HI Instrument – Design and Testing

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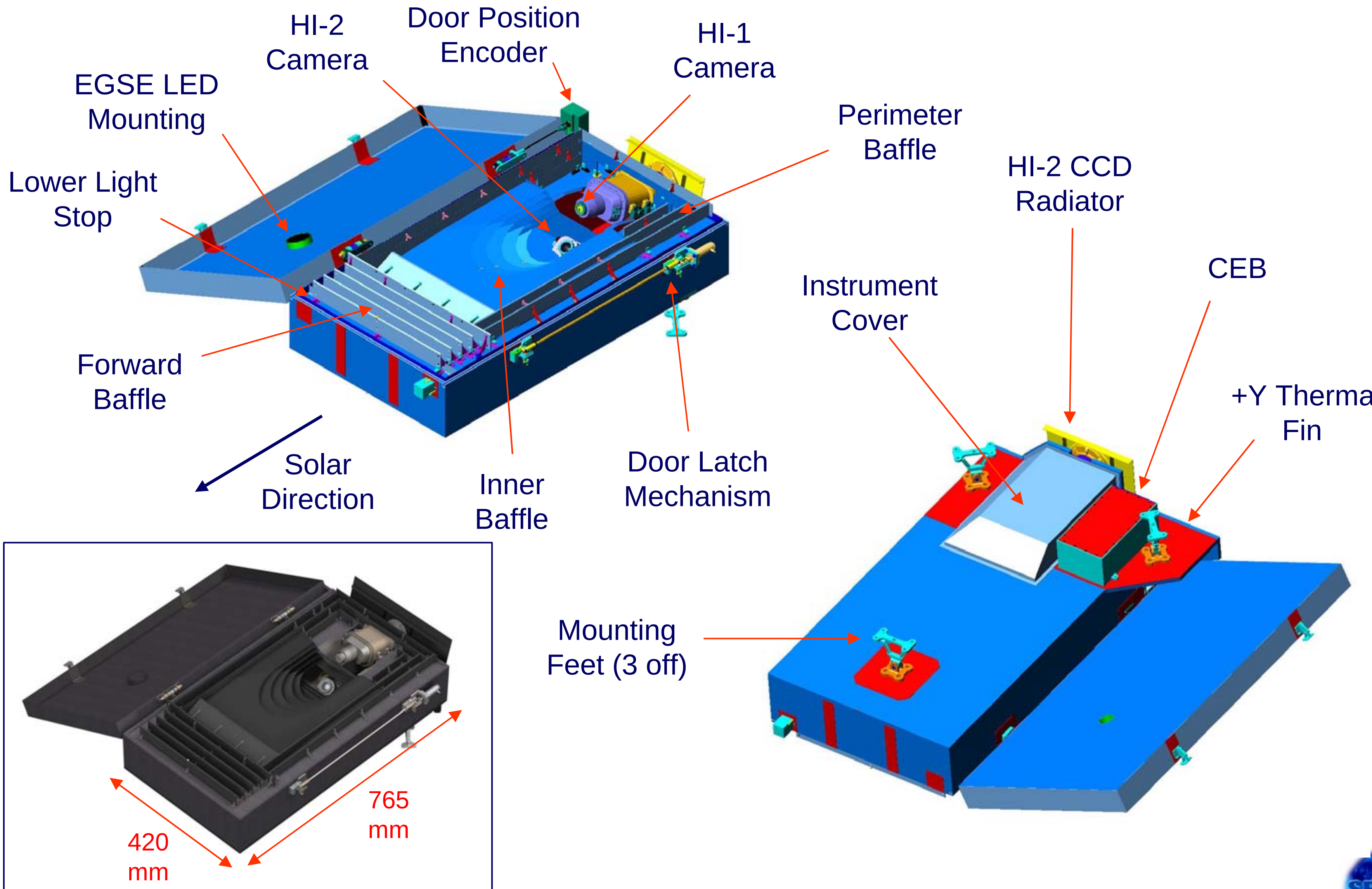
HI Performance Specification

	HI-1	HI-2
Instrument Type	Externally-Occulted Coronagraph	Externally-Occulted Coronagraph
Centre of Field-of-View Direction	Along Sun-Earth Line θ = 13.65 deg	Along Sun-Earth Line θ = 53.35 deg
Angular Field-of-View	20 deg	70 deg
Coronal Coverage	12 - 84 R_{sun}	66 - 318 R_{sun}
Overlap with COR2	12 - 15 R_{sun}	N/A
Overlap with HI-1	N/A	66 - 84 R_{sun}
Baseline Image (2 x 2 Binning)	1024 x 1024	1024 x 1024
Image Pixel Scale (Binned)	70 arcsec	4 arcmin
Spectral Bandpass	630 - 730 nm	400 - 1000 nm
Exposure Time	12 - 20 sec	60 - 90 sec
Nominal Images per Sequence	70	50
Required Cadence (per Sequence)	60 min	120 min
Brightness Sensitivity	3×10^{-15} B_{sun}	3×10^{-16} B_{sun}
Straylight Rejection	3×10^{-13} B_{sun}	10^{-14} B_{sun}
Brightness Accuracy	10%	10%

