Critical Design Review

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Mechanical Presentation Outline

- **Mechanical Requirements**
- **Configuration**
  - **Launch and Orbit Views**
  - **Launch Vehicle Interfaces**
  - **Instruments and Sensors, Optical Bench**
  - **Deck Layouts, Package Locations, etc.**
- **Spacecraft Structure**
  - **Primary Structure Description**
  - **Secondary Structure**
- **Solar Arrays**
  - **Requirements and Design**
  - **Testing and Qualification**
  - **Status**

Mechanical Requirements

- **Satisfy Instrument and Sub-System Interface Requirements**
- **Satisfy Instrument Clear Field of View Requirements**
- **Satisfy Instrument Stability Requirements**
- **Interface to Boeing Delta 2 7920-10 Launch Vehicle and fit within the Dual Payload Attach Fitting (DPAF) envelope**
- **Minimize all Mechanical Systems Cost and Mass**
- **Provide a Solar Array system that meets Mission Requirements**
- **Provide a system that can safely handle and transport the Spacecraft**

Changes from PDR

- **Configuration**
  - **Launch Vehicle (Taurus and DeltaII options held open, baseline is now DeltaII, 7920-10)**
    - **> Payload Adapter Fitting (PAF)**
    - **> Purge connection**
    - **> Umbilical disconnect**
  - **Reaction wheels relocated**
  - **Various packages relocated due to design maturity and size and mass increases**

Changes Since PDR

- **Structure**
  - **Magnesium replaces Aluminum where possible (mass)**
  - **Spools (deck fasteners) substituted for potted inserts where package mass increased and/or limited number of mounting feet increased local loading**
- **Solar Arrays**
  - **Low shock separation nut vs. Pin Puller**
  - **Array inclination change from 30 to 20 degrees**
  - **Negator spring (yoke) vs. torsion spring**
  - **4 point flexure support vs. 6 point rigid (over constrained) mount**
  - **Cells reversed to opposite substrate side**
  - **Instrumented bolt substituted for load cell**
  - **Dual damper/torsion spring hinge Assy's per panel reduced to a 1 damper/hinge assembly and 1 pivot assembly per panel**
  - **Aluminum vs. composite face sheets**

Spacecraft Configuration

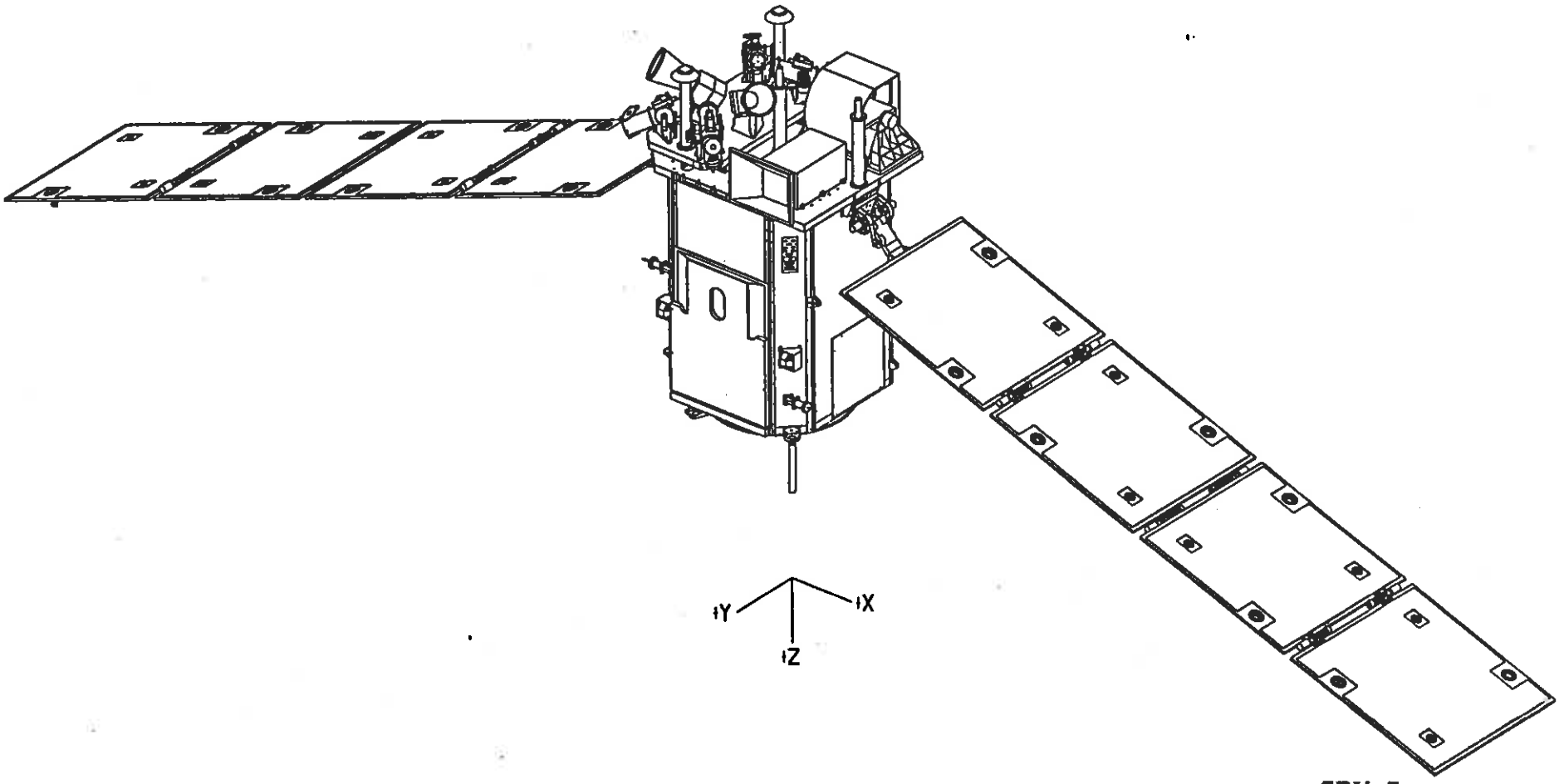
- **Spacecraft Orbit Views**
- **Launch Vehicle Interfaces**
- **Instruments and Sensors**
  - **Mechanical requirements placed upon the Spacecraft**
  - **SC Mechanical Interface Status**
  - **CFOV's**
  - **Optical Bench**
- **Sub-systems**
  - **Deck Layouts**

TIMED

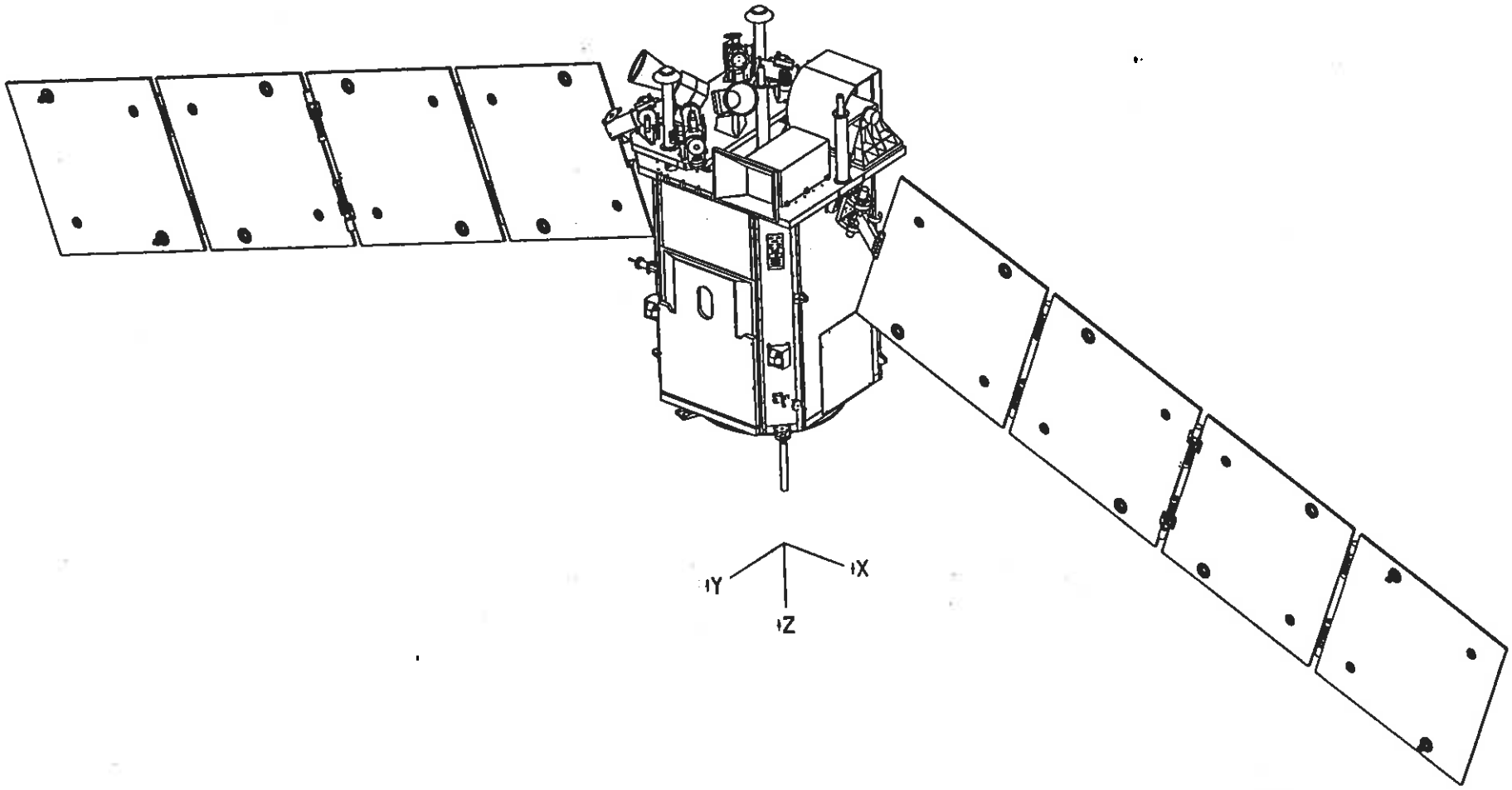
Critical Design Review

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

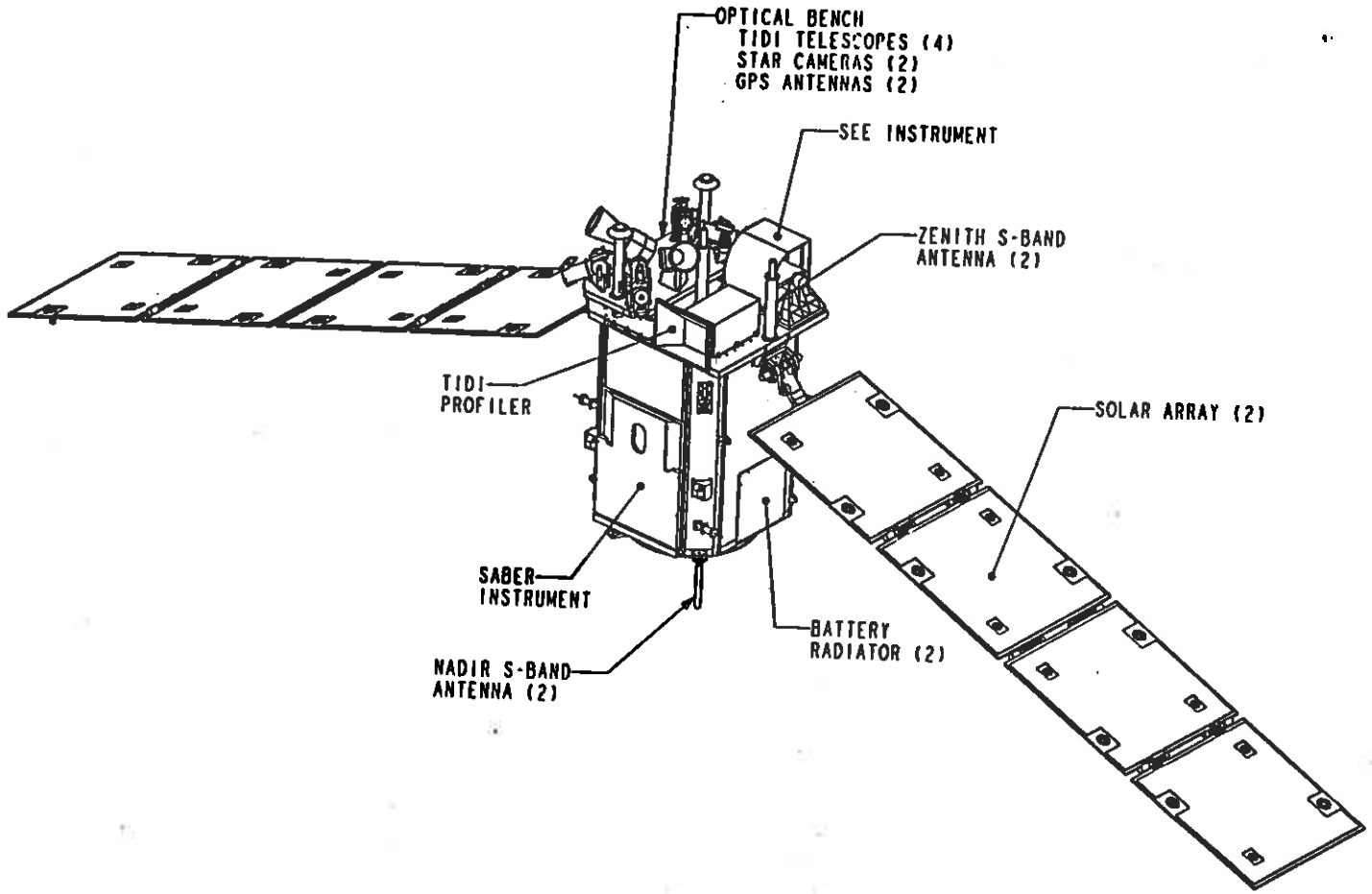
Spacecraft Configuration



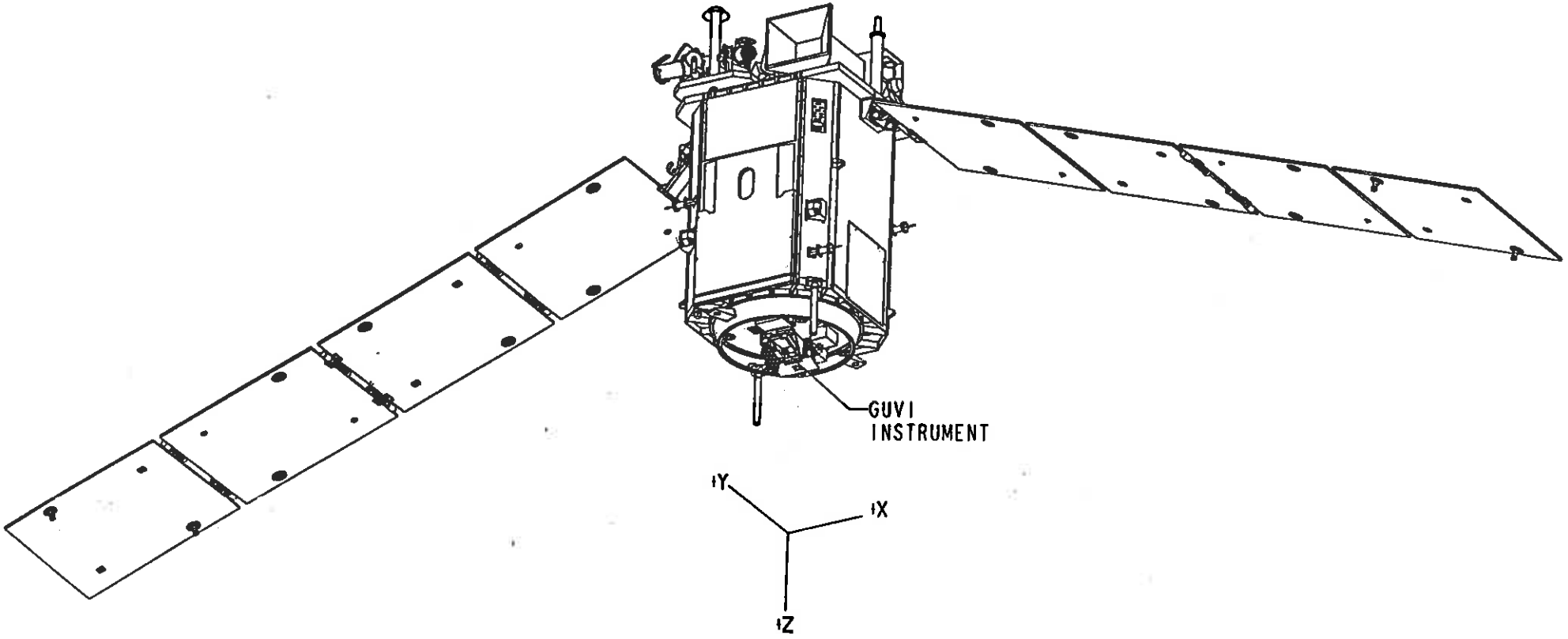
Spacecraft Configuration



Spacecraft Configuration



Spacecraft Configuration

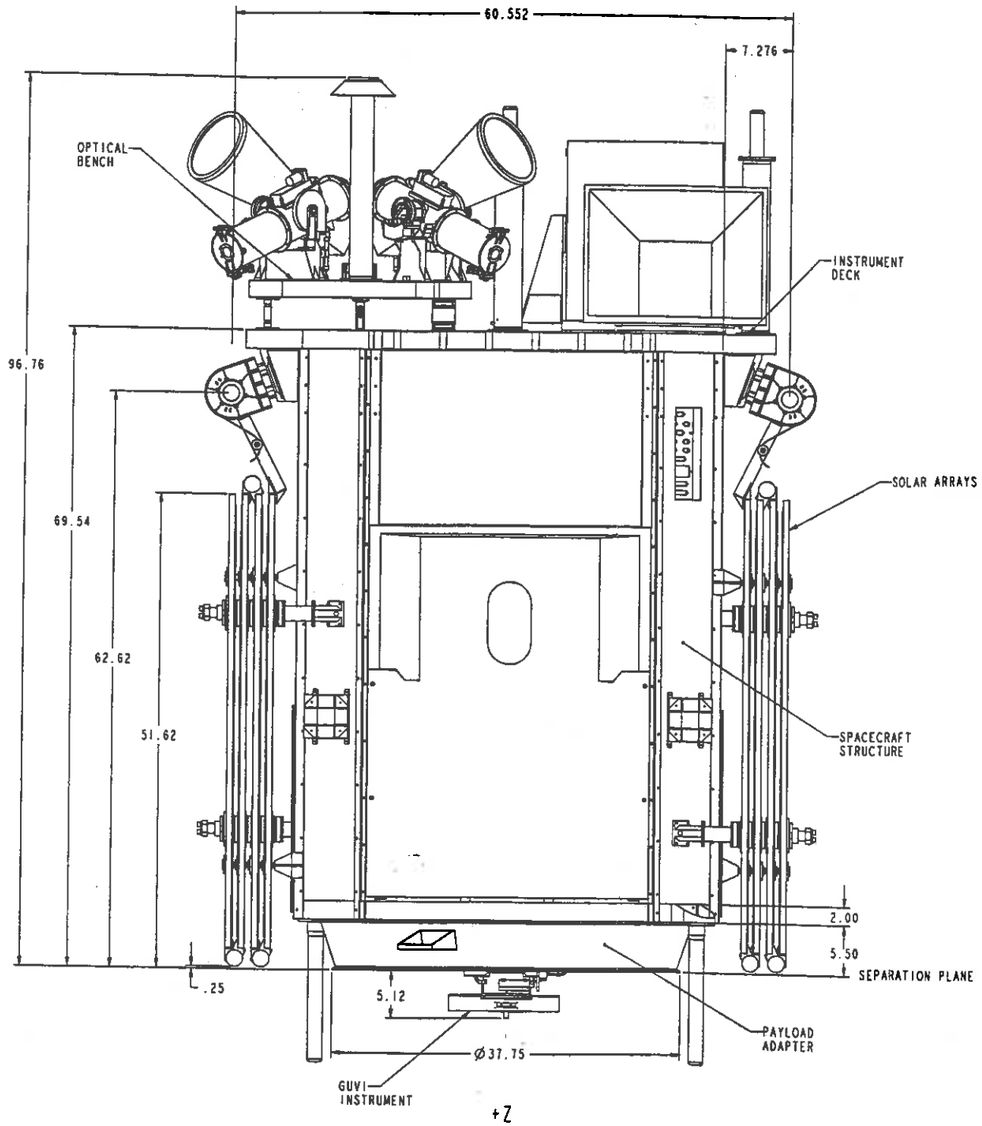


Launch Vehicle Interfaces

- **Requirements**
- **Spacecraft Launch Configuration**
- **Fairing**
- **Dual Payload Attach Fitting (DPAF)**
- **Payload Adapter Fitting (PAF)**
- **Status**

Launch Vehicle Interfaces

- **Requirements**
  - **Compatibility with the Boeing 7920-10 DeltaII LV**
  - **Interface to the Boeing 3712C PAF and separation system**
  - **T=0 GN2 purge for instruments**
  - **Mass less than 660 Kg.**
  - **Launch Configuration to fit within allowable DPAF envelops**
  - **Pad Access for arming plug removal**
  - **Contamination**
  - **T=0 Air Conditioning for battery**



INBOARD PROFILE
(View Looking at +Y)

NOTE:
FOR LAUNCH VEHICLE ENVELOPE AND INTERFACE DESCRIPTION, SEE SHEETS 2 & 3.

