:30
Testing of GPS	0:10	0:15	0:30
Testing of LVPS and HVPC	0:10	0:25	0:45
TOTALS	2:35	6:00	16:00

4.2.3 Condition of Experiment when Delivered to KSC

The experiment will be delivered to KSC fully assembled and sealed.

4.3 Ground Safety Assessment and Verification

A safety assessment for ground hazards has been completed and assessed against KHB1700.7B. There have been no credible hazards identified for the G-056 experiment. Material Safety Data Sheets (MSDS's) have been forwarded to the Launch Sight Support Manager (LSSM) at KSC.