Heliospheric Imager Overview



Top Level Documents

Design Requirements:

- **SECCHI Science Requirements and Instrument Performance Specification (NRL 7906-SPC-9-0-0003)**
- **SECCHI Instrument Suite Resource Allocation Report (NRL 7906-RPT-9-0-0008)**
- **STEREO Environmental Definition, Observatory, Component and Instrument Test Requirements Document (APL 7381-9003)**
- **SECCHI Environmental Test Plan (NRL 7906-PLN-9-0-0004)**
- **STEREO Contamination Control Plan (APL 7381-9006)**
- **SECCHI Contamination Control Plan (NRL 7906-PLN-0-0007)**
- **STEREO EMC Control Plan and EMC Performance Requirements Specification (APL 7381-9030)**

Interface Control:

- **Interface Control Document for the SECCHI Investigation (APL 7381-9011)**
- **SICMs for Internal (SECCHI) Interfaces**

Other Top Level Design Documents:

- **HI-1 Instrument Design Analysis (CSL, 18 Feb 2002)**
- **HI-2 Instrument Design Analysis (CSL, 7 Mar 2002)**

HI Design Changes Since PDR (1 of 2)

- Replaced LASCO 3-2-1 Degree-of-Constraint Mounting Legs With Simple Flexure Mounts
  - Mass Saving; Reduced Misalignment Uncertainty
- Door Has Double Rather Than Single Latch Point (Still With Single Actuator)
  - Improve Latching and Reduce Door Flexing
- Door Seal Viton O-Ring Eliminated; Small Clearance Around Door Perimeter, Depend on Bagging and Purging to Maintain Cleanliness
  - Response to PDR RFA #8
- Deleted Shutter Mechanisms
  - Mass Saving
  - Shutterless Operation Feasible With Full-Frame CCD
- Replaced Camera/FPA Rotary Mounts With Simple Trunnion Mounts
  - Mass Saving; Simplified Arrangement
- Mass Reductions of CFRP Structure
- All CFRP Baffle Construction

HI Design Changes Since PDR (2 of 2)

- Revised Internal Baffle Design
  - Mass Saving; Easier Fabrication
- Baffles Painted With Z307 Not Z306
  - Response to PDR RFA #8
- Structure Rear Panel Extended at Sides to Provide Thermal Fins
  - Concerns About Interaction of –Y Fin With LGA
  - +Y Fin Acceptable
- Earth/moon Occulter Required (TBC); Planetary Occulter (TBD)
  - Final Decisions Awaiting Further Tests With CCD
  - Straightforward to Implement Occulter at Focal Plane
- Change in HI-1 Passband to 630-730nm
  - Facilitate Optics Testing With 633nm Laser
  - Slight Mismatch With COR2 Passband Not Considered an Issue

HI Mechanical Design Requirements & Drivers

Design Requirement Documents:

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- **SECCHI Contamination Control Plan (NRL 7906-PLN-0-0007)**

Design Drivers:

- **Provide Mounting Attachments for Subassemblies**
  - **Baffles**
  - **CEB**
  - **FPAs**
  - **Mounting Legs for Spacecraft Interface**
- **Minimize Structure Mass**
- **Highly Stable Structure Required**
  - **$\Rightarrow$ CFRP Structure - Measured CTE Values Typically < 0.2 PPM / Degree C**

HI Mechanical Design Heritage Summary

- CFRP Structure
  - Solar-B EIS Structure
- Leg Flexure Mounts
  - SPIRE Instrument on Herschel Space Observatory
- Door Hinges
  - Solar-B EIS Clamshell Door
- Door Latches
  - SMEI
- Door Encoder Components
  - LASCO