PRELIMINARY
11/6/97

APPLIED PHYSICS LABORATORY

INTERFACE CONTROL DRAWING

TIMED SPACECRAFT

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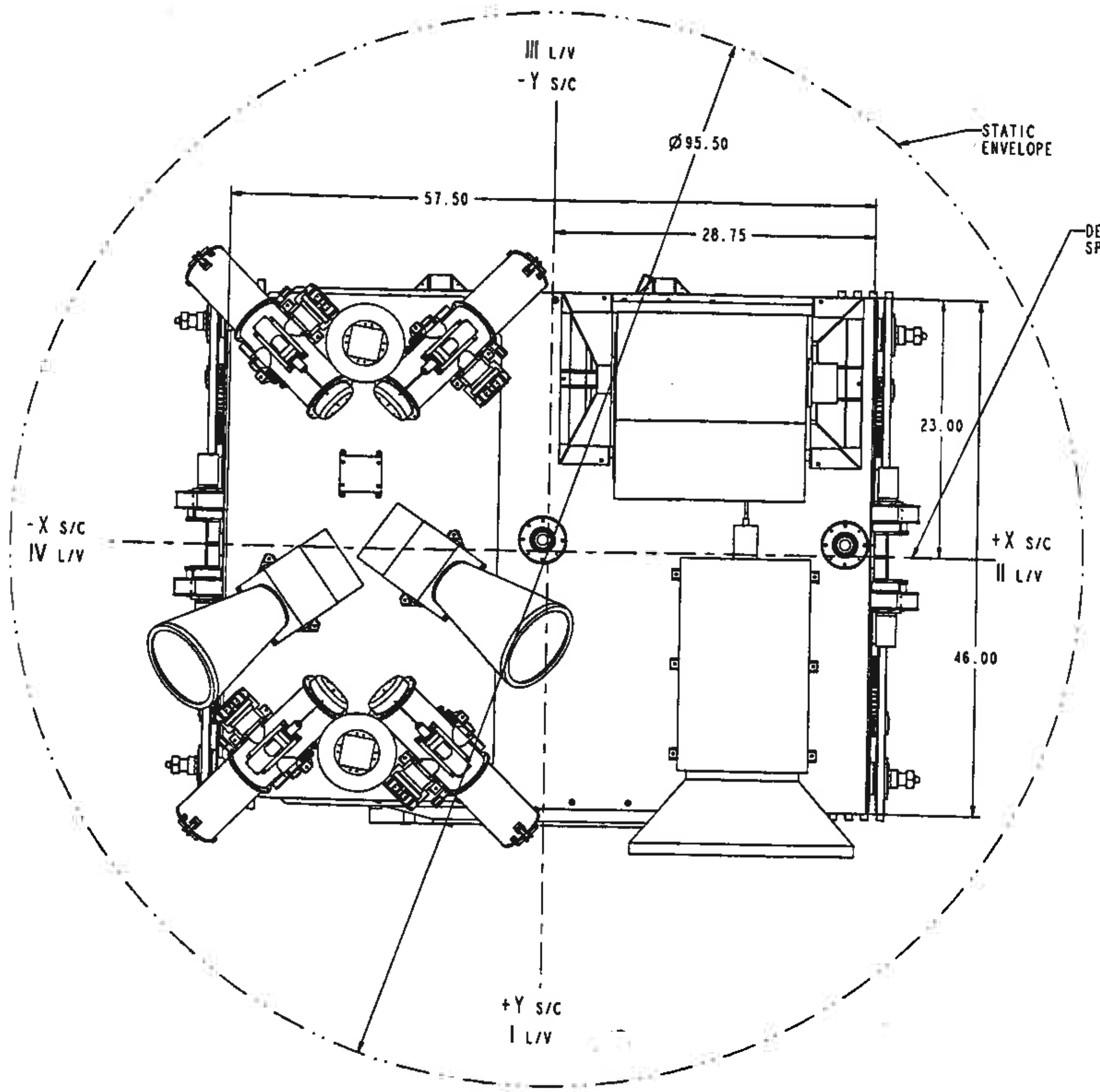
SCALE 1/5 MODEL

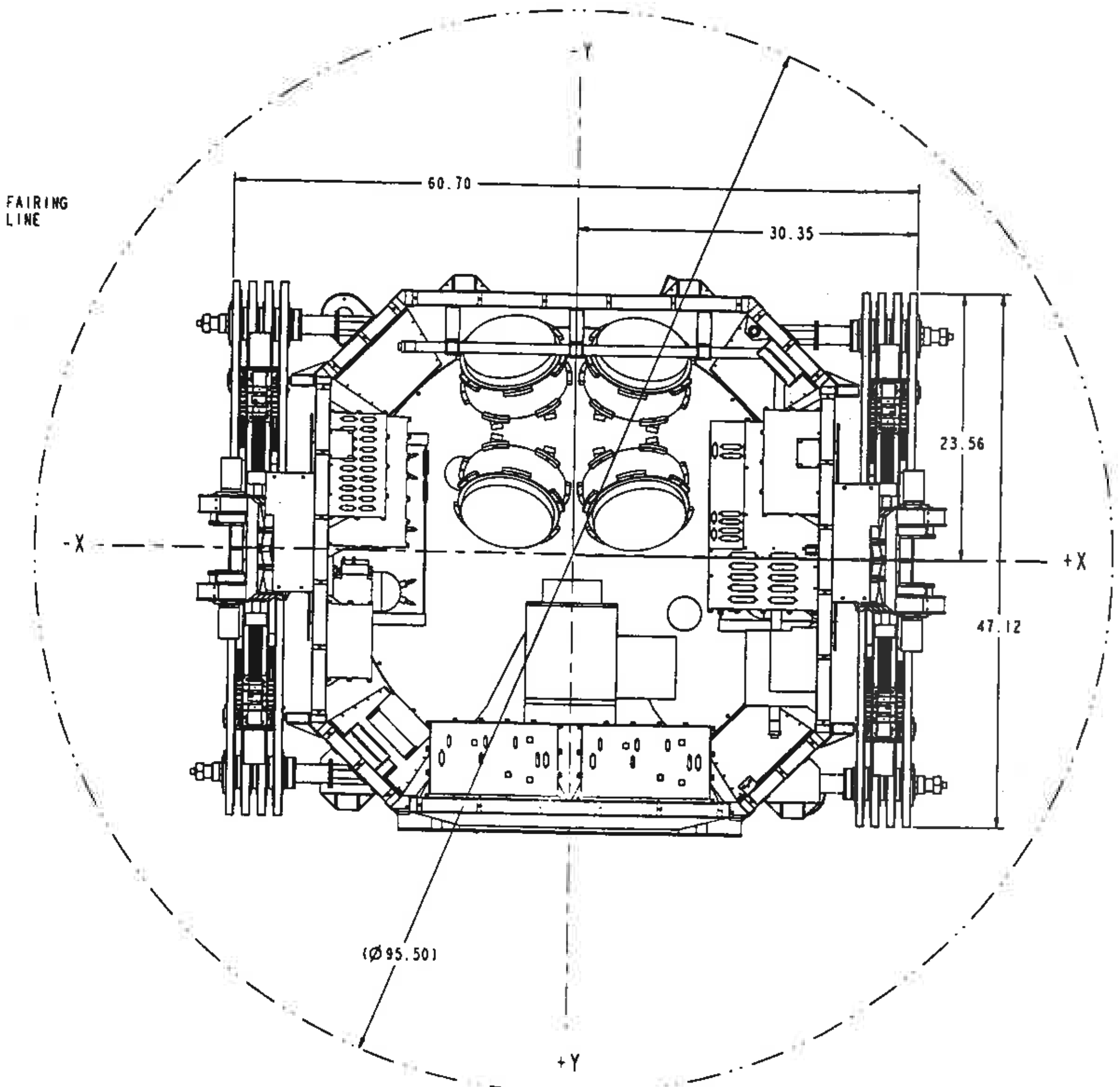
SHEET 3 OF 3

7363-0001

NOT ARCHIVED



TOP VIEW



TOP VIEW
W/ INSTRUMENT DECK REMOVED

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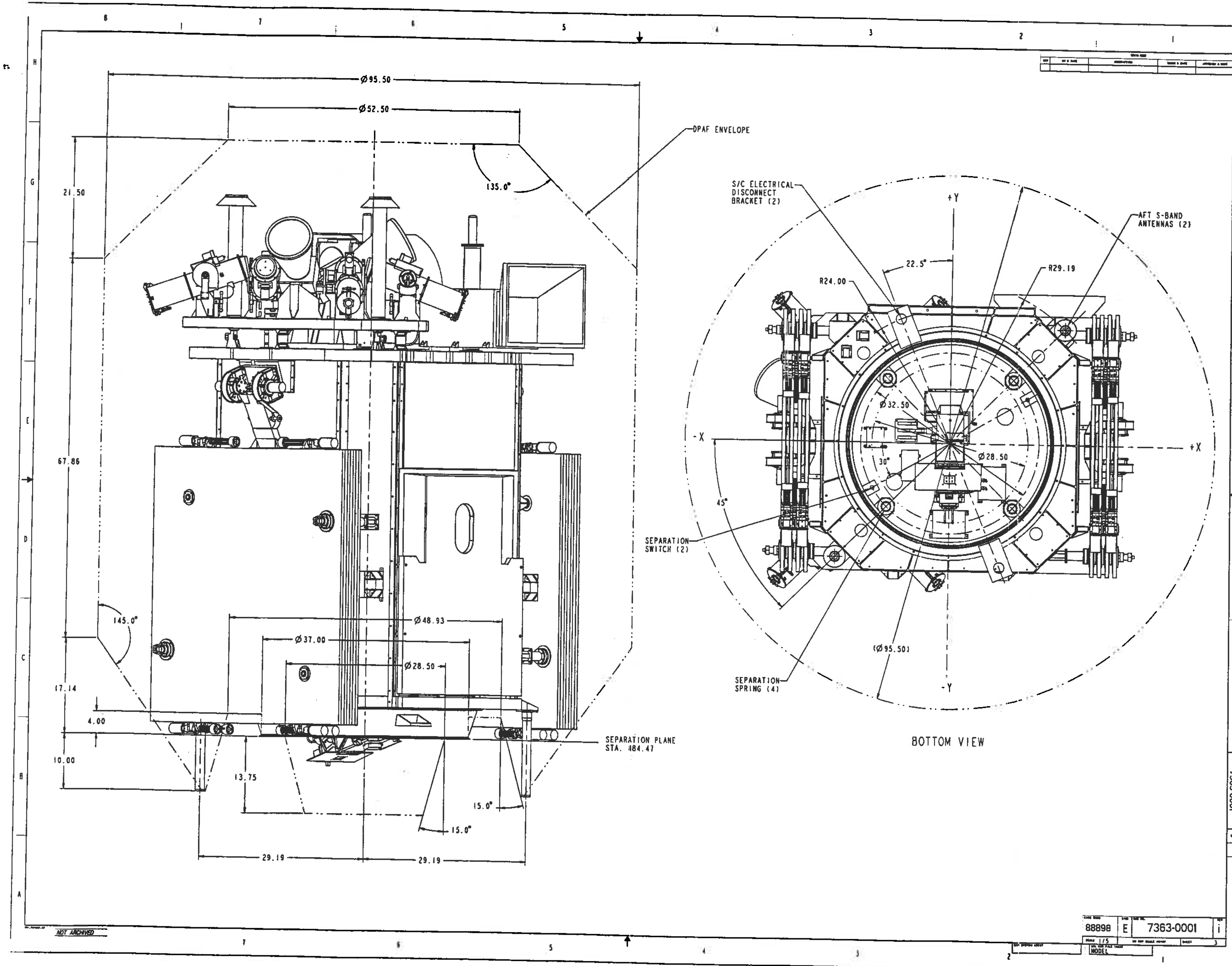
SCALE 1/5 SHEET 2

MODEL

7363-0001 2



Ø95.50
Ø52.50
DPAF ENVELOPE
135.0°
21.50
67.86
145.0°
Ø48.93
Ø37.00
Ø28.50
17.14
4.00
10.00
13.75
15.0°
15.0°
29.19
29.19
SEPARATION PLANE
STA. 484.47
S/C ELECTRICAL
DISCONNECT
BRACKET (2)
+Y
AFT S-BAND
ANTENNAS (2)
22.5°
R24.00
R29.19
Ø32.50
-X
+X
Ø28.50
30°
45°
SEPARATION
SWITCH (2)
(Ø95.50)
SEPARATION
SPRING (4)
-Y
BOTTOM VIEW
NOT ARCHIVED
88898
E
7363-0001
1/5
MODEL

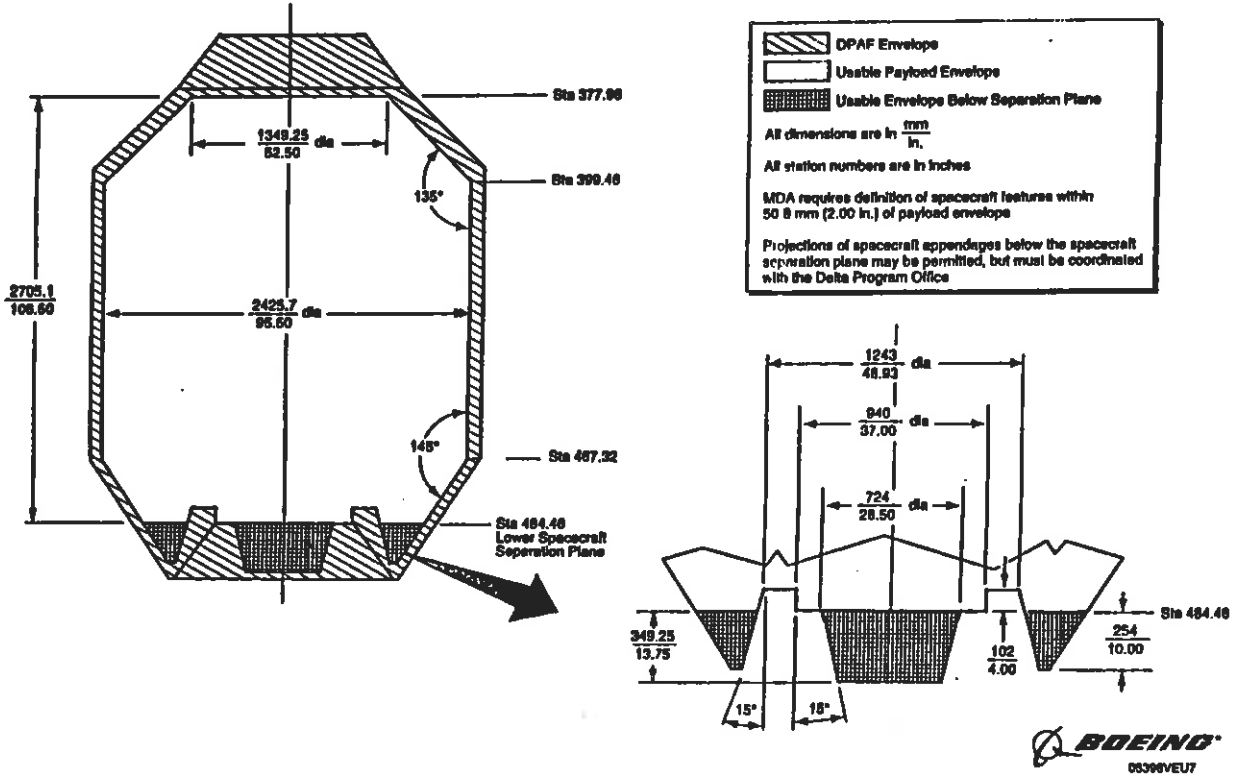
Launch Vehicle Interfaces
Fairing and DPAF

- **Fairing**
  - **Boeing 10 foot Composite Fairing**
  - **Access Holes (1 in fairing and 1 in DPAF both located at STA 430.00, QUADII) 24 inch diameter for arming plug removal on the pad**
- **DPAF**
  - **Under Development, Managed by Boeing**
  - **Successful PDR held October, 1997 in Stevenage England**
  - **On Schedule with proper mass margins (15% at PDR)**
  - **T=0 AC and GN2 purge concepts presented**
  - **First Flight on EOS-1/SAC-C mission**
  - **TIMED Interfaces understood and acceptable**

Launch Vehicle Interfaces

DPAF

Lower Payload Usable Envelope
10-ft Composite Fairing / DPAF Configuation

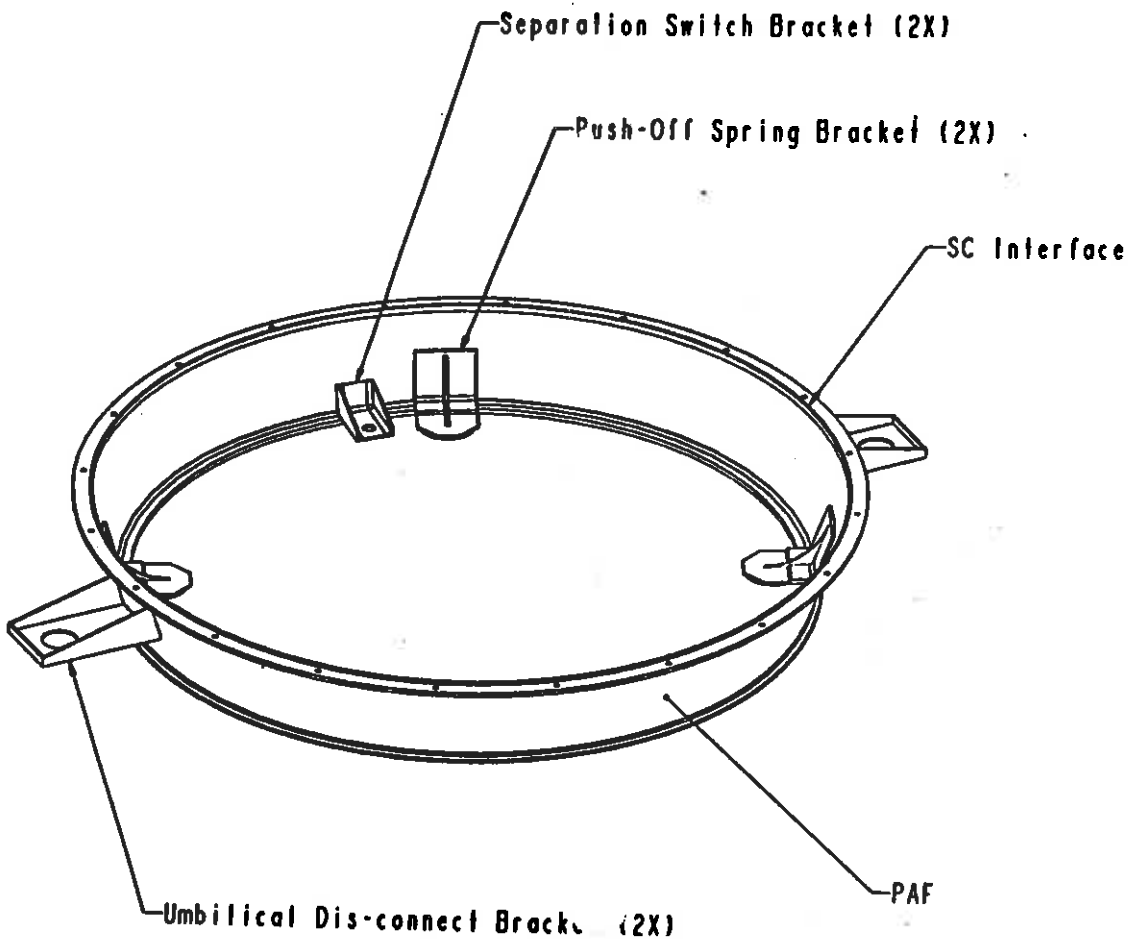


Launch Vehicle Interfaces

Payload Attach Fitting (PAF)

- **Boeing 3712-C separation system**
- **APL fabricates TIMED side of adapter**
  - **GUVI CFOV requirement**
  - **Allows more mass efficient load transfer to TIMED structure**
- **Aluminum 6061-T6 forging**
- **Design approved by Boeing**
- **Separation spring (4X) provisions with 2 integral separation switches**
- **Used for thermal radiator in orbit**

Launch Vehicle Interfaces
Payload Attach Fitting (PAF)



Launch Vehicle Interfaces
Status, Issues and Concerns

- **Status**
  - **TIMED SC envelope acceptable to Boeing per 10/22/97**
    - **> APL has observed solar panel interference at STA. 481.46**
    - **> Boeing notified and unable to respond to date**
    - **> Resolution expected by CDR**
  - **PAF**
    - **> Drawing release 12/12/97**
    - **> Delivery 4/4/97**
  - **Access doors approved by Boeing**
  - **T=0 AC and GN2 purge in development**
  - **Umbilical dis-connect (2X 37 pin) acceptable to Boeing and TIMED**
- **Issues and Concerns**
  - **Interference (yes/no,???)**
  - **Separate brackets for separation springs TBD, awaiting details**

Spacecraft Configuration
Instruments and Sensors

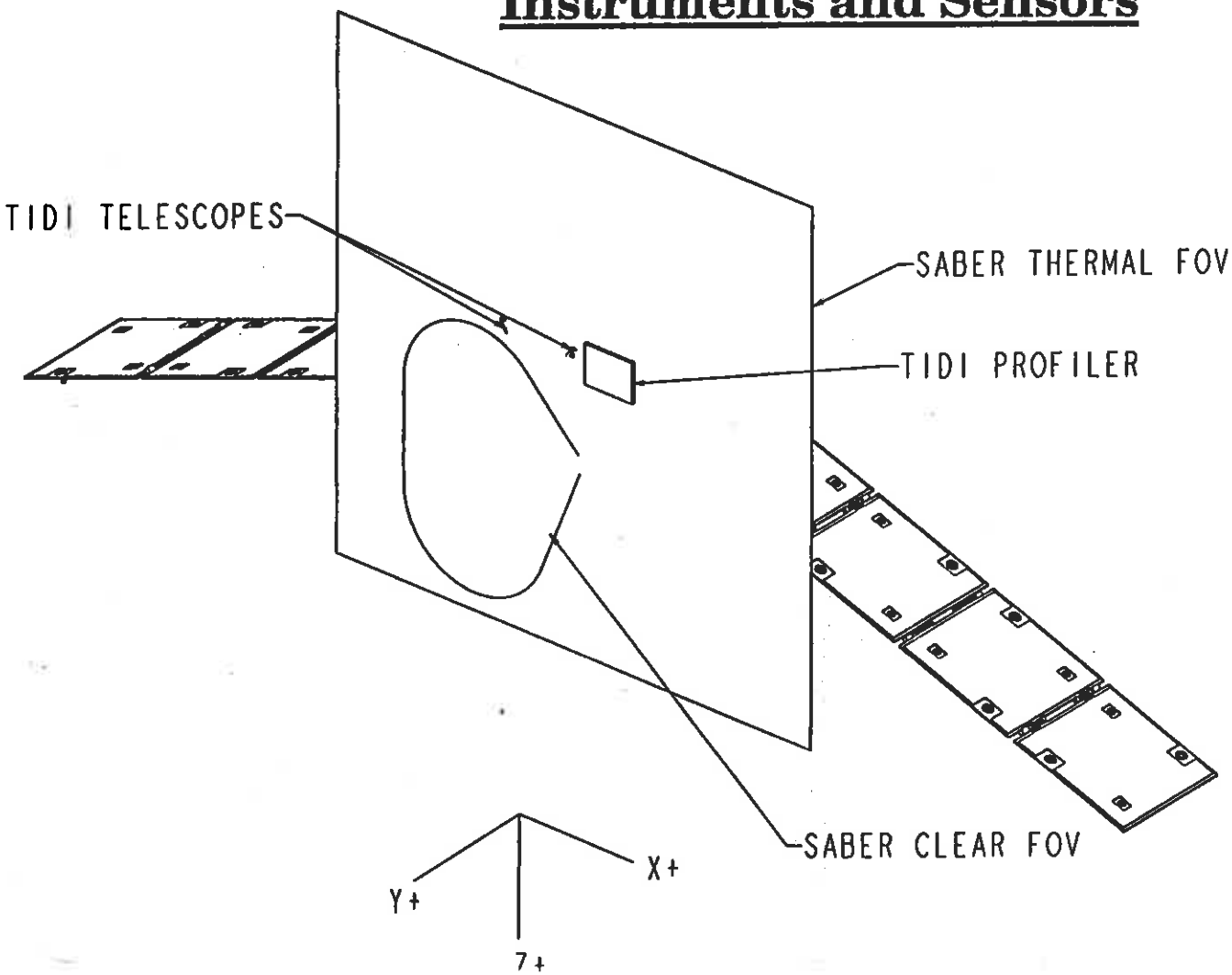
- **SABER**
  - **Provider: NASA Langley and Utah State SDL**
  - **SC Mechanical Requirements**
    - **> Location on +Y side of SC**
    - **> Current Mass = 65.63 Kg**
    - **> Limited number of fasteners (6X, .375-20 Titanium) and thermal isolation to SC**
    - **> Thermal Radiator Requires CFOV on entire +Y side of SC**
    - **> Purge**
    - **> Grounding**

Spacecraft Configuration

Instruments and Sensors

- **Saber Current Mechanical SC Interface Current Status**
  - **CDR held 10/22/97 @ Logan, Utah**
  - **Mechanical ICD's 1-101 and 1-106 approved by APL (10/22/97)**
  - **Alignment requirements: shim if needed, standard manufacturing tolerances acceptable**
  - **CFOV is 60 x 80 degrees per Saber ICD drawing No. 1-107**
  - **Thermal FOV has some incursions, SDL, Langley and APL approve**
  - **Purge location known and accommodated**
  - **Connector Interfaces known and accommodated**
  - **Mechanical Integration and lift fixtures have received preliminary APL approval for conceptual design**
  - **Grounding provisions: 2 ground straps to structure**

Spacecraft Configuration
Instruments and Sensors



Spacecraft Configuration

Instruments and Sensors

- **SEE Instrument**
  - **Provider: University of Colorado, LASP**
  - **Mechanical Requirements**
    - **> Location: Top (-Z SC Deck)**
    - **> Current Mass= 24.26 Kg.**
    - **> Mechanical Alignment: Close tolerance hole and slot, no pinning required**
    - **> Mechanical Interface : 6X Titanium (.250-28) Fasteners, no thermal isolation Reqd.**
    - **> CFOV (-33 to+100)**
    - **> Purge**
    - **> Grounding provisions: strap connected to deck**

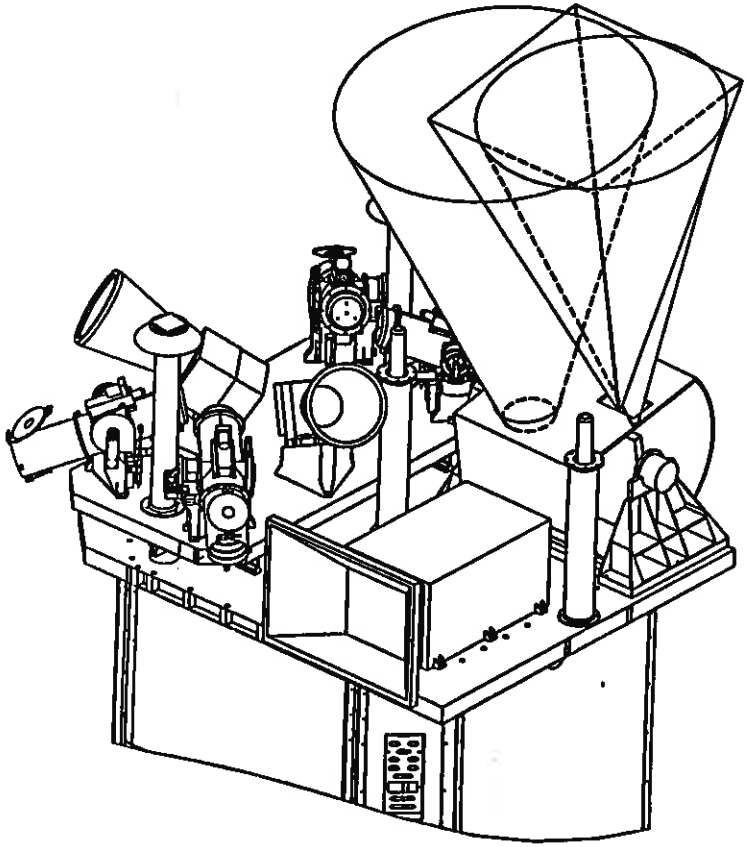
Spacecraft Configuration

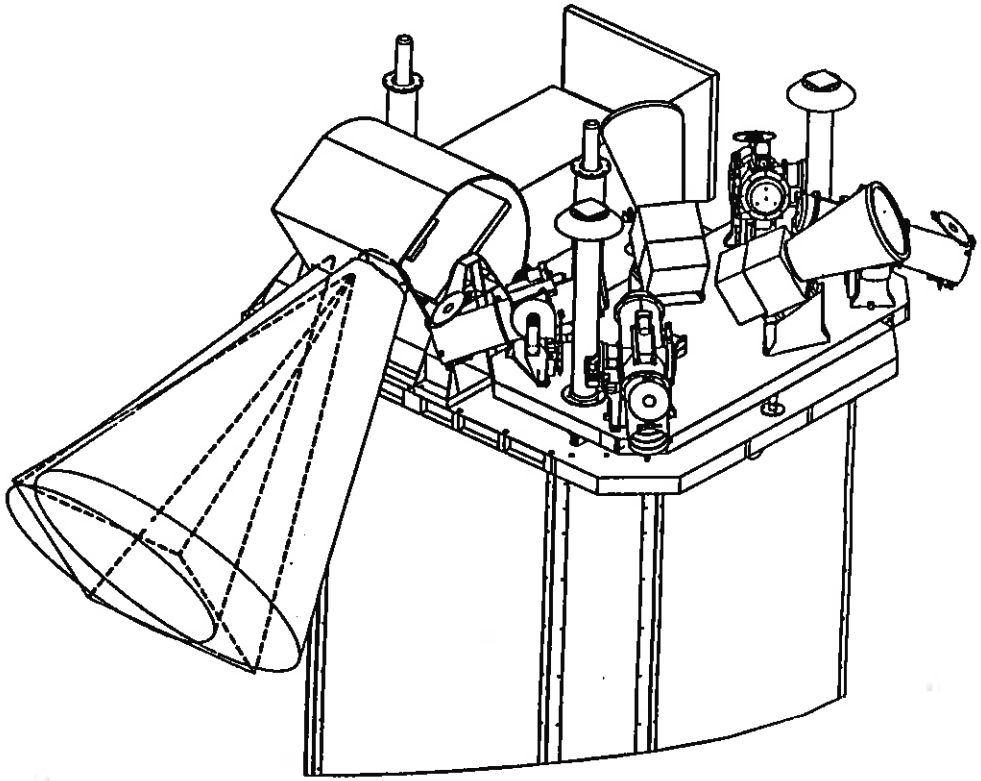
Instruments and Sensors

- **SEE Instrument Current SC Mechanical Interface Status:**
  - **SSPP Platform PDR Held**
  - **Instrument PDR held**
  - **Latest ICD approved by APL (SC interface, purge and connector locations etc. shown at SSPP PDR)**
  - **Mechanical Lift and Integration concept approved by APL**
  - **Partial radiator blockage by TIDI profiler in beta 0 case, approved by LASP and APL**
  - **APL supplied fasteners (6X, titanium, .250-28)**
  - **Grounding insert in deck provided**
  - **CFOV: Requirements met per SSPP PDR material dated 9/17/97 and SEE ICD 20550-D1-9002 dated 11/4/97**

Spacecraft Configuration

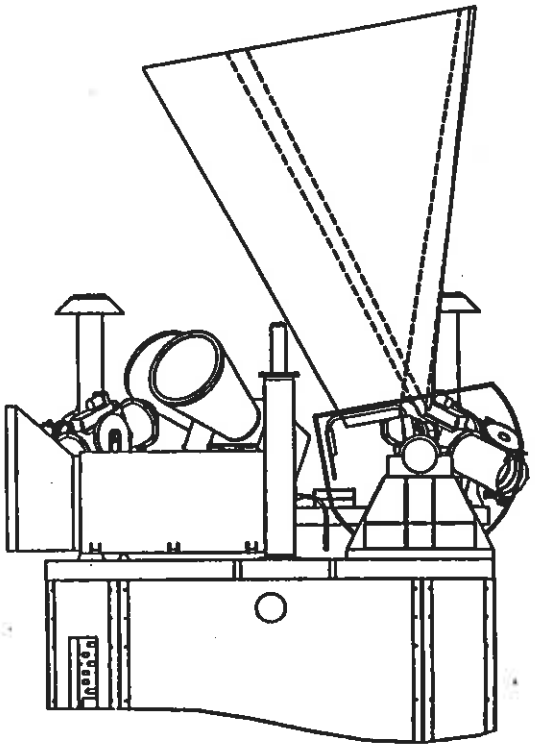
Instruments and Sensors

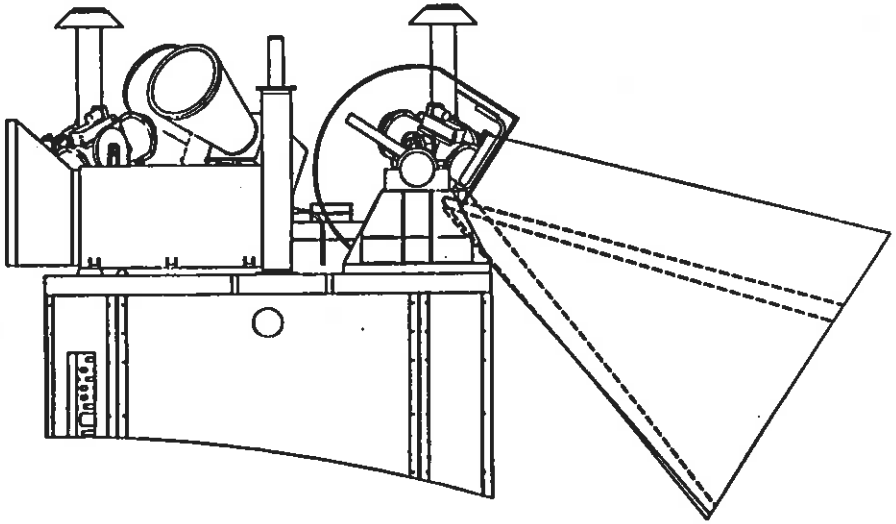




Spacecraft Configuration

Instruments and Sensors





Spacecraft Configuration
Instruments and Sensors

- **GUVI Instrument**
  - **Provider: APL, Aerospace Corp.**
  - **ICD approved by APL, all package locations approved by APL**
  - **Mechanical Requirements**
    - **> Location: Aft (-Z) SC Deck**
    - **> Current Mass =6.41 Kg.(ECU), SIS=9.4 Kg, 19.24 Kg. (total system)**
    - **> Mechanical Alignment: Possible shims, pinning required**
    - **> Mechanical Interface : Several packages, ICD (7366-0001) approved by APL received 11/4/97**
    - **> GUVI ECU minimum cable length to SIS= 6 feet**
    - **> Grounding**

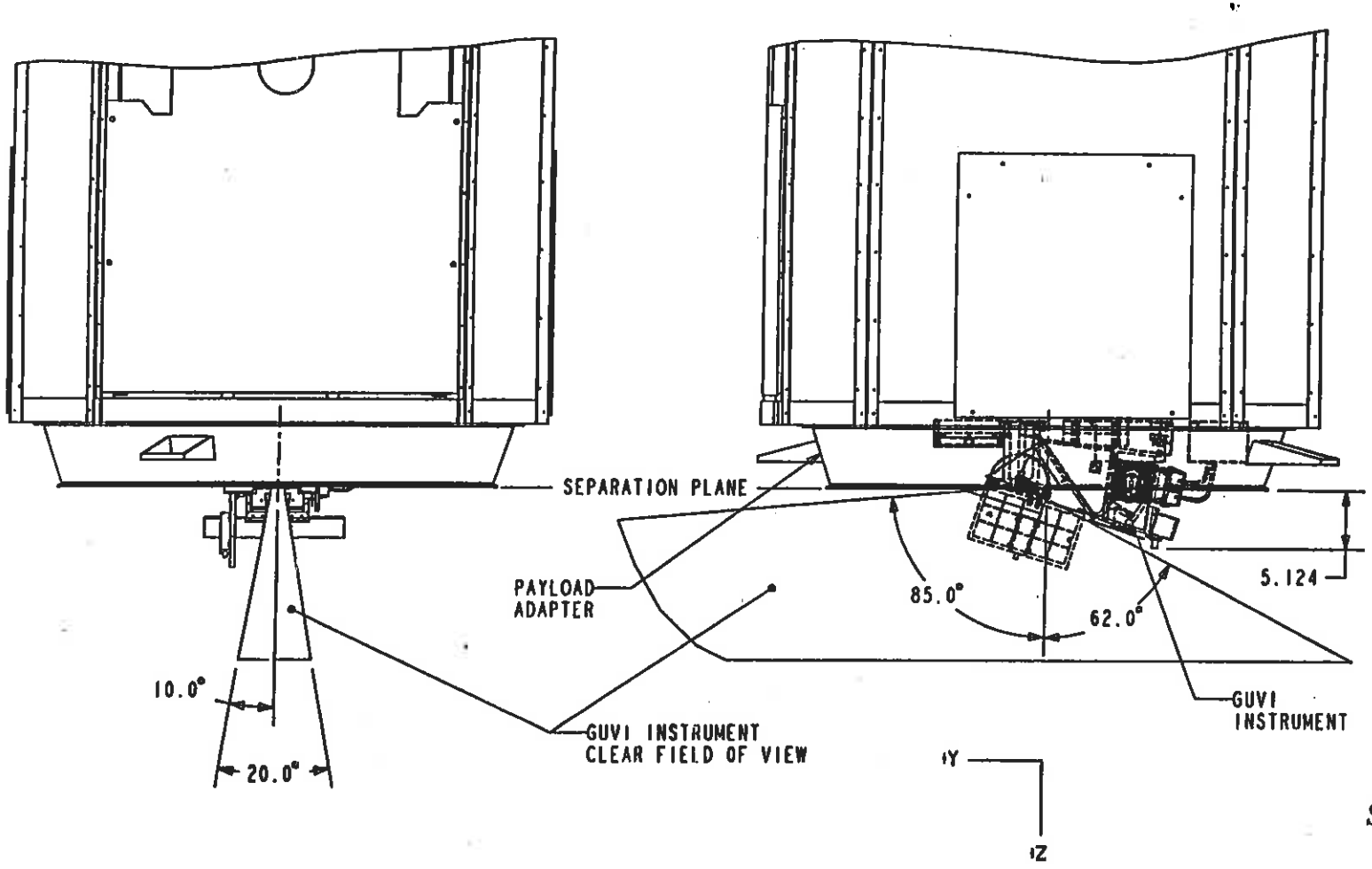
Spacecraft Configuration

Instruments and Sensors

- **GUVI Current Mechanical Spacecraft Status**
  - **Mounting interface**
    - **> ECU, 6x 10-32 fasteners, location (-X panel) approved**
    - **> SIS, 8x, .250-20 fasteners, no thermal isolation**
  - **ECU location requirement met: 6 feet Max cable length,**
  - **Ground straps provided**
  - **Purge connector location accommodated**

Spacecraft Configuration

Instruments and Sensors



Spacecraft Configuration
Instruments and Sensors

- **TIDI Instrument**
  - **Provider: University of Michigan**
    - **> Telescope sub-contracted to APL**
  - **ICD approved by APL for telescopes and profiler**
  - **Mechanical Requirements**
    - **> Location:**
      - **—Telescopes : Optical Bench (co-alignment requirement with Star Cameras)**
      - **—Profiler: Top (-Z deck), clear Radiator FOV**
    - **> Mass= 4.6 Kg. (each telescope) Profiler = 15.7 Kg., Electronics=5.9 Kg, Total system Mass=40 Kg.**

Spacecraft Configuration
Instruments and Sensors

- **TIDI Instrument (cont.)**
  - **> Mechanical Interfaces:**
    - **—Telescope: 3 point mount directly to bench via .250-20 UNF 2B Titanium fasteners**
    - **—Profiler: 6 thermally isolated 10-32 Titanium fasteners**
    - **—Electronics: 6 fasteners, size TBD**

Spacecraft Configuration

Instruments and Sensors

- **TIDI Instrument Current SC Mechanical Interface Status**
  - **ICDs approved by APL for Telescope (7372-0010), Profiler (055-0101 dated 10-31-97) and electronics(055-XXXX dated 10/29/96)**
  - **CFOV (profiler and telescopes) accommodated**
  - **Envelope accommodated (bearing maintenance scanning and cable service loops considered)**
  - **APL supplied fasteners (6X, titanium)**
  - **Grounding straps required, Optical Bench grounding design under development**