HI CFRP Structure Mass Saving

Approach to CFRP Structure Fabrication –

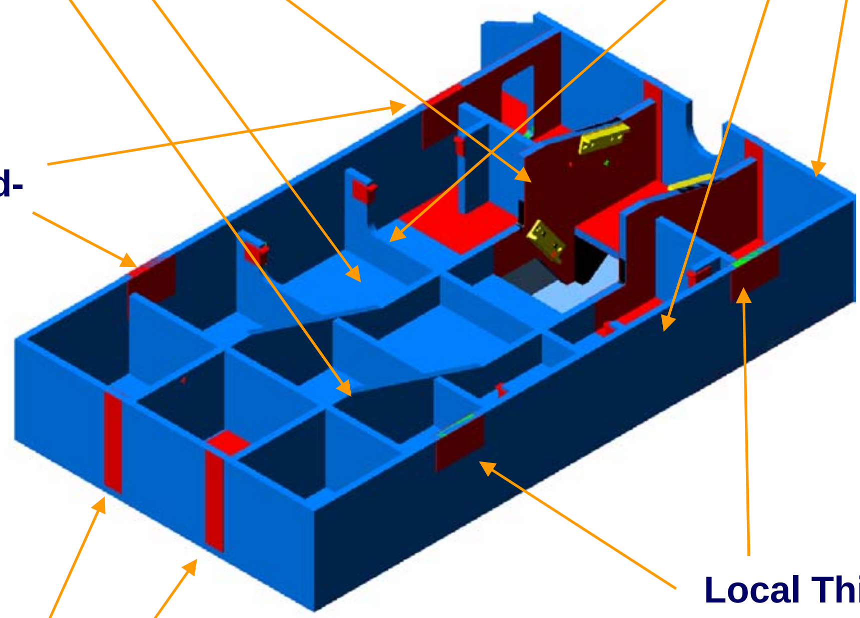
- **Minimize Skin Mass by Using Construction With 3 Layers of M55J/RS3 Per Skin With Lay-Up [0, +60, -60 Degrees] Where Practicable**
  - **Skins Themselves Are Not Quasi-Isotropic, but Panel Is Used for All Side Walls and Lateral Internal Panels (Non Load Bearing)**
- **Base Panel and Longitudinal Bulkheads (Load Bearing) Have 6 Layers of M55J/RS3 Per Skin With Lay-up [0, +60, -60 Degrees]**
  - **Problematic to Construct Panels From 3 Layer Skins With Hot-Bonded Inserts**
  - **Better Thermal Conductivity Along Length of Structure**
  - **Some Local Thickening Around Hot-Bonded Inserts**
- **Using Bonded Joints With Right-Angle Joining Strips Rather Than Potted Inserts for All Panel Connections Except for Longitudinal Bulkheads to Base Panel**
- **Using Low Mass Epoxy (0.000182 g mm^{-2}) for Bonding Skins to Honeycomb**
- **All Baffles Are Now CFRP**

HI Structure Fabrication

Base Panel and Longitudinal Bulkheads Have 6 Layer Skins [0, +60, -60 Degrees]$_s$ Hot-Bonded Inserts in Base Panel for Mounting Feet and CEB Attachments

Outer Panels and Lateral Internal Panels Have 3 Layer Skins [0, +60, -60 Degrees]

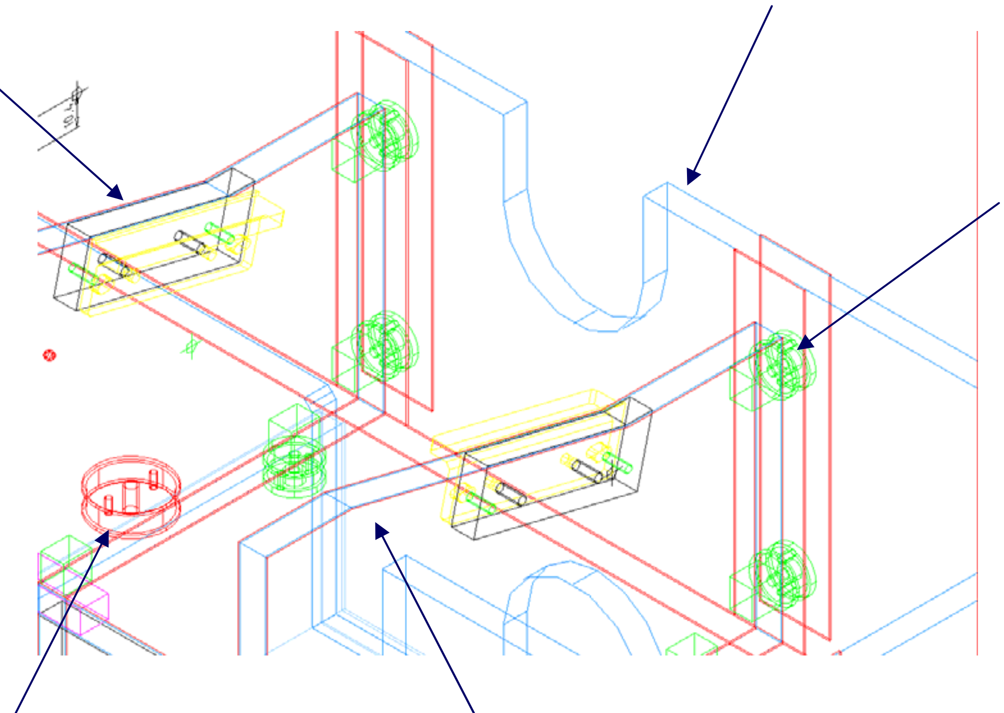
Local Thickening and Cold-Potted Inserts at Hinge Mounts



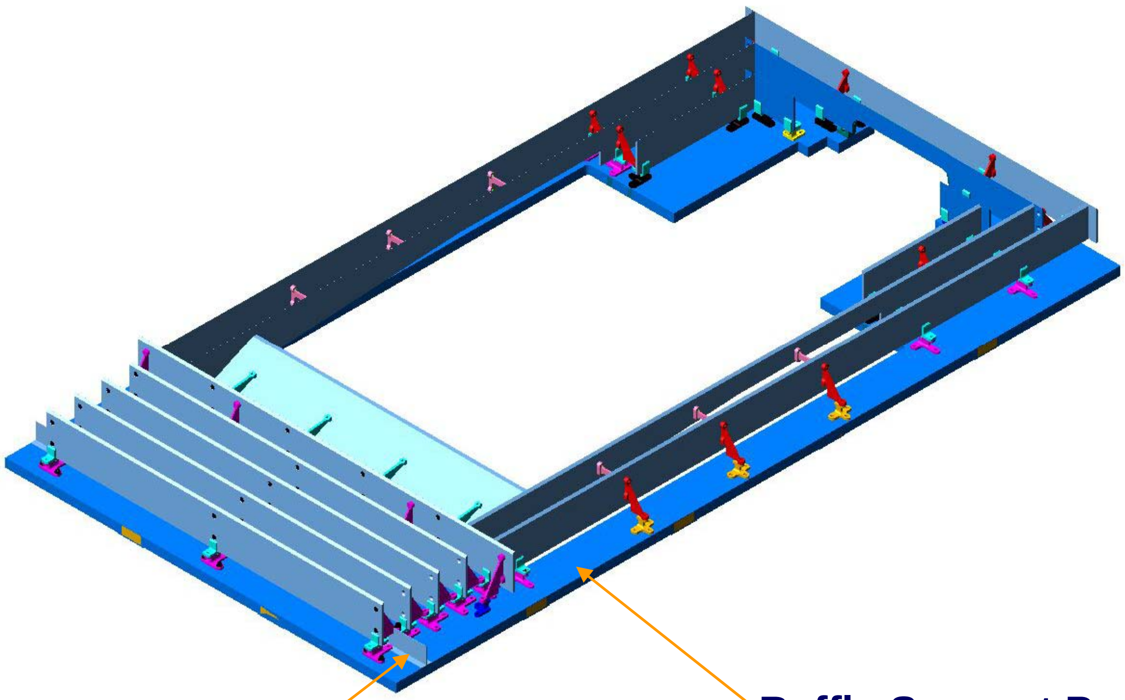
Local Thickening at Attachment Points for Longitudinal Bulkheads