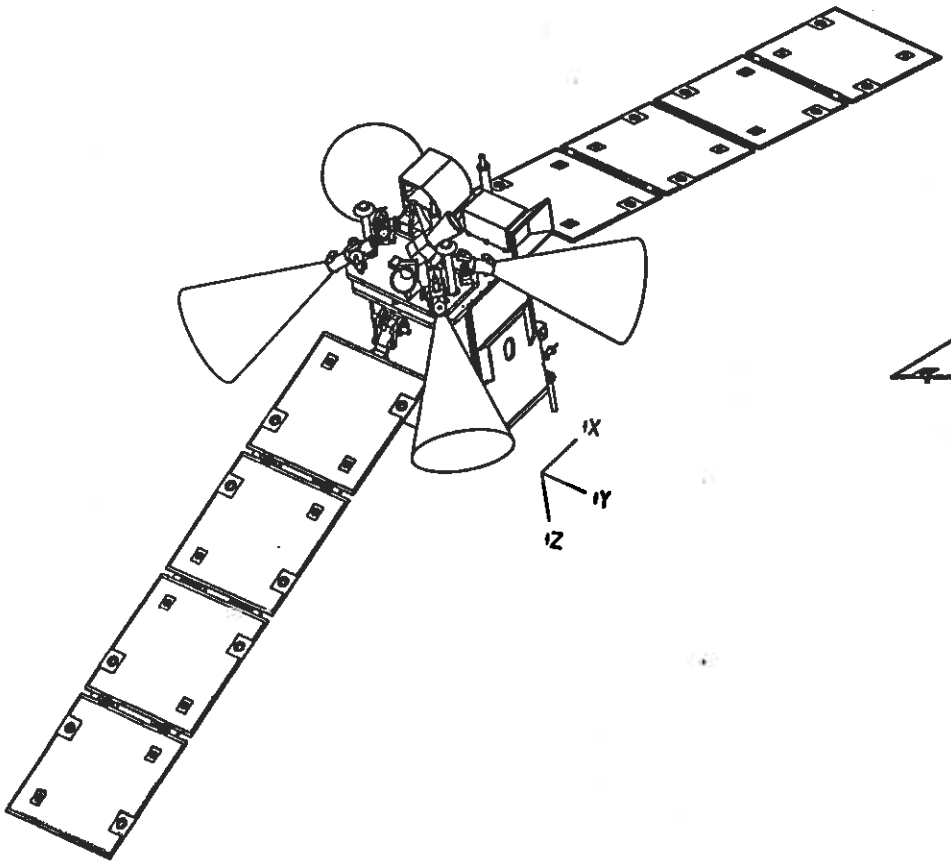
TIMED

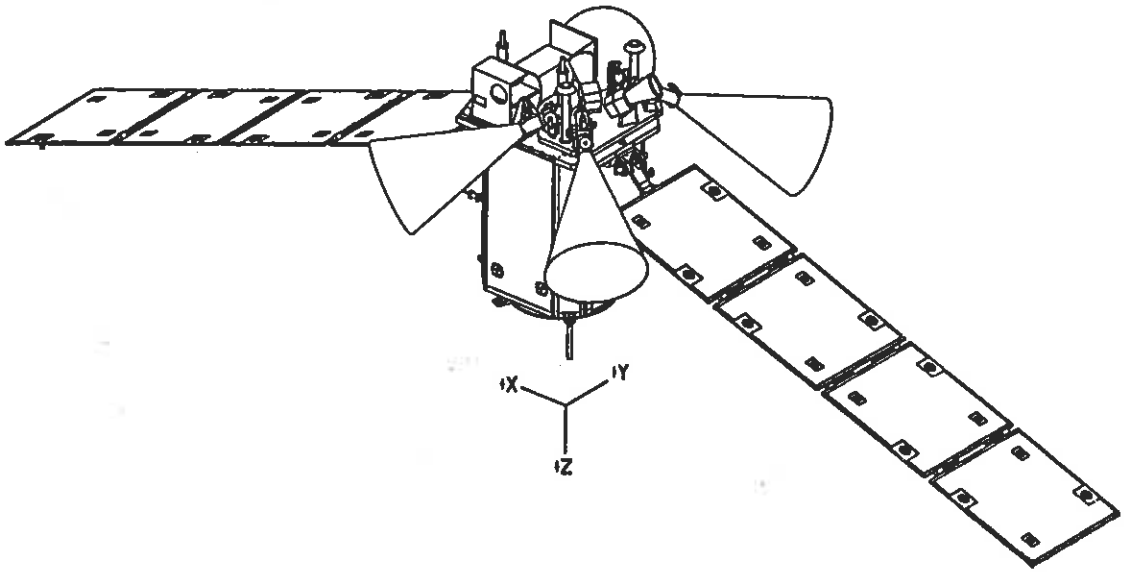
Critical Design Review

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

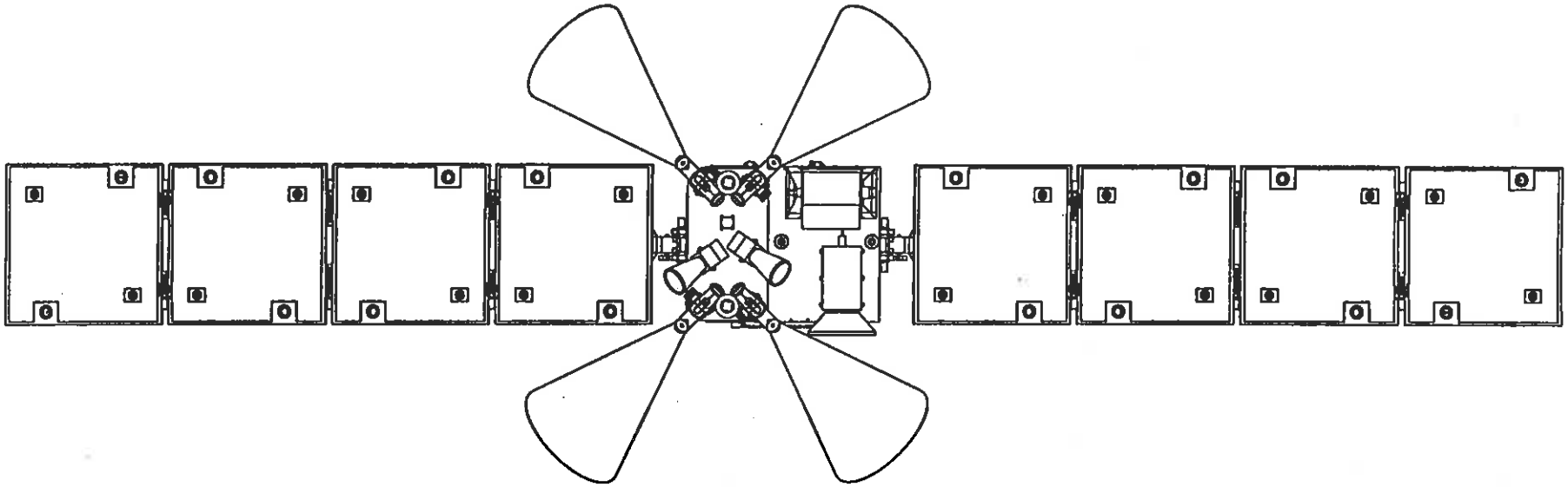
Spacecraft Configuration

Instruments and Sensors





Spacecraft Configuration
Instruments and Sensors



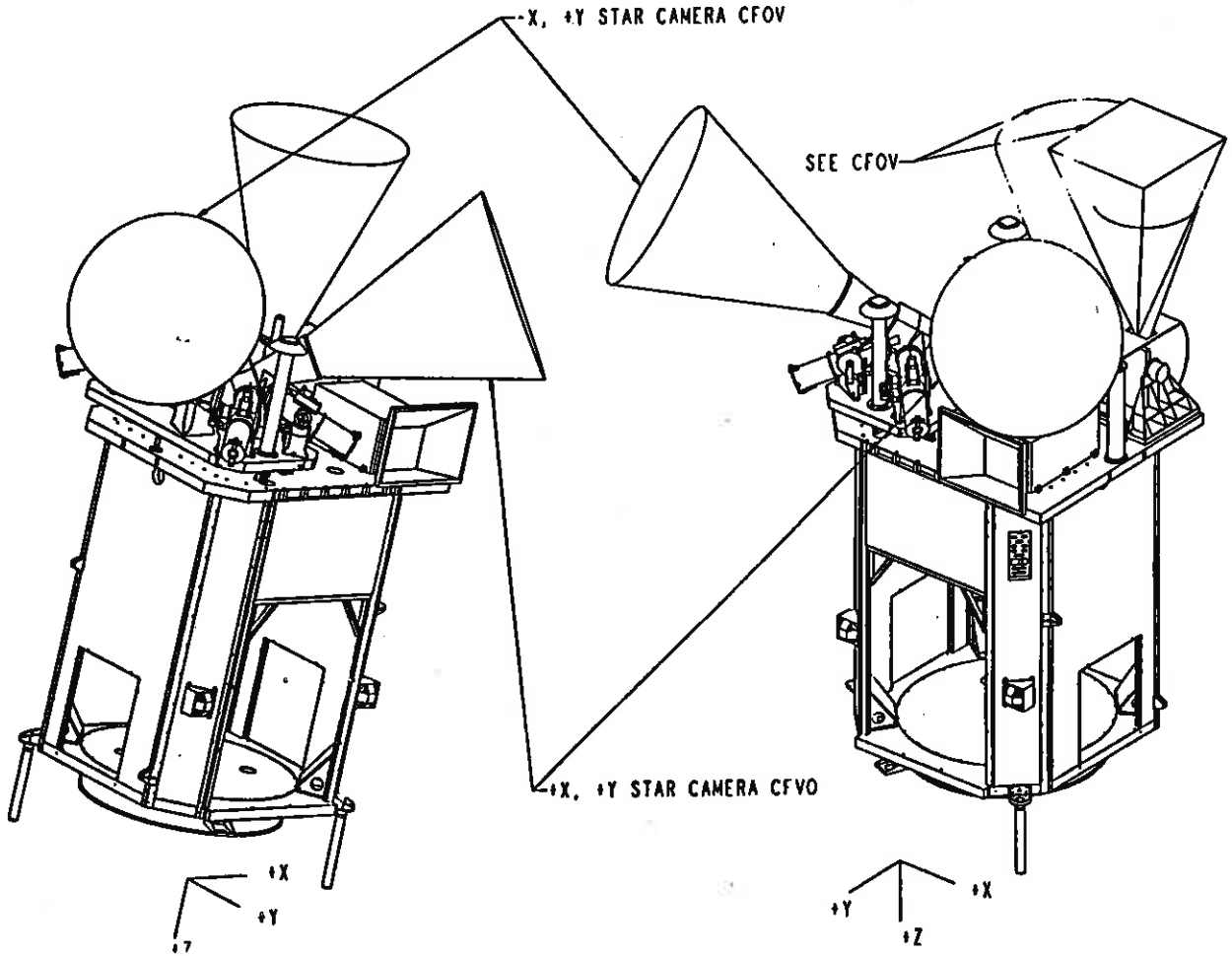
TIDI TELESCOPE CLEAR FIELD OF VIEW
35° FULL CONE IN AZIMUTH

Spacecraft Configuration

Instruments and Sensors

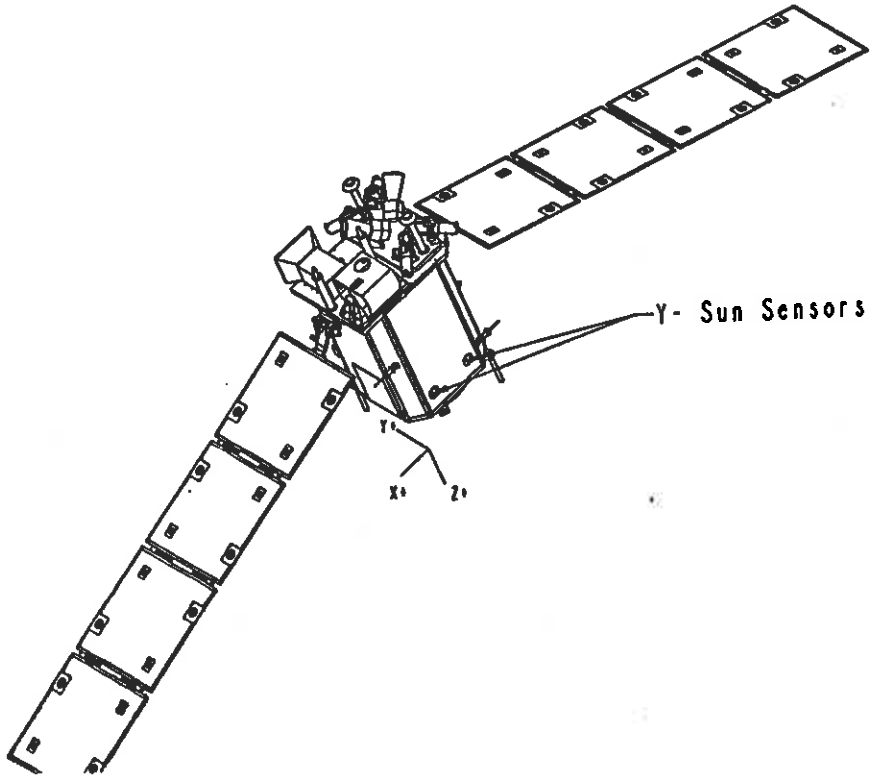
- **Star Camera**
  - **Lockheed-Martin AST-xx**
  - **CFOV of +/- 20 degrees off Boresite**
  - **Current mass = 4.9 kg.**
- **Star Camera Current Mechanical Status**
  - **CFOV requirement exceeded by xx degrees**
  - **Mechanical mounting interface 12x, #8-32 Titanium bolts**
  - **Possible pinning requirements to bracket and/or bracket to bench will be provided as required**
  - **ICD drawing 18245 approved and subject to change**

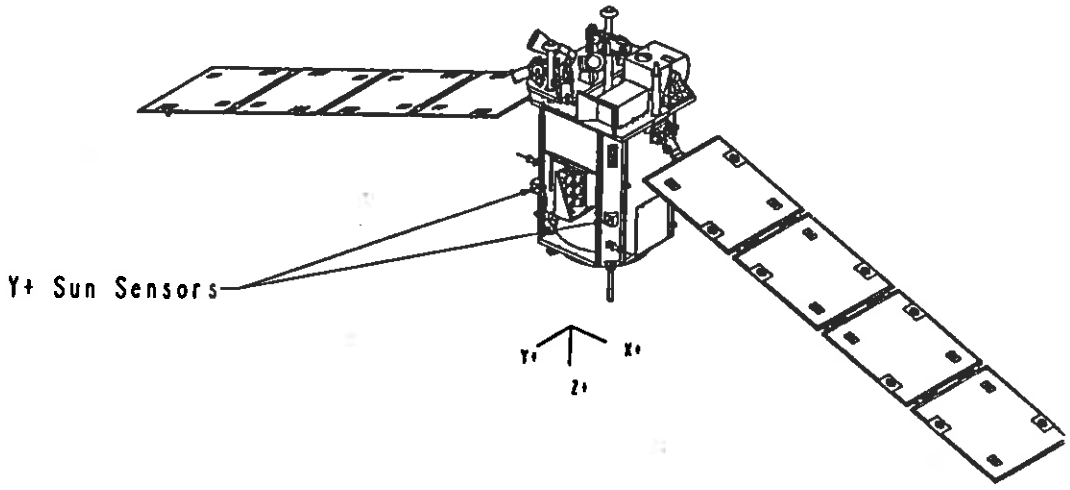
Spacecraft Configuration
Instruments and Sensors



Spacecraft Configuration
Instruments and Sensors

- **Sun Sensors**
  - **Location on +Y and -Y panels**
  - **Best possible FOV location requirement**





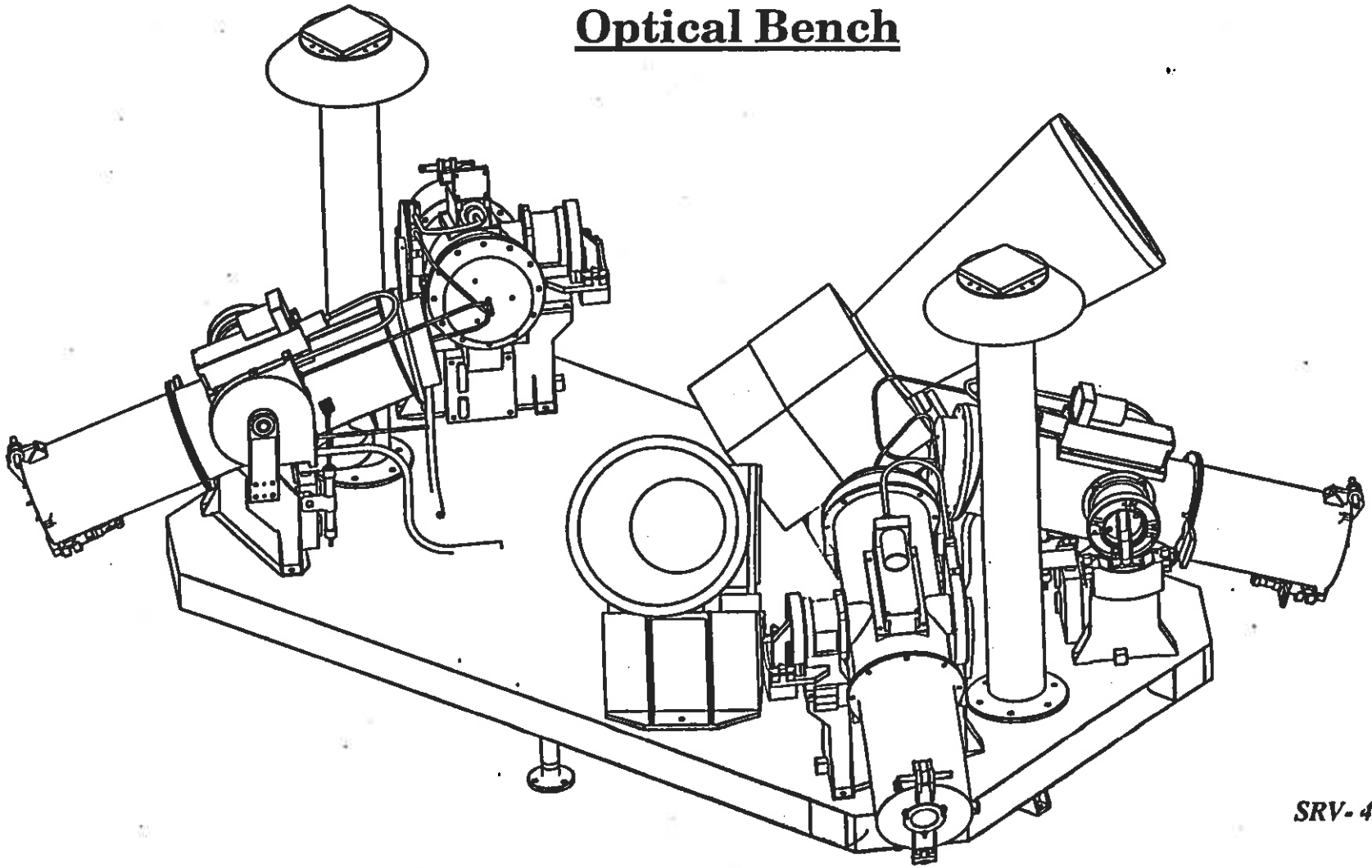
Spacecraft Secondary Structure

Optical Bench

- **Requirements**
  - **Thermal and Mechanical stable mounting for:**
    - **> Star Cameras**
    - **> TIDI Telescopes (2X)**
    - **> GPS Antennas (2X)**
- **Design Features**
  - **Kinematic/flexure mounting system**
  - **Pyro activated preload release (raises flexure frequency to handle launch conditions and releases bench for flight operations)**
  - **Aluminum honeycomb core**
  - **Graphite epoxy face sheets**
  - **Titanium inserts**