Local Thickening and Cold-Potted Inserts at Latch Mounts

HI Structure Fabrication



Linear Baffles Assembly

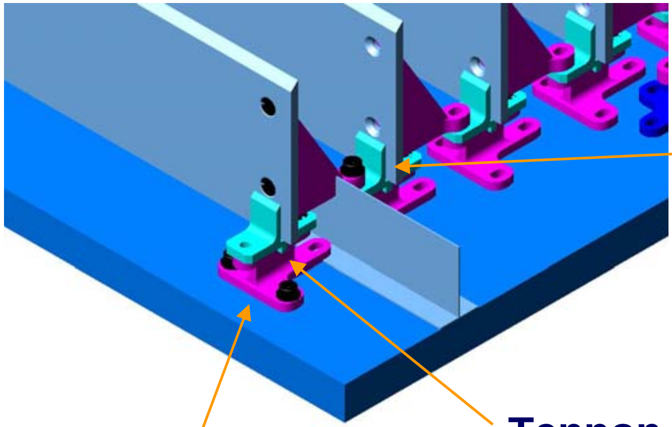


Baffle Support Panel TC2

Adjustable Attachment to Main Structure in +X / -X Direction – Then Pinned

Secondary Lower Light Stop

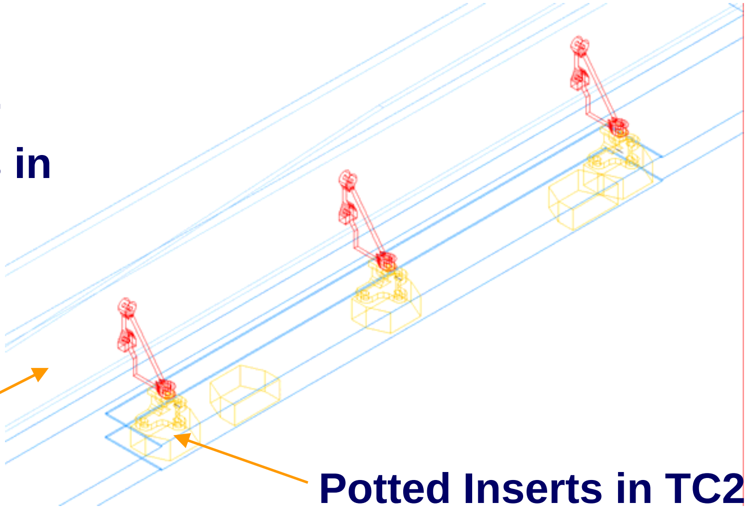
Linear Baffles Mounting Arrangements



Baffle Vanes Bonded Into Upper Fixtures

Tennon Between Upper and Lower Fixtures Constrains in +X / -X Direction

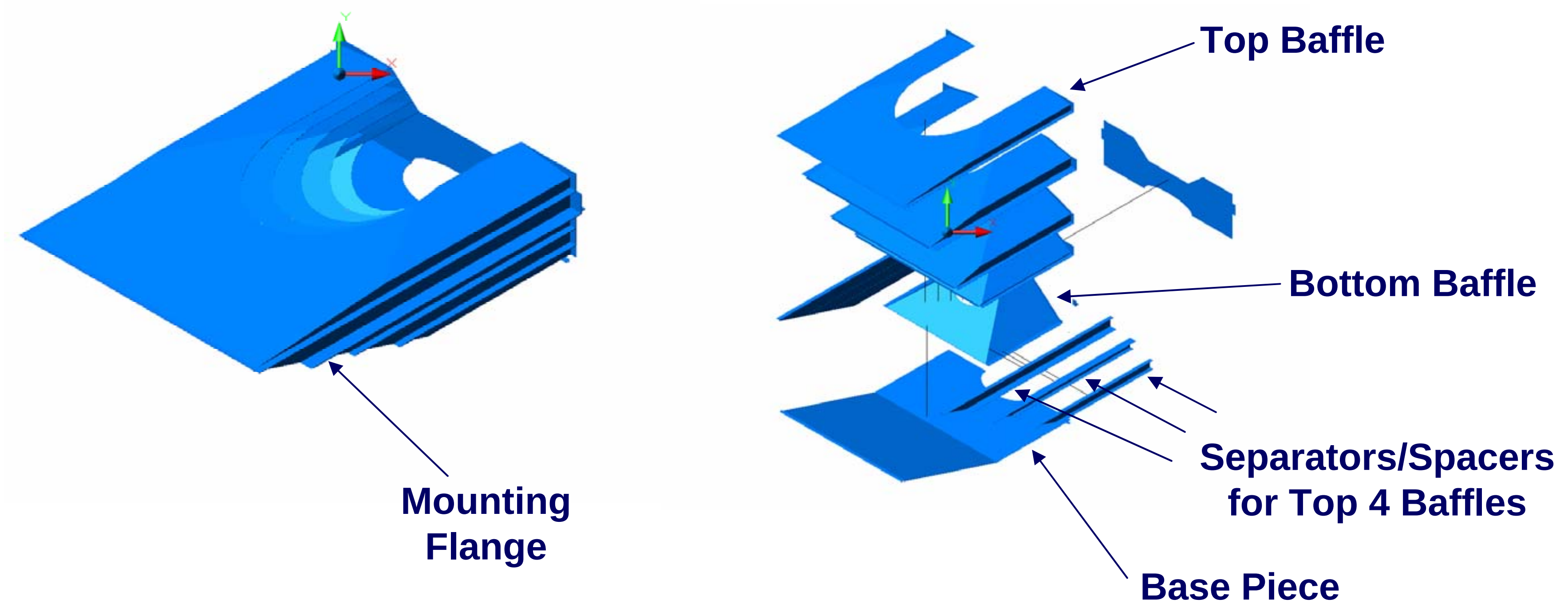
Base Fixture Adjustable in +X / -X Direction



Longitudinal Perimeter Baffle

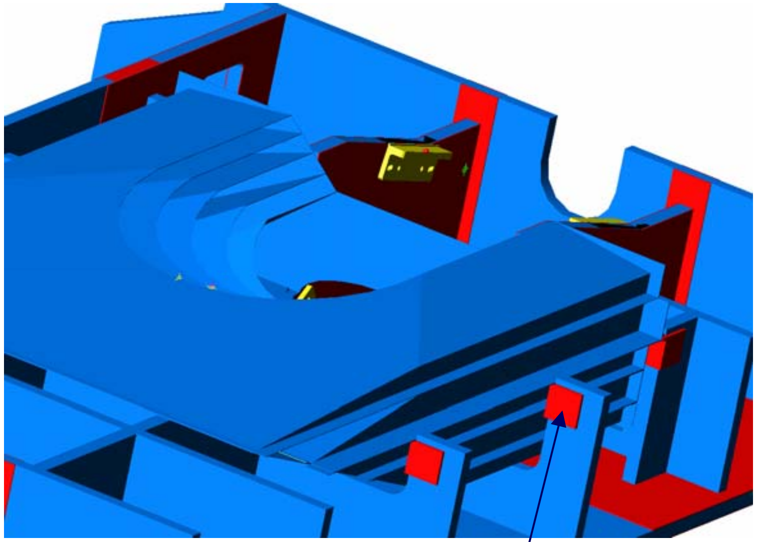
Potted Inserts in TC2 for Baffle Mounting Fixtures

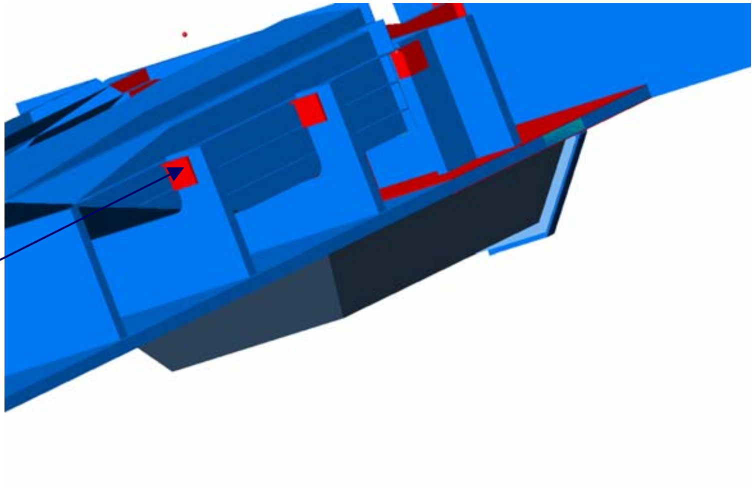
Internal Baffle Construction



- Baffles Fabricated From 3 - 8 Layers of T-300 Woven CFRP
- Adhesively Bonded to Give Strong Integral Structure
- Large Mass Saving Compared With Original Aluminum Concept
  - Estimated Mass 620g
- Reduced Fabrication Time Compared With Machining From Solid Aluminum
- Stray Light Rejection of Revised Geometry Studied by CSL

Internal Baffle Mounting in HI Structure





Mounting Flange Screwed Down Onto Lateral Panels

Baffle Assembly Alignment

- **Forward and Perimeter Baffle Edges Built up on a Single Baffle Support Panel (TC2):**
  - **Mounting Points on Main Structure for TC2 Will Be Finished Machined to Be Co-Planar**
  - **TC2 Is Fabricated on a Tooling Plate So Bottom Should Be Good Planar Surface**
    - **However, If Not Option to Cold-bond Pads Onto TC2 and Machine These to Be Co-Planar**
  - **Baffle Mounting Fixtures Provide Adjustability in ±X or ±Z Directions As Appropriate**
  - **Critical Baffle Height Positioning (±Y Direction) Achieved by Shimming And/or Machining in Situ**
    - **Successfully Used for EQM Forward Baffle Test Assembly**
  - **Setting up and Verification Will Be Done by Metrology Using 3-axis Coordinate Measurement Machine (CMM)**
- **Internal Baffle Mounting Provides for Adjustment by Shimming and Pinning**
  - **Also Set up and Verified Using CMM**
- **FPA Mounting Adjustment by Shimming and Pinning at Trunnion Mounts**
  - **Set up Optically by Procedure Described in CSL Technical Note 'HI – Pointing and Alignment', TN-CSL-STE-01007**
- **Optical Reference Cube Mount Adjusted by Shimming to Be Aligned With Reference Points on Tc2**