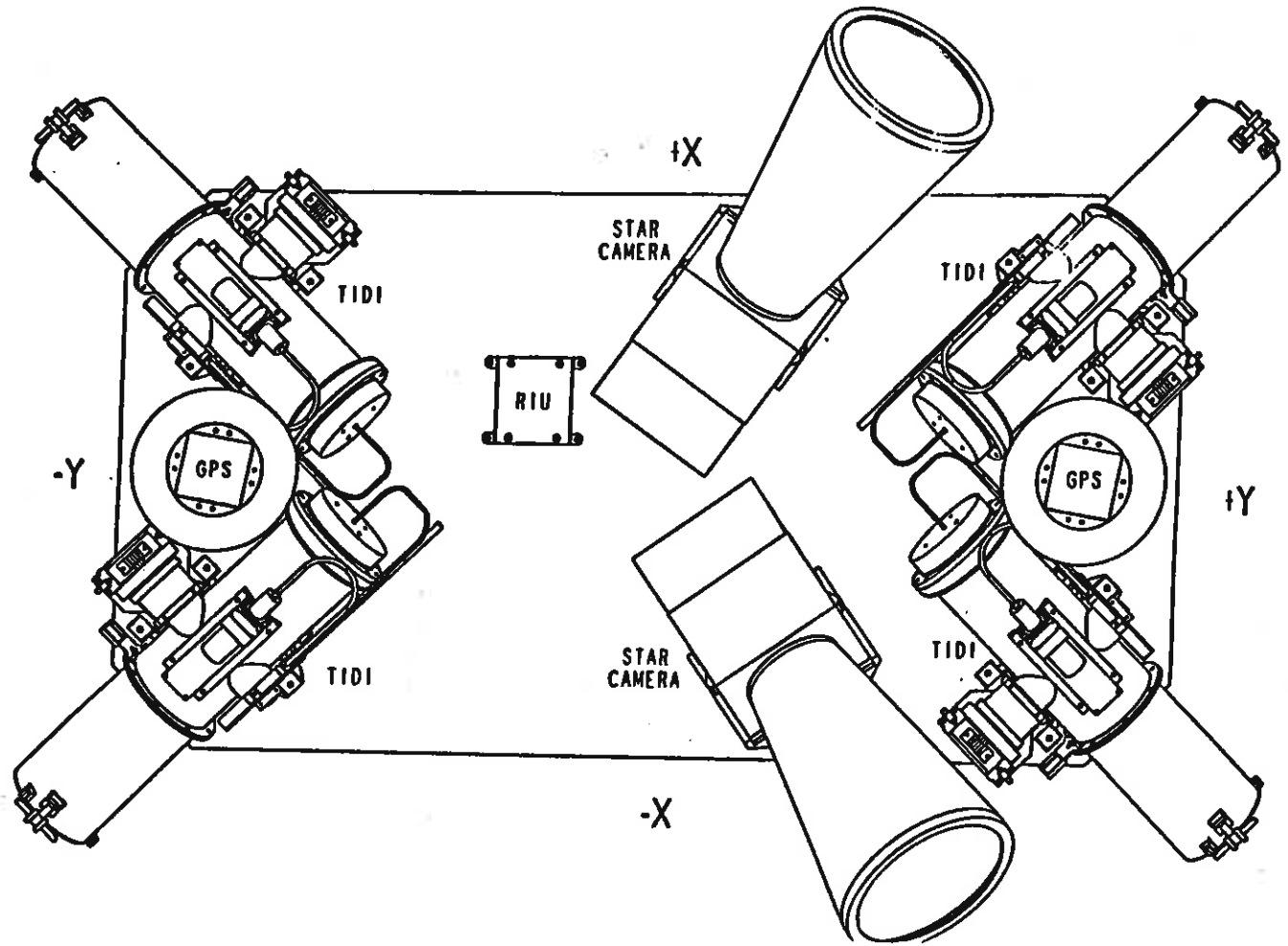
Spacecraft Secondary Structure

Optical Bench



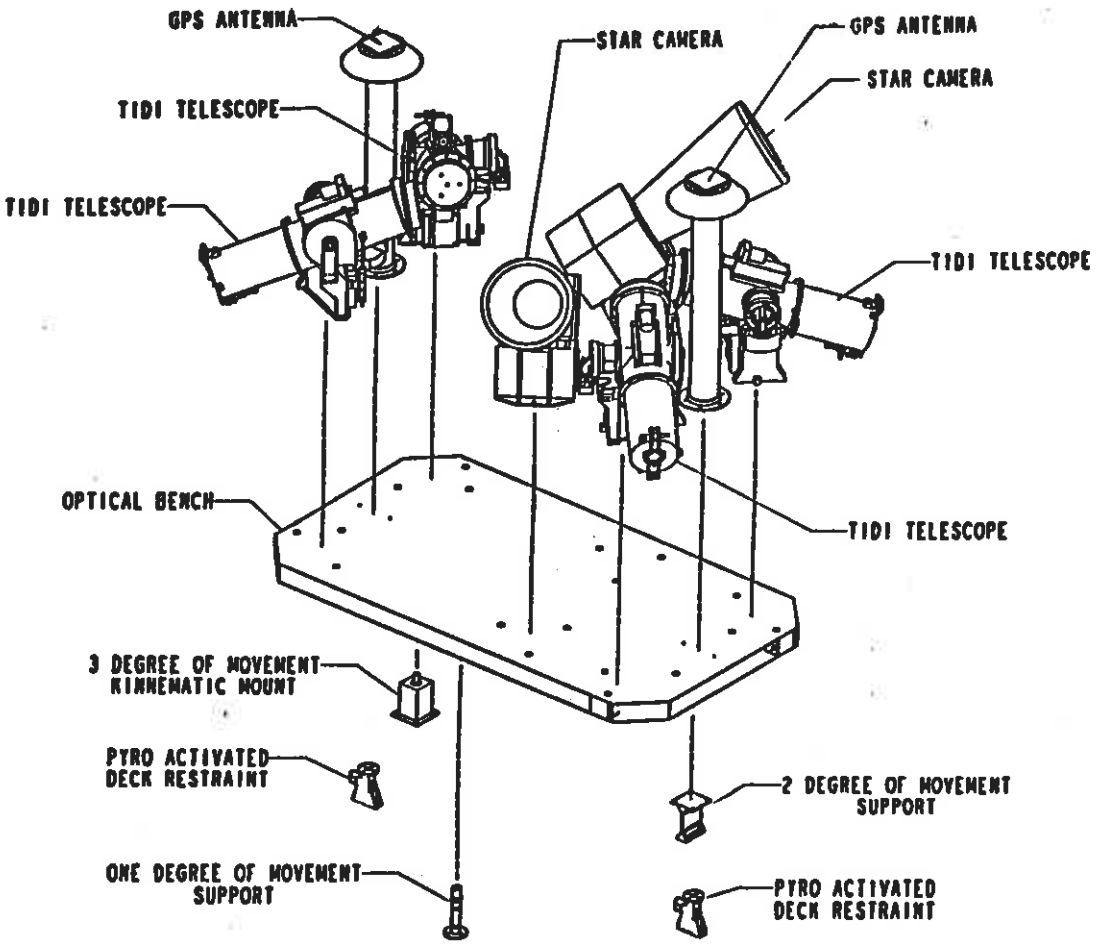
Spacecraft Secondary Structure

Optical Bench



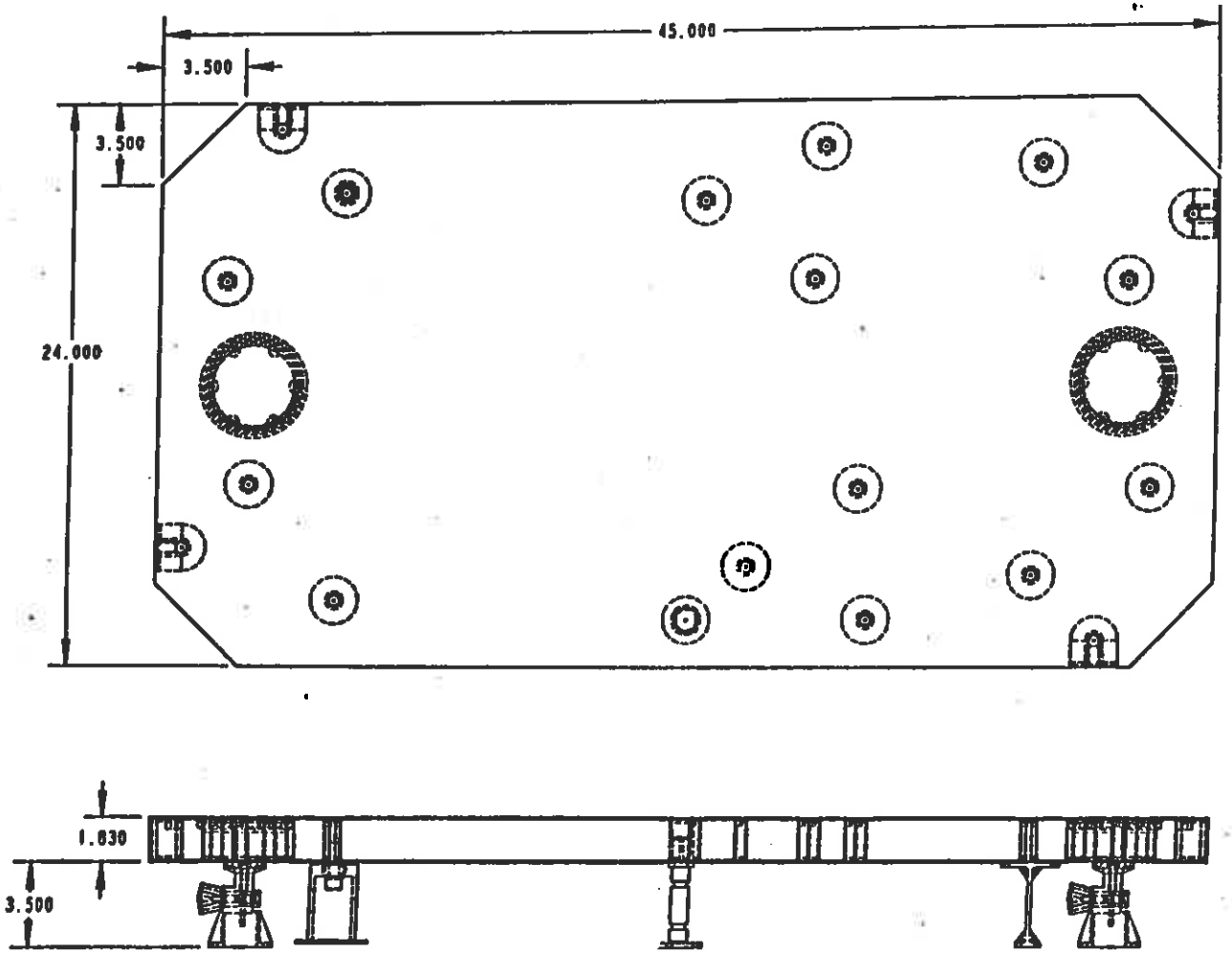
Spacecraft Secondary Structure

Optical Bench



Spacecraft Secondary Structure

Optical Bench



Spacecraft Secondary Structure

Optical Bench

- **Status**
  - **Bench Design 85% complete**
  - **Most parts in drafting**
  - **Released drawings early January 1998**
  - **Delivery 9/9/98**

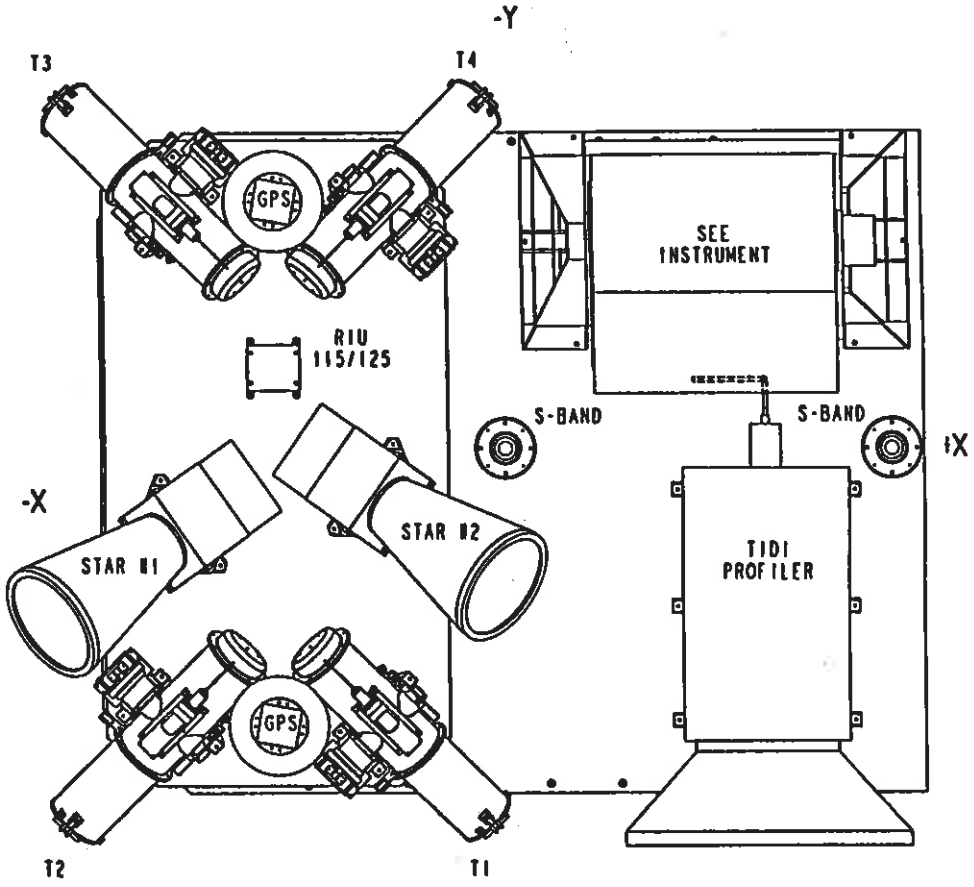
Spacecraft Configuration

Deck Layouts

- **All sub-system locations shown**
- **Locations determined by access, functional, space, mechanical and thermal requirements.**
- **All major iterations on locations complete with some minor movements anticipated for harness.**
- **Thermal analysis complete**
- **Thermal doublers identified where applicable (mass accounted for)**