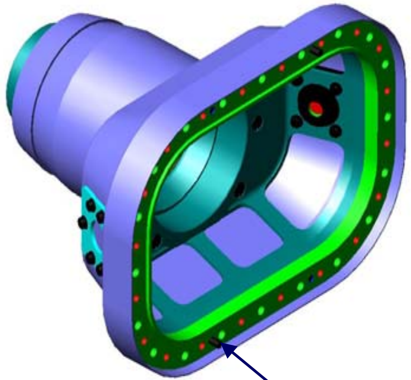
Alignment Requirements and Tolerances

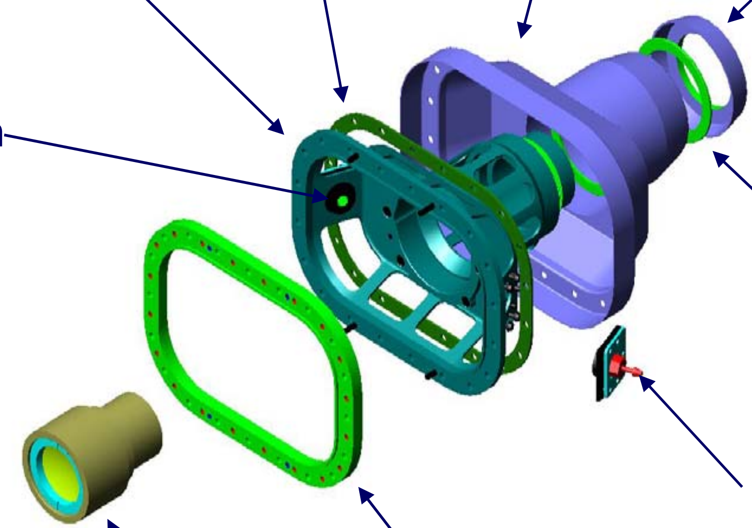
- **From 'HI – Pointing and Alignment', TN-CSL-STE-01007, Draft 3 –**

Constraints		**Acceptable error**
Forward baffle vane positioning & dimension	Avoid loss of one forward edge and reduce baffle efficiency **(1)**	Maximum ± 66µm on edge heights difference of two consecutive edges (y direction). A value of ± 50µm is recommended to keep margin.
	Keep the optimal inter-vane configuration	± 500-µm on edge separations (x direction)
Lateral and rear baffle vane positioning & dimension	Avoid loss of one forward edge and reduce baffle efficiency **(2)**	± 100-µm on relative edge heights (y direction)
	Keep the optimal inter-vane configuration	± 500-µm on edge separations (x & z directions)
Internal baffle vane positioning & dimension	Keep the optimised configuration	± 250-µm on relative edge tip heights ± 250-µm on edge tip position (x & y directions)
HI-1 FOV vs. HI elements	Avoid vignetting of HI-1 FOV by last forward edge	125 arcsec (θz direction) between border of FOV and the reference cube Sun centre direction
	Avoid vignetting of HI-1 FOV by lateral edges	.± 30 arcmin (θy direction) between border of FOV and lateral edge
	Only 1 line of pixels affected by last forward tip illumination (in case of vignetting) **(3)**	± 201arcsec of roll (θx direction)
HI-2 FOV vs. HI elements	Avoid vignetting of HI-2 FOV by internal edges	250 arcsec (θz direction) between border of FOV and the reference cube Sun centre direction
	Avoid vignetting of HI-2 FOV by lateral edges	± 30 arcmin (θz direction) between border of FOV and lateral edge
	Only 1 line of pixels affected by Earth illumination (Earth is moving in the FOV)	± 201 arcsec of roll