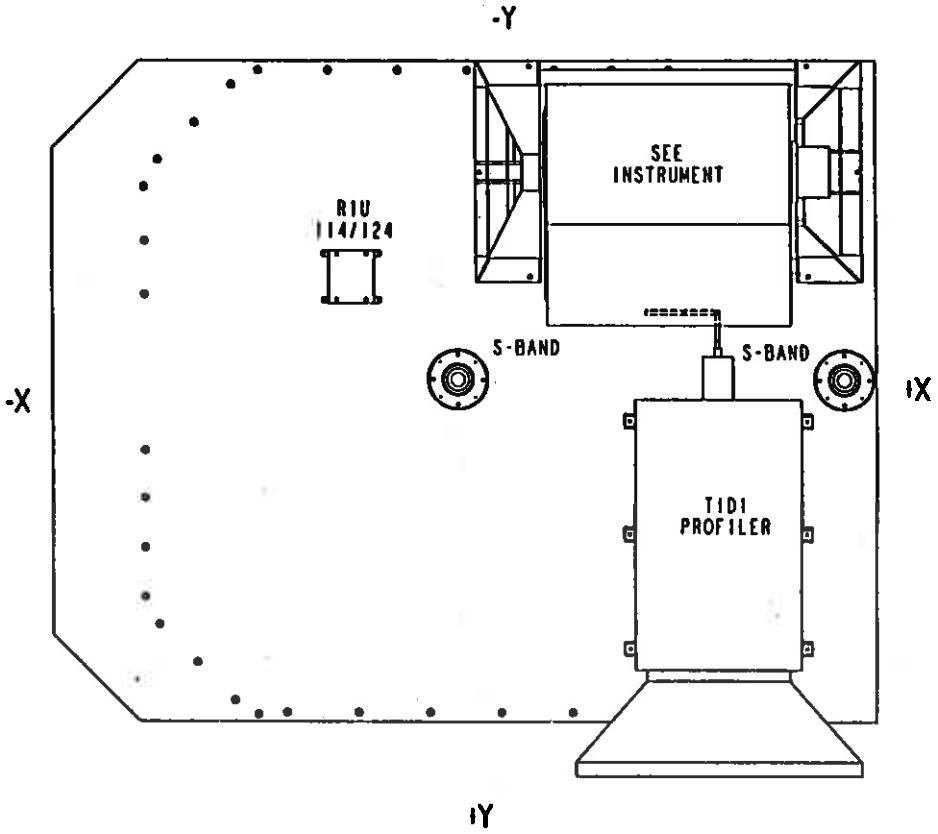
Spacecraft Configuration

Deck Layouts



Spacecraft Configuration

Deck Layouts

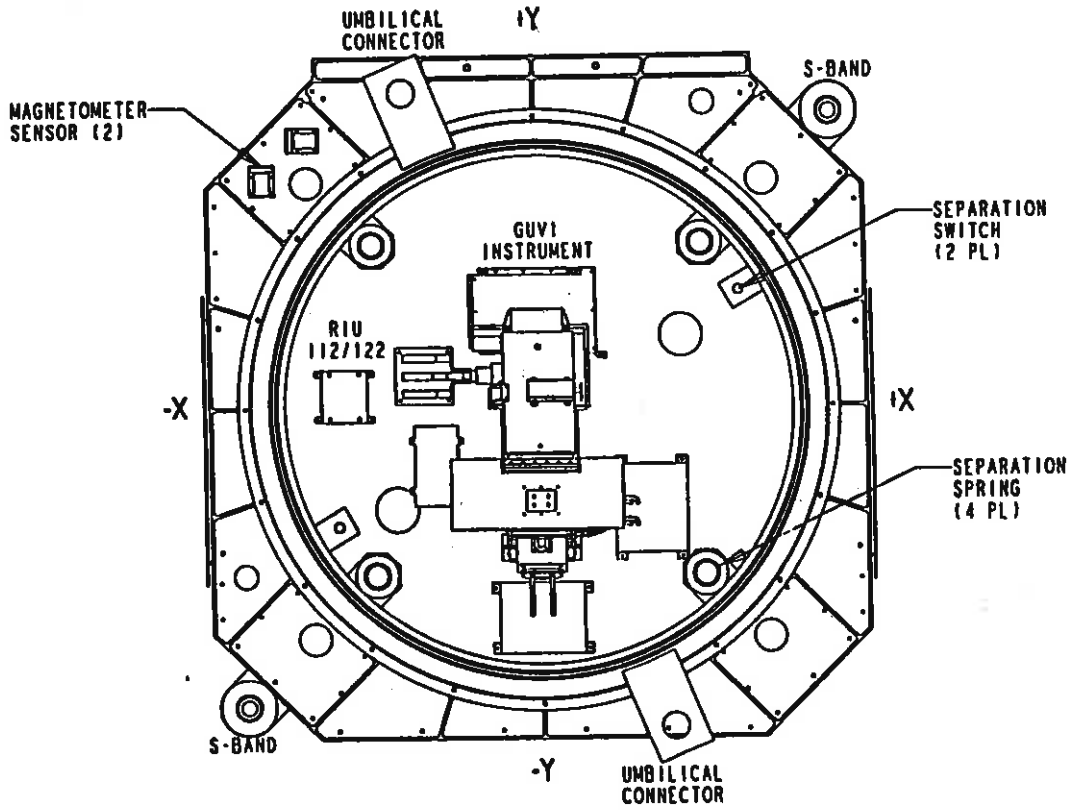


-? DECK

TOP SIDE OPTICAL BENCH

Spacecraft Configuration

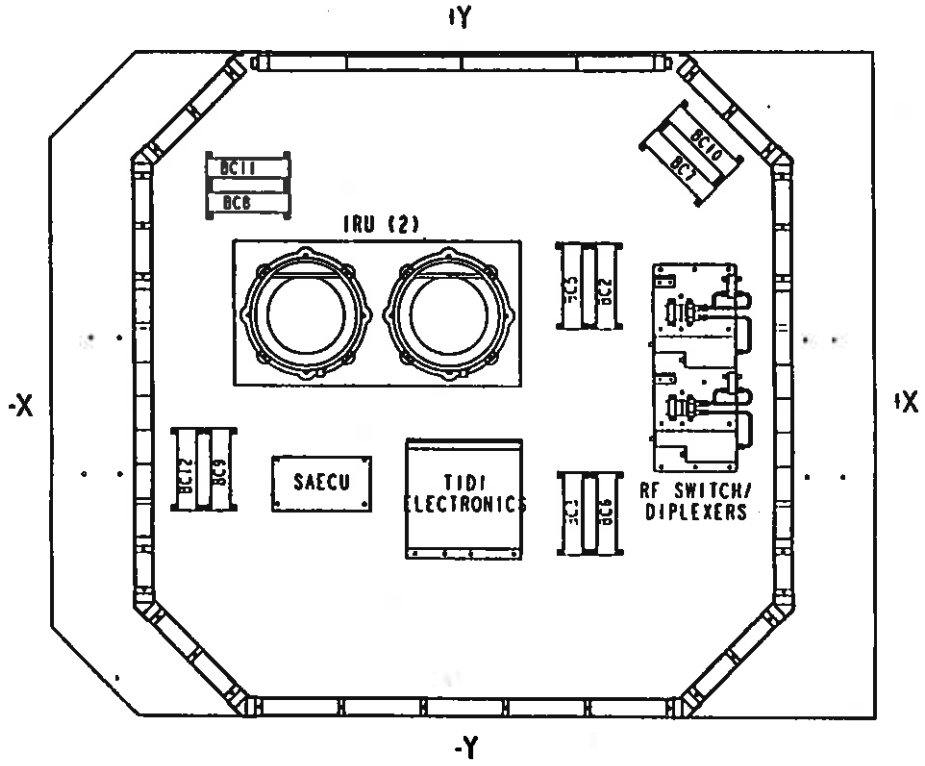
Deck Layouts



+Z DECK
BOTTOM SIDE

Spacecraft Configuration

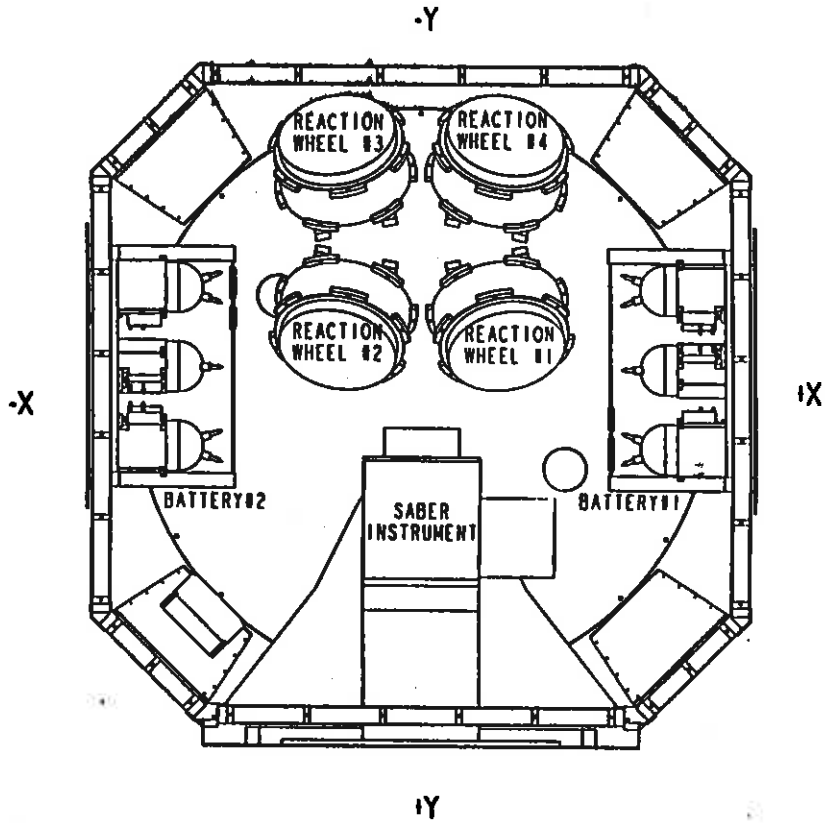
Deck Layouts



-Z DECK
BOTTOM SIDE

Spacecraft Configuration

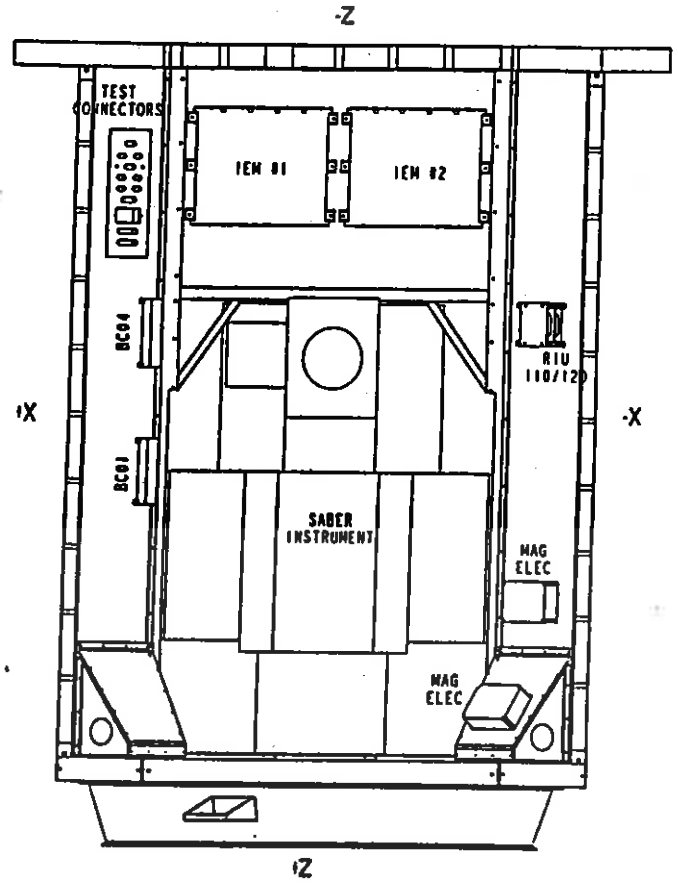
Deck Layouts



+Z DECK
TOP SIDE

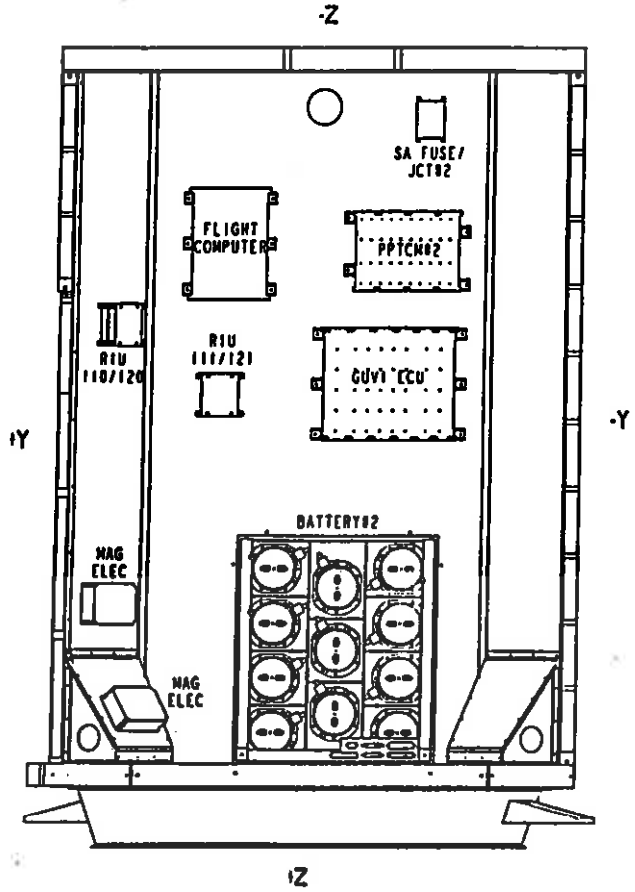
Spacecraft Configuration

Deck Layouts



Spacecraft Configuration

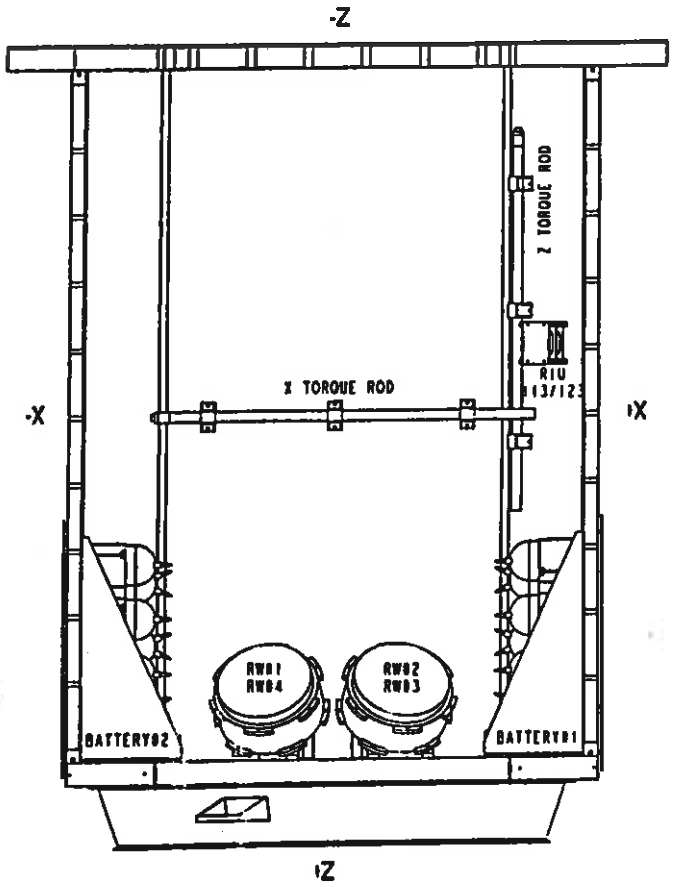
Deck Layouts



-X PANEL
INTERIOR VIEW

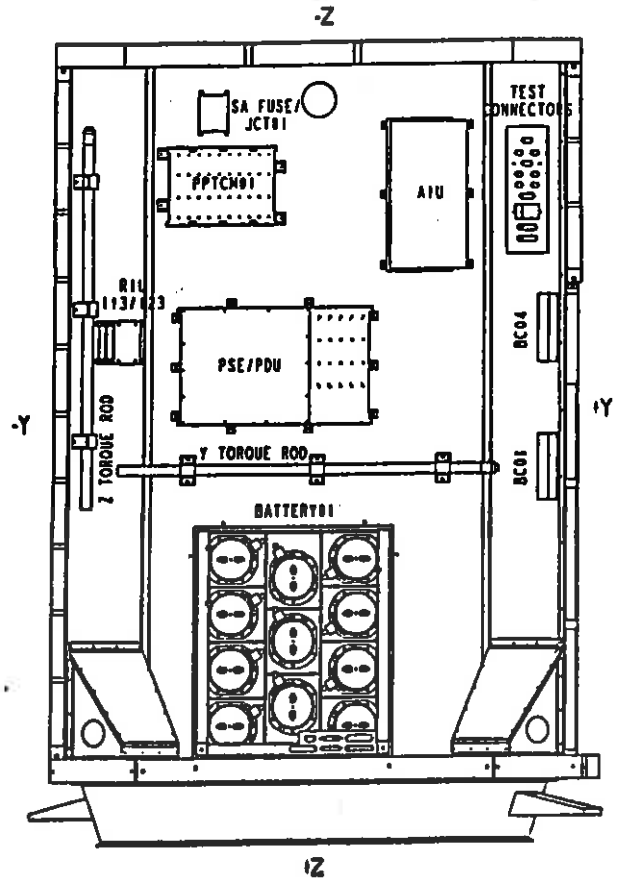
Spacecraft Configuration

Deck Layouts



Spacecraft Configuration

Deck Layouts



Spacecraft Structure

Primary Structure Requirements

- **Instrument Interfaces**
- **Provide Required stiffness and strength**
- **Accommodate harness, thermal, sub-systems**
- **Low Cost**
- **Minimize mass**
- **Interface to Boeing DeltaII 7920-10 Launch Vehicle via 3712C PAF**

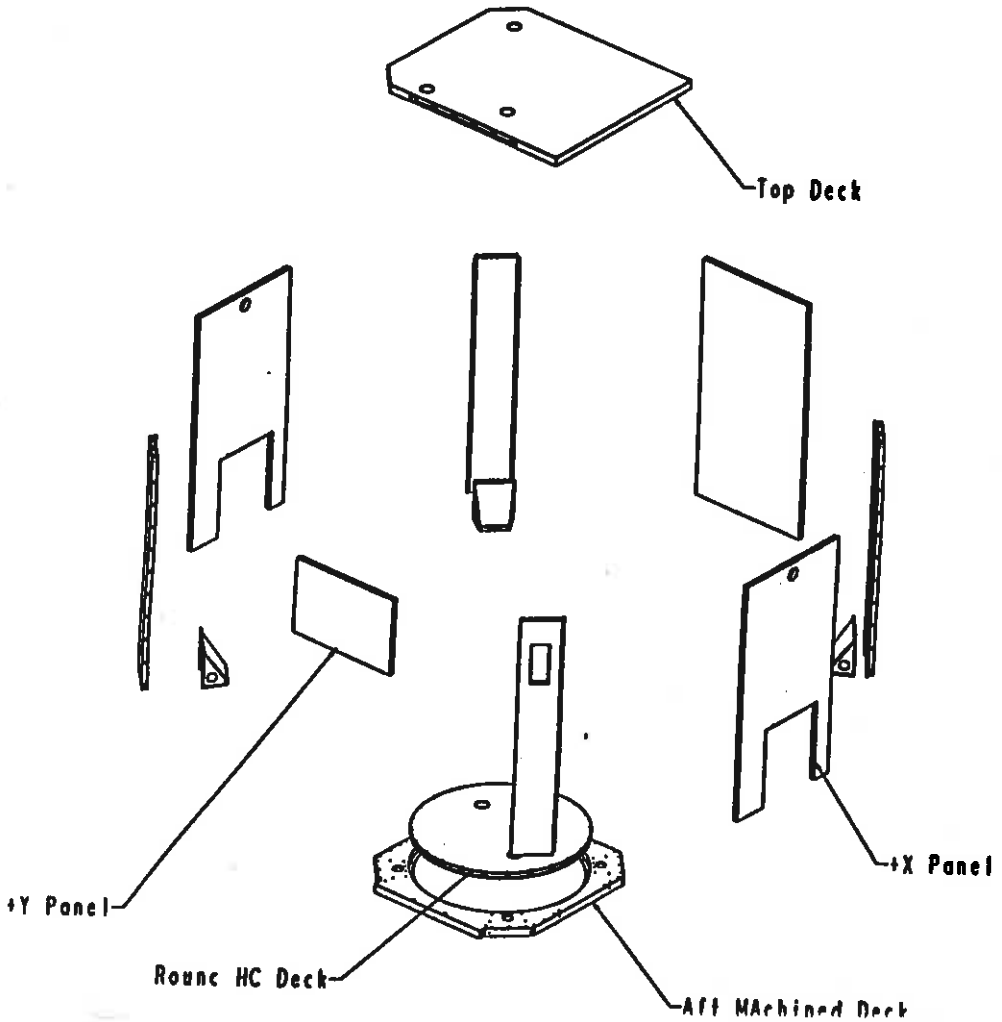
Spacecraft Structure

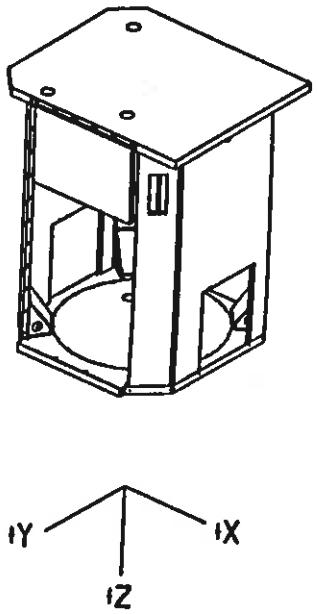
Primary Structure Description

- **Frameless Design**
- **Aluminum Honeycomb structural panels**
- **Magnesium edge members and spools**
- **Machined aft (+Z) deck with circular removable Aluminum Honeycomb center deck**
- **Inserts**
  - **Locking Helicoils in edge members where possible**
  - **Spools (packages >30 pounds)**
  - **Post potted inserts (packages < 30 pounds)**
  - **Riv-nuts (packages <5 pounds)**

Spacecraft Primary Structure

Exploded View

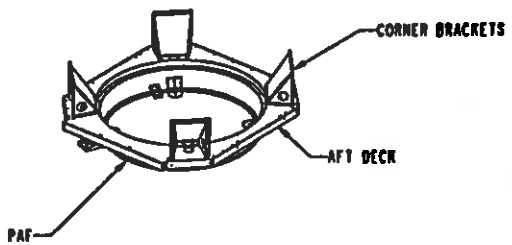




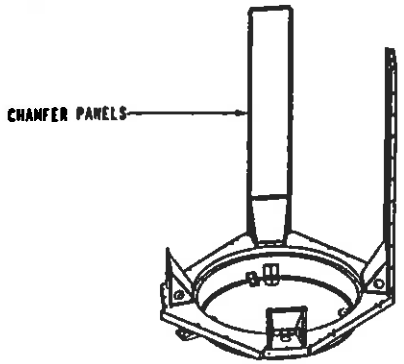
Spacecraft Primary Structure (cont.)

Assembly Sequence

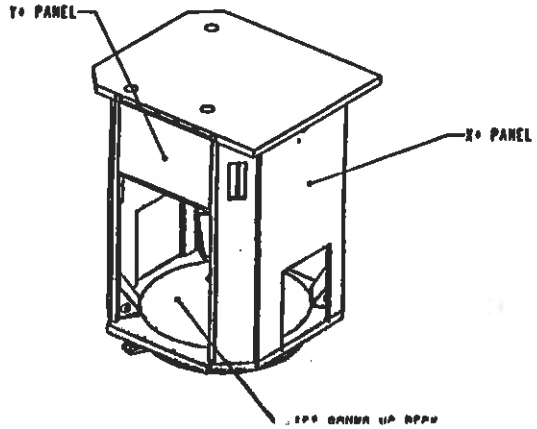
STEP 1



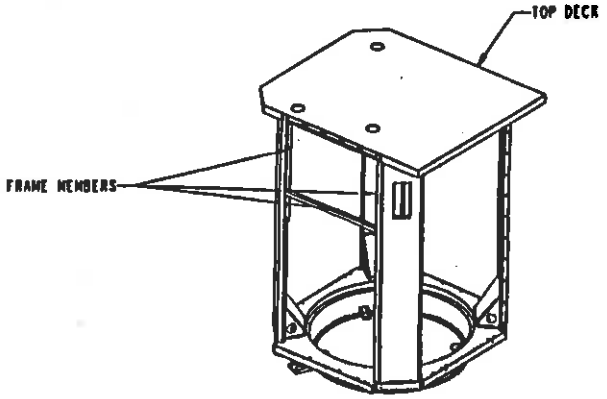
STEP 2



STEP 4

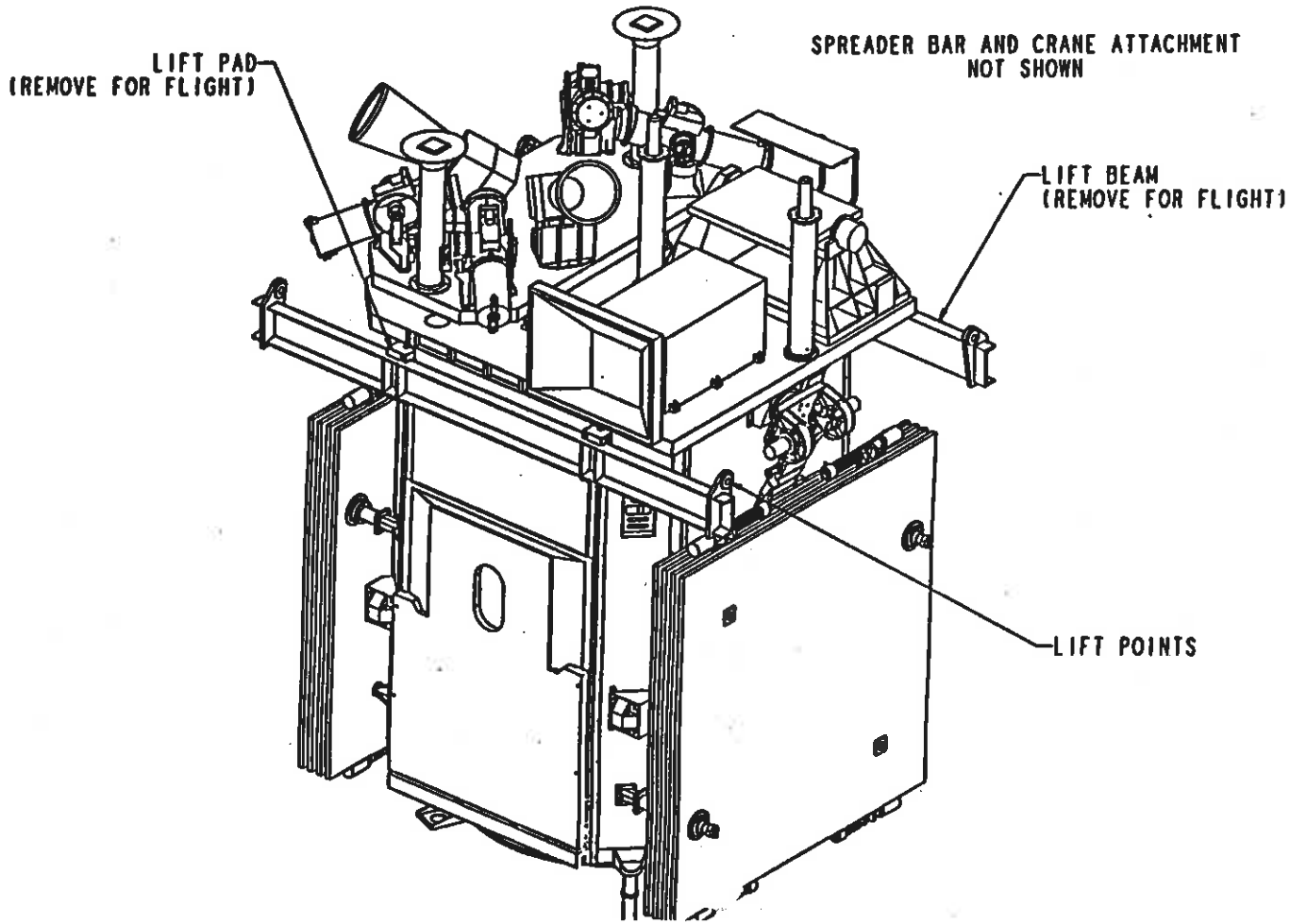


STEP 3



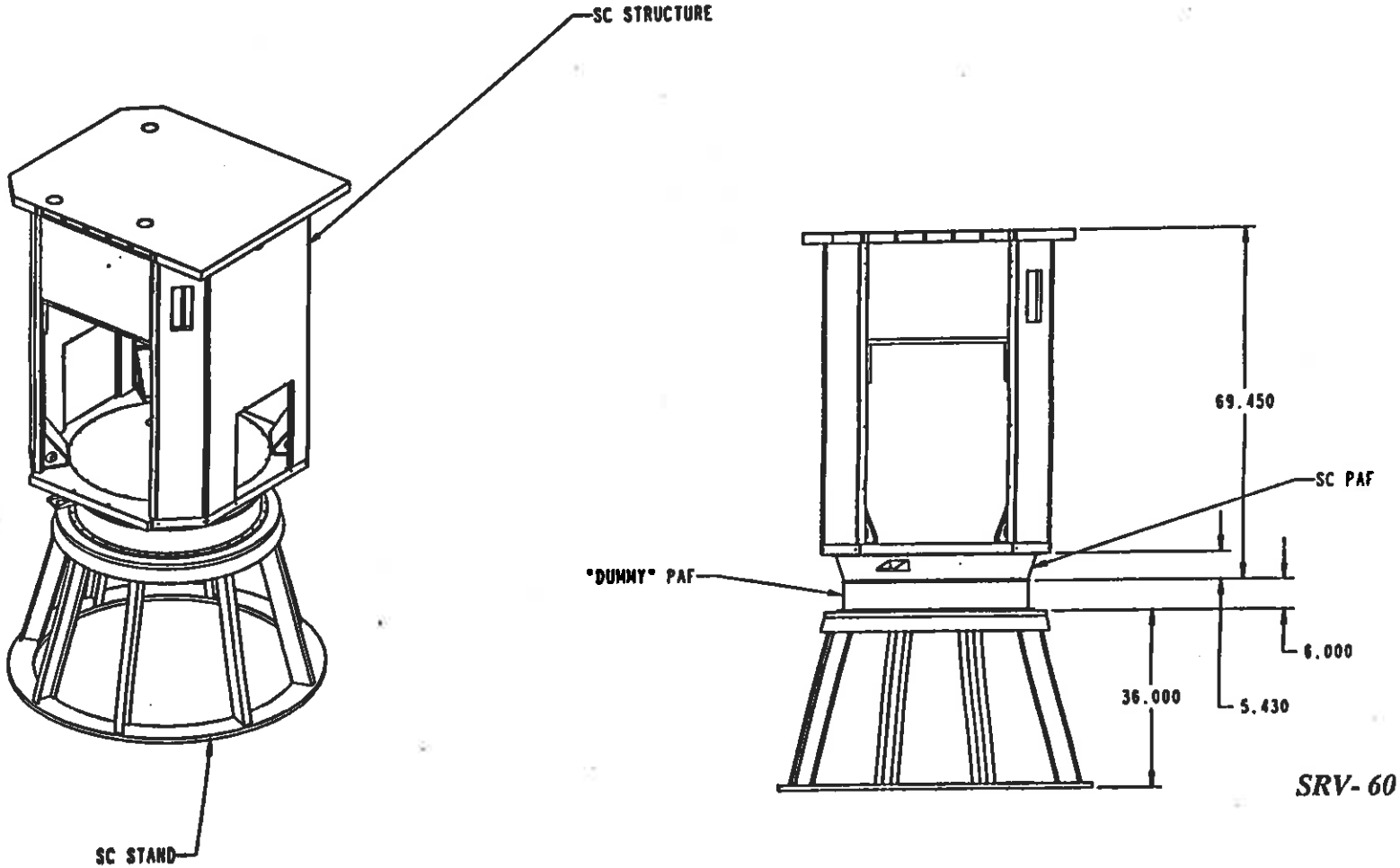
Spacecraft Primary Structure (cont.)

Spacecraft Lifting and Handling



Spacecraft Primary Structure (cont.)

Integration and Test Stand



Spacecraft Primary Structure

Current Status

- **Primary Structure**
  - **Package locations frozen (some relocation of smaller packages (<5 pounds) still allowed**
  - **Instrument interfaces frozen**
  - **Most structural panels in drafting**
  - **Remaining panels released to drafting by 12/15/97**
  - **Aft machined deck and PAF in checking**
  - **Structure delivery scheduled for I&T (8/15/98,) on track, (actually required 10/22/98)**
  - **EDR held 10/17/97, No outstanding issues or concerns**

Spacecraft Secondary Structure

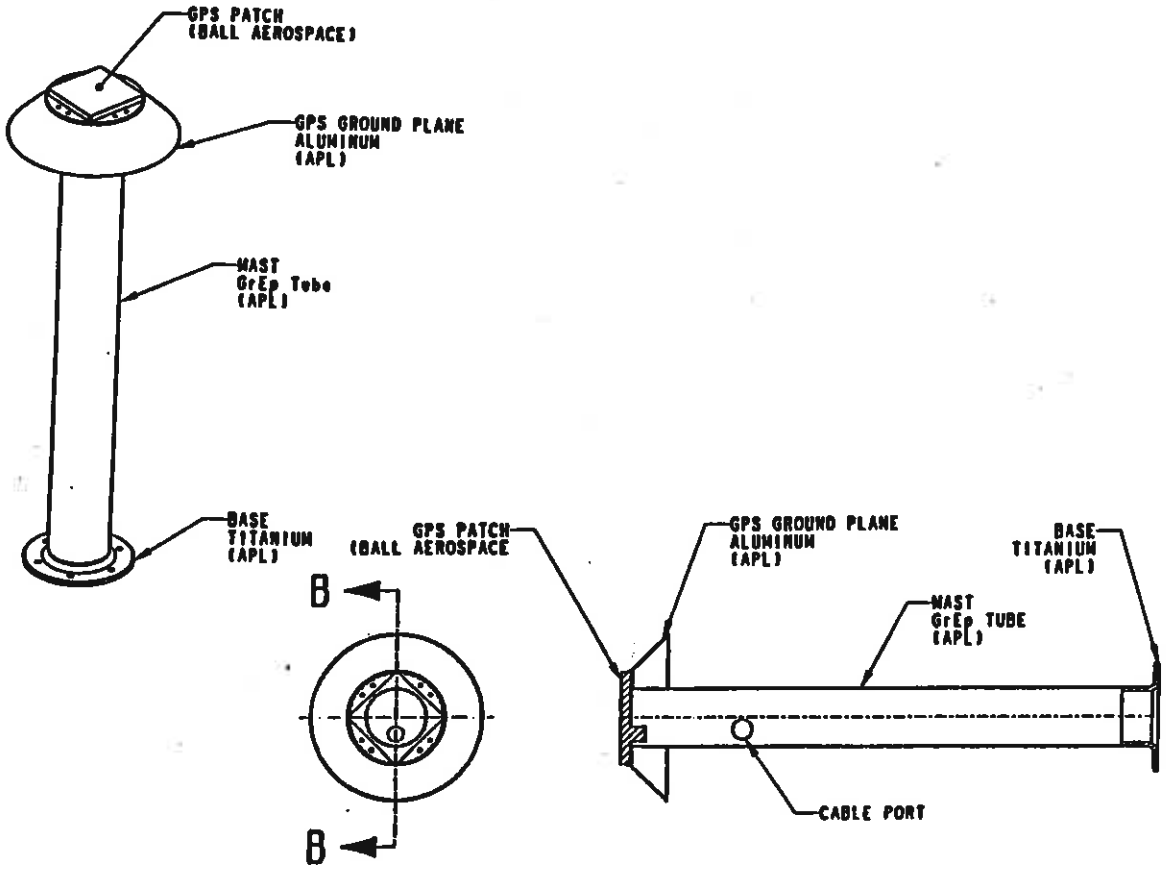
- **GPS Antenna Masts (2X)**
- **S-Band Zenith (-Z) and Nadir (+Z) Communication Antenna masts**
- **Solar Array Drive Motor Brackets**
- **Reaction Wheel Brackets**

Spacecraft Secondary Structure
GPS Antennas and Masts

- **Requirements**
  - **Low Mass**
  - **Support Antennas**
  - **Placement for CFOV to be (180 x 360 degree) highest point on Zenith (-Z) deck**
  - **Mechanical Interface to Optical Bench (titanium interface flange)**
  - **Hat Coupler Interface**
  - **Minimal thermal distortion in orbit between antennas (Optical Bench required location)**
- **Status**
  - **Design Complete**
  - **Release to Drafting 12/12/97**
  - **Deliver 1/28/98**
  - **Calculated Mass = 0.62 Kg.**

Spacecraft Secondary Structure

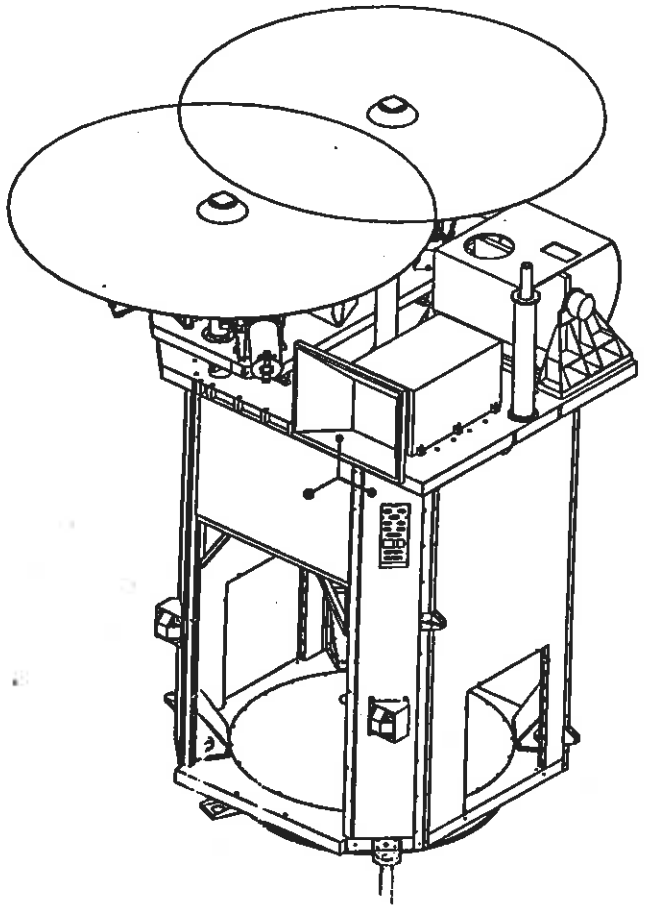
GPS Antennas and Masts



SECTION B-B

Spacecraft Secondary Structure

GPS Antenna FOV



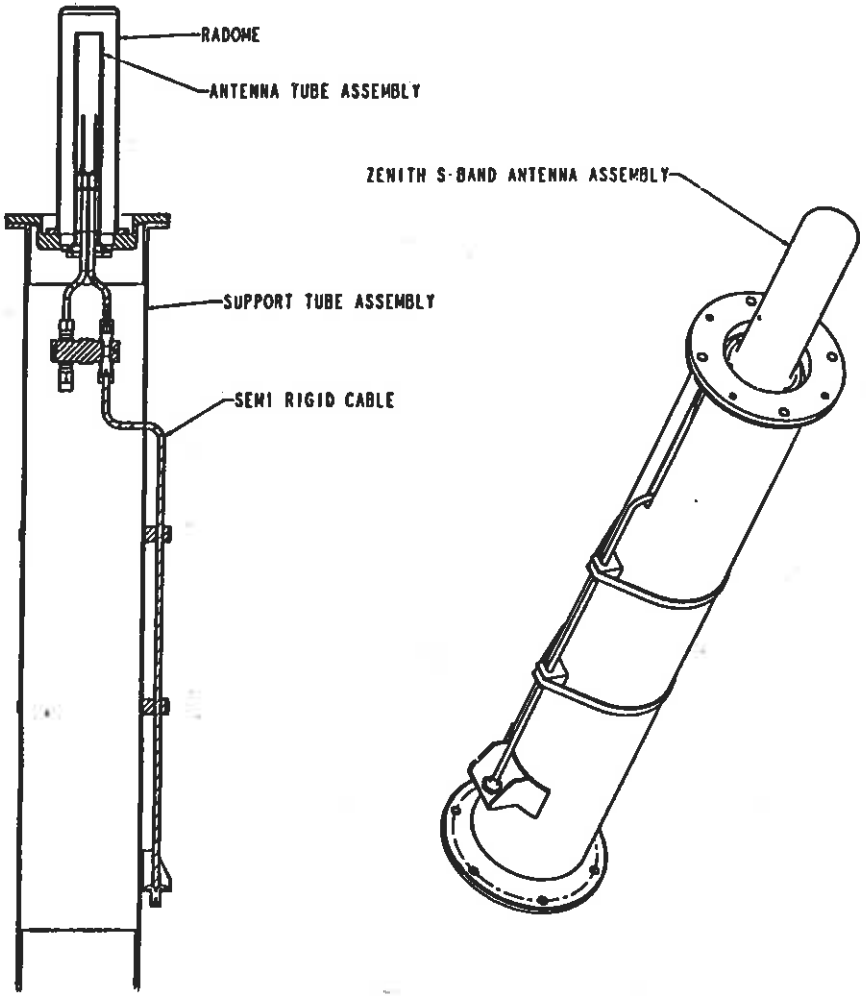
Spacecraft Secondary Structure

S-Band Zenith (-Z) Mast

- Requirements
  - Low Mass
  - Support Antennas
  - Placement for "best available" CFOV
  - Hat Coupler Interface
- Status
  - Design Complete
  - Drawings in Checking
  - Delivery:
  - Flight 7/15/98
  - Flight 7/15/98, EM 12/15/97
  - Calculated Mass (entire assembly)=0.6 Kg. each

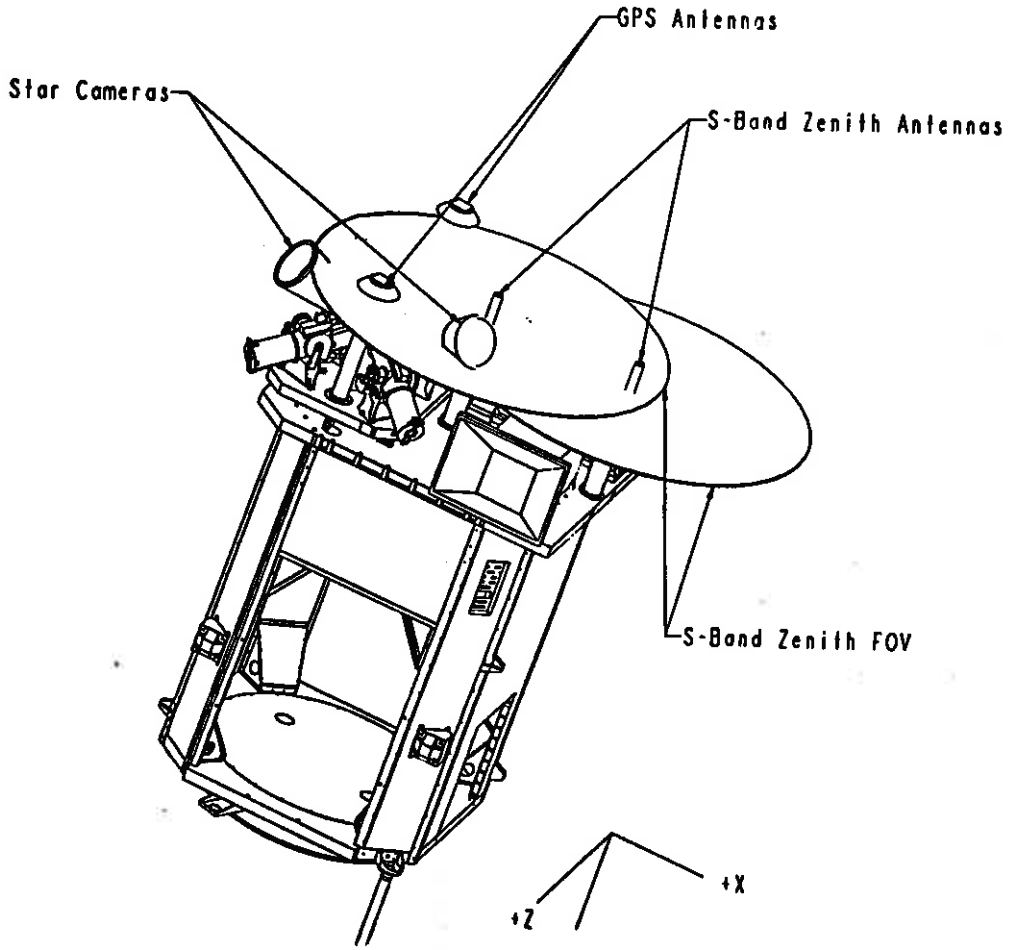
Spacecraft Secondary Structure

S-Band Zenith (-Z) Mast



Spacecraft Secondary Structure

S-Band Zenith (-Z) FOV



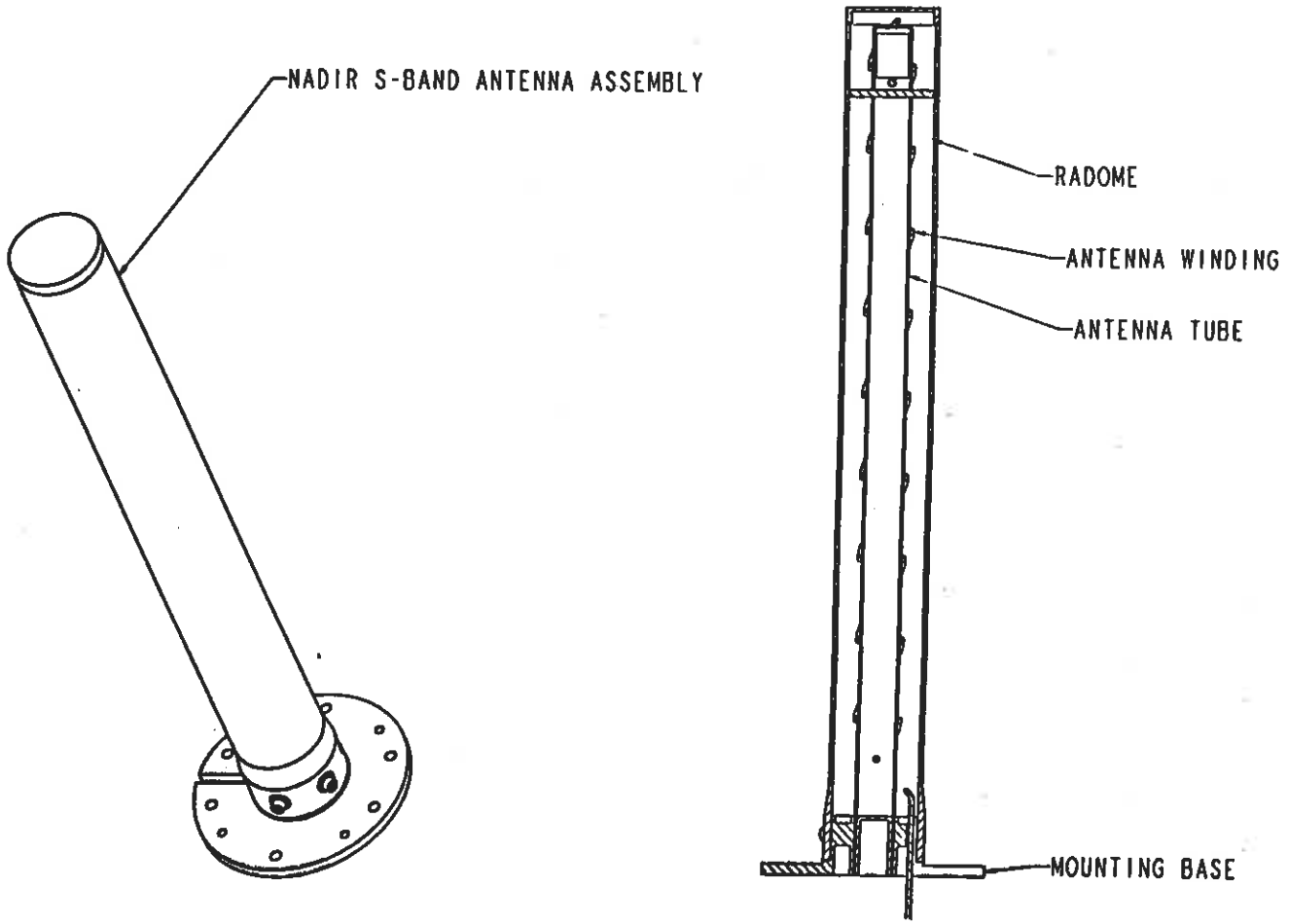
Spacecraft Secondary Structure

S-Band Nadir (+Z) Mast

- **Requirements**
  - **Low Mass**
  - **Support Antennas**
  - **Placement for CFOV**
- **Status**
  - **Design 90% Complete**
  - **Drafting efforts started**
  - **Delivery: Flight 4/16/98, EM January 98**
  - **Calculated Mass (entire assembly)=0.91 Kg.**

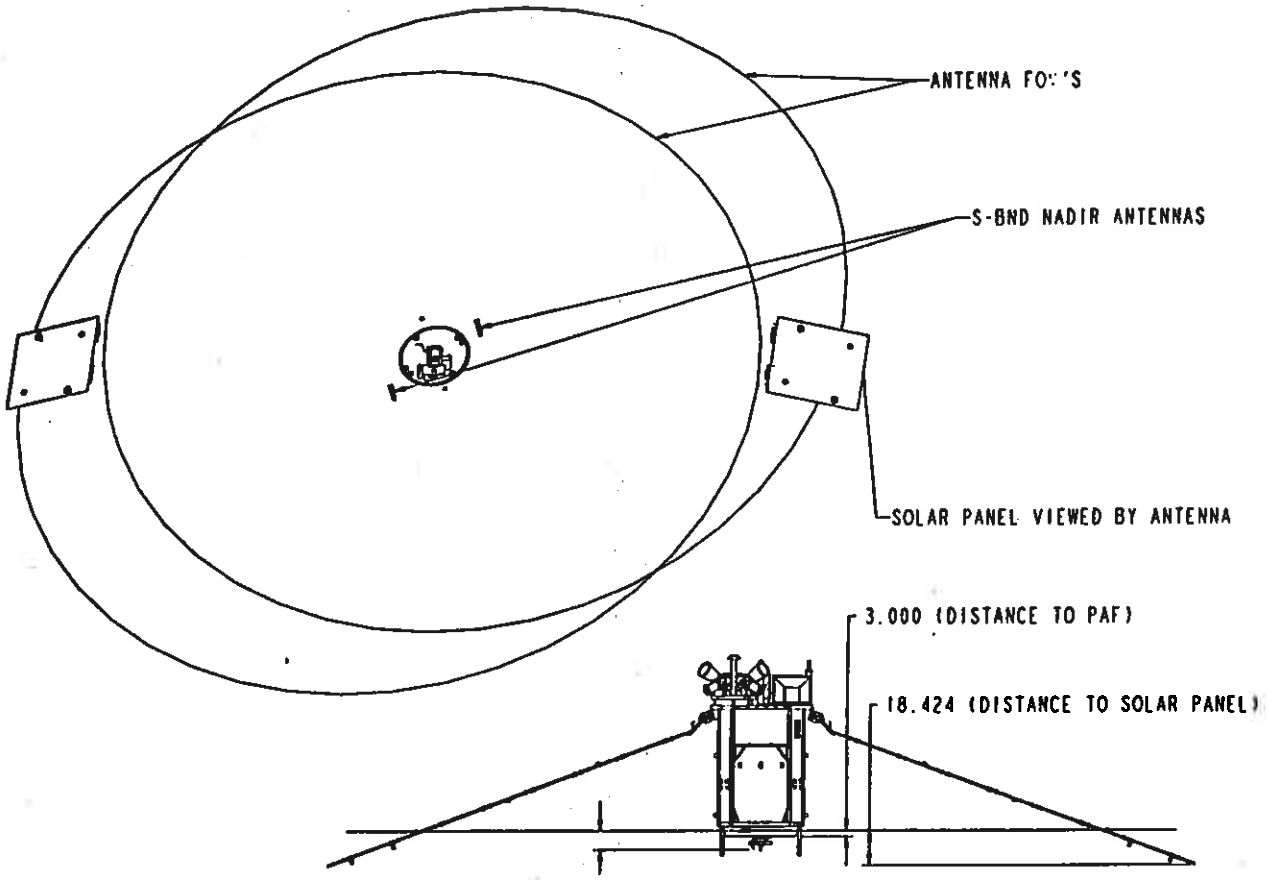
Spacecraft Secondary Structure

S-Band Nadir Mast



Spacecraft Secondary Structure

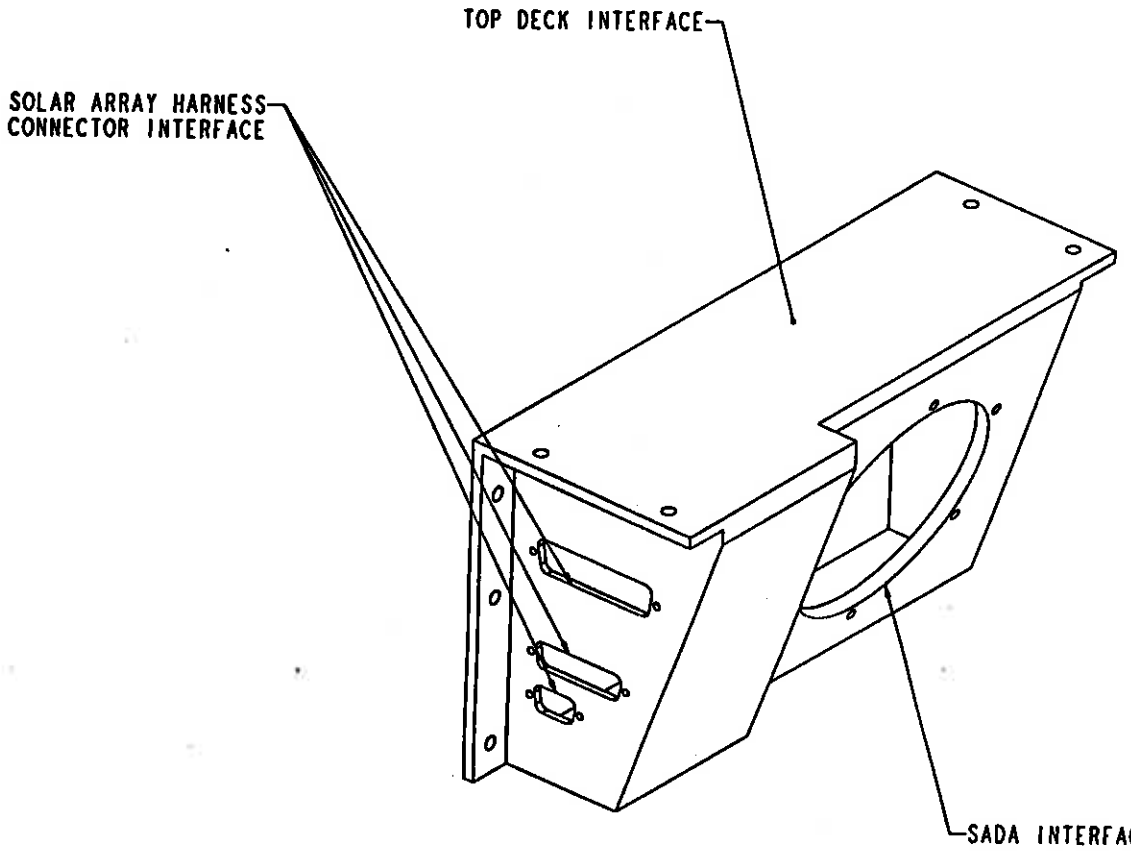
S-Band Nadir FOV



Spacecraft Secondary Structure
Solar Array Drive Motor Brackets

- **Requirements**
  - **Interface to Schaeffer type 3 SADA**
  - **Provide Array harness interface connectors**
- **Status**
  - **Detail Design Complete**
  - **Release to Drafting 1/27/98**
  - **Delivery Required 6/4/98**
  - **Calculated Mass = 1.0 Kg.**

Spacecraft Secondary Structure
Solar Array Drive Motor Brackets



Spacecraft Secondary Structure
Reaction Wheel Brackets

- **Requirements**
  - **Interface to all 4 reaction wheels**
  - **Conduction heat path to deck**
- **Status**
  - **Detail design in process**
  - **Release to Drafting 1/27/98**
  - **Delivery Required 4/16/98**
  - **Calculated Mass = 4.52 Kg. (total for all 4 wheels)**

Solar Arrays

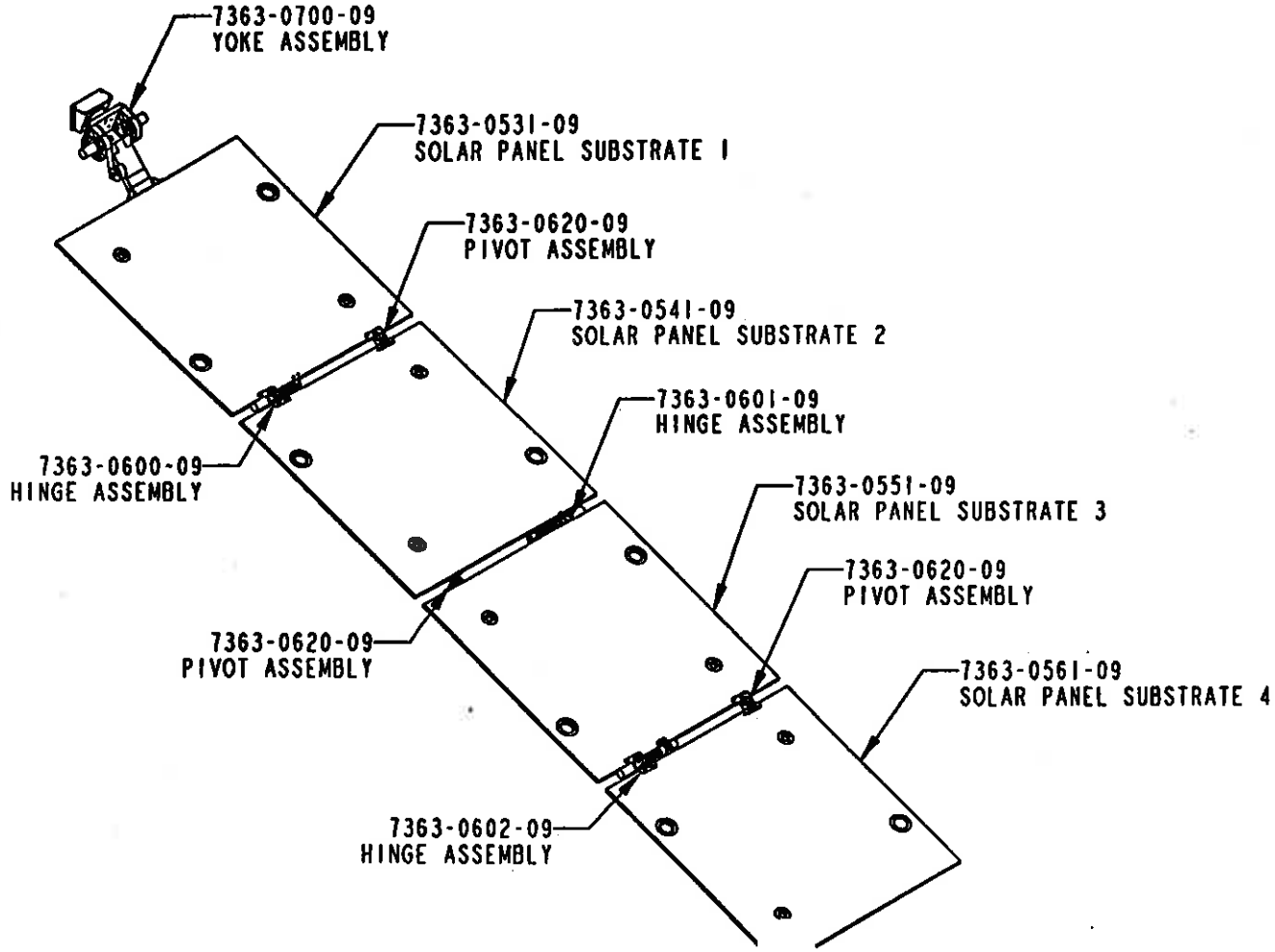
- **Requirements**
- **Flight Design**
- **Engineering Model Development efforts**
- **Testing and Qualification**
- **Issues and Concerns**

Solar Arrays

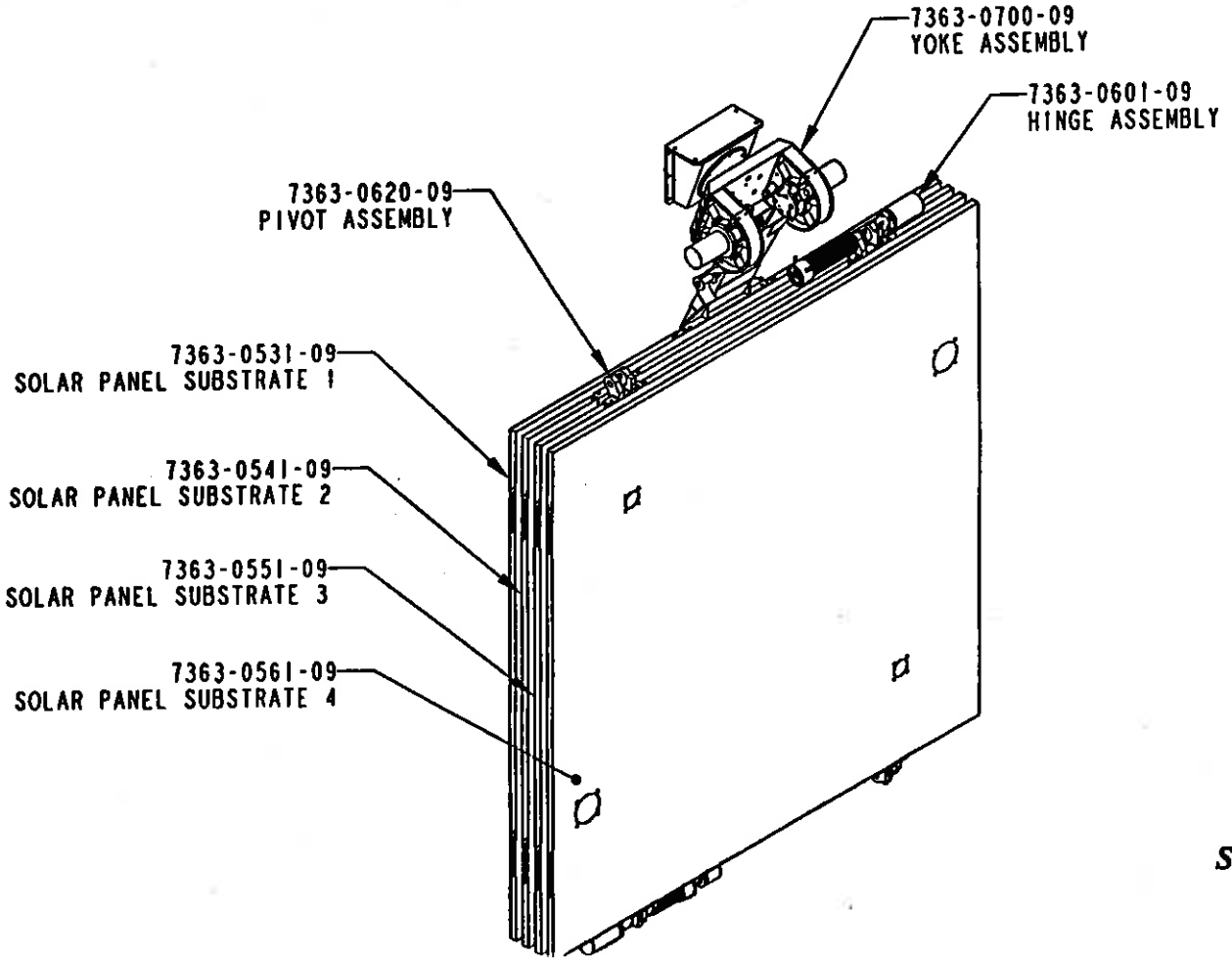
Requirements

- 120 square feet overall area for 410 watts orbit average power
- Rotate 0-100 degrees
- Fit within TIMED DPAF envelope
- Clear all Instrument and Sensor FOV's
- 20 degree tilt towards Nadir

Solar Arrays
Flight Design



Solar Arrays
Flight Design



Solar Arrays
Flight Design

- 4 Panels (per wing)
  - Aluminum face sheets and honeycomb core
  - Magnesium inserts
  - Kapton .002 (inch thick) insulator on cell side of panel
- Panel Hinges (2 per hinge line)
  - Viscous Damper connects to hinge shaft via flexible coupling (no arms and/or levers, etc.)
  - Elgiloy Torsion Spring, heat treated to 300 ksi tensile
  - Viscous Damper keeps lockup moments below 1200 in-lb limit.
  - Self aligning spherical Bearing
  - Latch at end of travel
  - Pivot (clevis) hinge on opposite panel side (no damper, spring or latch)

Solar Arrays - Flight Design

- Yoke Hinge
  - 4, preloaded angular contact bearings
  - Layered constant torque spring
- Release Mechanism
  - Hi-Shear 9321 low shock series separation nut
  - Retraction Spring
  - Instrumented (strain gauge) Bolt for precise preload control
- Supports
  - 4 point support system
  - Kinematic mounts:
    - > 2 Flats
    - > 1 Ball & Socket
    - > 1 'V' Groove

Solar Arrays
Flight Design

Analysis:

- Rigid body Kinematic analysis performed using 'Working Model' v. 4.0.
- Nastran FEM built for both the stowed and deployed conditions:
  - 2888 Elements
  - Deployed with rigid constraints to the SADA Shaft:
    - F1 = 0.25 Hz Out of Plane Bending
    - F2 = 1.3 Hz In Plane Bending of Yoke
    - F3 = 1.6 Hz Out of Plane Bending, 2nd Mode
    - F4 = 2.0 Hz Torsion
  - Stowed with rigid constraints to spacecraft body:
    - F1 = 36.6 Hz Panel 4 Out of Plane Bending
    - F2 = 39.9 Hz Stack Thrust Rocking
    - F3 = 41.4 Hz Panels 2 & 3 Out of Plane Bending

Solar Arrays
Flight Design

Analysis (cont):

- **Nastran FEM (cont):**
  - **7 Static Load Cases:**
    - **1) 0.094 in Preload at Ball & Sockets**
    - **2&3) ± 7.5 G's in X (Spacecraft Tangential)**
    - **4&5) ± 15.0 G's in Y (Spacecraft Thrust)**
    - **6&7) ± 15.0 G's in Z (Spacecraft Radial)**
  - **Stress Results:**
    - **Yoke: Max Stress from all Cases: 1314 Psi**
    - **Panels: Max Stress from all Cases: 13679 Psi**
    - **Ball & Socket Inserts, all Cases: Minimum Msu = +0.05 Flange Bending**
    - **Release Fitting Inserts, all Cases: Minimum Msu = +0.03 Flange Bending**
    - **Hinge Arms and Shaft, all Cases: Minimum Msu = +0.14 Shaft Pin Shear**

TIMED Solar Array Deployment Analysis Results

Joint		3-4	2-3	1-2	Root
Pin Friction	in-lbs	4	4	4	5
Harness Friction	in-lbs	5	10	15	20
Damper Friction	in-lbs	1	1	1	1
Total Friction	in-lbs	10	15	20	26
Viscous Damping	in-lb-sec/rad	350	545	715	1750
Design Torque, in-lbs	BOT	51.25	72.5	115	112.5
	EOT	37.5	57.5	67.5	112.5
Spring Rate	in-lb/degree	0.076	0.083	0.264	1.607
Available Torque,in-lb	BOT	41.25	57.5	95	86.5
	EOT	27.5	42.5	47.5	86.5
Torque Margin	BOT	5.13	4.83	5.75	4.33
	EOT	3.75	3.83	3.38	4.33
Lockup Time	sec	31.8	32.8	32.9	19.7
Lockup Velocity	deg/sec	4.7	4.4	4.9	2.9
Lockup Moment	in-lbs	315	545	895	540

Constant Torq Root Spring
20 Deg Panel Droop
49.34 L x 47.12 W x 5/8 H

3/25/97
DFPersons
Tsator14.wm

Solar Arrays
Flight Design

- **Status**
  - **Solar Array EDR held 7/15/97.**
  - **11 Action Items answered per memo SEM-2-781, 11/11/97.**
  - **EM Wing deployment testing underway.**
  - **Flight substrate procurement in process, Delivery to APL 3/31/98**
  - **Final 'V' and Ball & Socket support in detail design**

Solar Arrays

Engineering Model Development Efforts

- **Goal Stated at SC PDR**
  - **Design, fabricate and test a high fidelity, full scale engineering model Solar Array for TIMED prior to SC CDR**
- **Purpose**
  - **Identify problems early in the development effort when time and resources are available**
  - **Ring out the GSE system on Engineering Model hardware prior to flight hardware arrival**
  - **Gain experience for technical personnel responsible for handling the system and minimize problems with Flight Hardware**
  - **Optimize the design before Flight hardware fabrication efforts commence**

Solar Arrays
Engineering Model Development Efforts

- **Status**
  - **All EM procurements and fabrication efforts completed**
  - **System Assembly (GSE and array wing w/yoke) completed**
  - **Harness fabrication complete (not yet integrated into system)**
  - **Deployment testing underway**
- **Tasks Remaining**
  - **Damper temperature vs. Torque testing**
  - **Integrate Harness and service loops**
  - **Measure rates at each hinge, acquire and analyze the data**
  - **Integrate and test with flight release and pyro assemblies**

Solar Arrays

Engineering Model Development Efforts

- **Overview of Engineering Model System**
  - **Aluminum panels simulate flight weight, size, inertia**
  - **Viscous Dampers**
  - **Flight hinge design (pivot and torsion hinges)**
  - **Flight Release mechanism design**
  - **Upgraded as designs mature**

Solar Arrays
Testing and Qualification

- **Engineering Model**
  - **Characterizes and verifies Flight design and GSE**
  - **Proof of Concept**
  - **Component and Sub-Assembly Level Thermal (Hot and Cold) release tests on Hinges, Yoke, and release mechanisms**
  - **Damper Vibration, Torque measurement (hot, cold)**
  - **System Level deployments and dynamics measurements**

Solar Arrays
Testing and Qualification

- **Flight Qualification Program**
  - **Component Level Thermal (Hot and Cold) on each Hinge and Yoke**
  - **Damper:**
    - **> Torque vs. temperature**
    - **> Vibration (generate bubbles)**
  - **Deployment testing (each wing, rates measured)**
  - **Complete System Level (each wing) Vibration test**
  - **Spacecraft Level Acoustic followed by "pop-n-catch" release**
  - **Walkout testing prior to Spacecraft Integration in the Field**

Solar Arrays

Testing and Qualification

TIMED Spacecraft TIMED Solar Array Testing Plan Chart Testing												
	Engineering Model						Flight Hardware					
Assembly/Component	TV Cold	TV Hot	Vib.	Torque Measure	Release Test	Deployment Dynamics	TV Cold	TV Hot	Vib.	Torque Measure	Release Test	Deployment Dynamics
Hinge Assy	X	X		X	X	X	X	X				X
Damper(component)	X	X	X	X		X	X	X	X	X		X
Spring (component)				X		X				X		
				X		X						
Release Mechanism Assy	X	X			X (hot&cold)	X	X	X			X (SC Level)	
Separation Nut					X (hot&cold)		X	X			X (SC Level)	
Ball & Socket	X	X			X (hot&cold)		X	X			X (SC Level)	
Support Flats	X	X			X (hot&cold)		X	X			X (SC Level)	
Retraction Mechanism Assy.					X (hot&cold)						X (SC Level)	
Yoke Assembly	X	X		X	X (hot&cold)	X	X	X		X	X (SC Level)	X
Bearings				X						X		
Negator Spring				X						X		
Harness												
Service Loop				X (hot&cold)		X				X (hot&cold)		X
Inter-Panel Harness				X (hot&cold)		X				X (hot&cold)		X
Complete Array Wing						X			X		X (SC Level)	X

Solar Arrays

Issues and Concerns

- **No Major Issues**
- **No major Concerns**

Schedule and Status

- **Primary Structure**
  - **All components in drafting**
  - **Deliveries 4/98-6/98, On Schedule**
- **Solar Arrays**
  - **Engineering Model Fab 90% complete (100% on major components)**
  - **Engineering Model (full scale) testing in process**
  - **Flight Design**
    - **> Substrates: Contract award late November 1997, Delivery is 4/98**
    - **> Hinges, Yoke, etc.**
      - **—Drafting 90% complete, Drawing Release 2/98**
      - **—Procurements in process**
      - **—Assembly and testing commences 5/21/98, Early Delivery 6/1/98**
- **Optical Bench**
  - **All components in drafting, Fabrication Start Jan. 98. Delivery 9/98**