Table 2 Constraints and acceptable errors

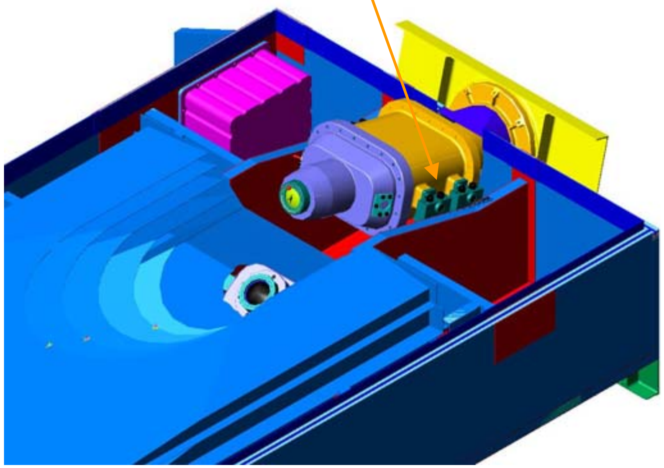
HI-1 Telescope Assembly

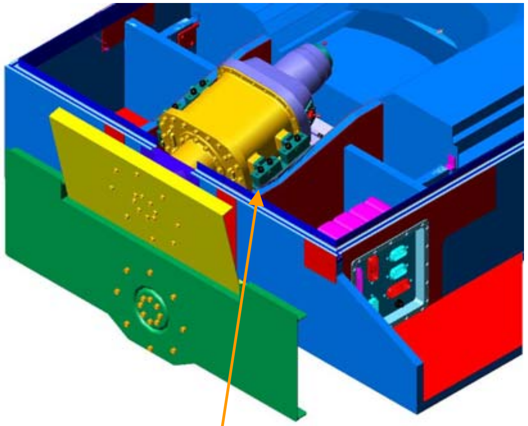




HI-1 FPA on Trunnion Mounts

Trunnion Mounts This
Side Constrain in 3 Axes



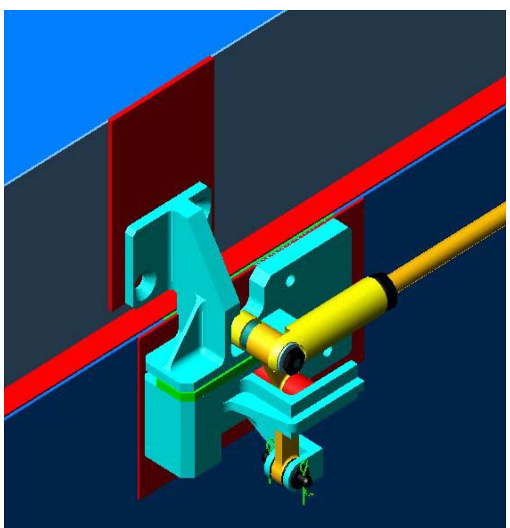


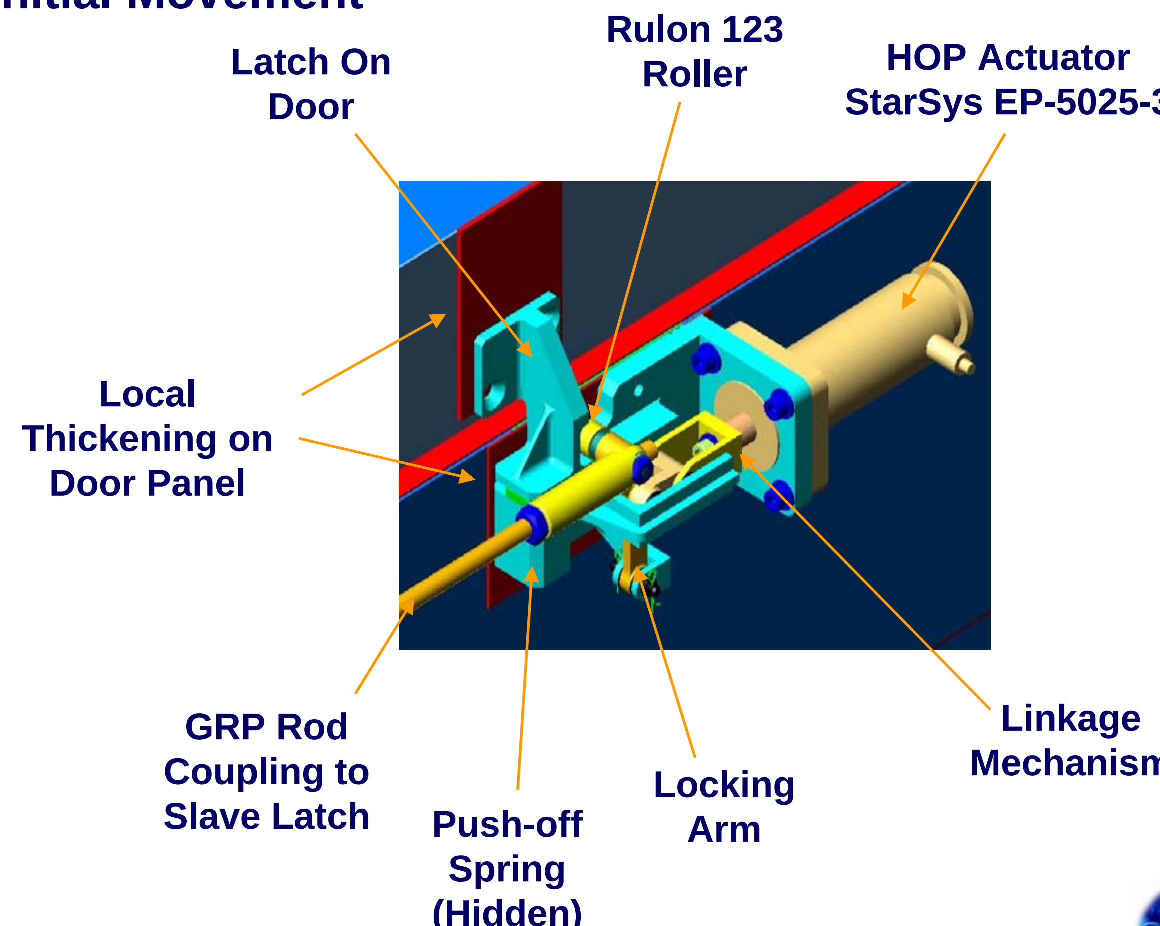
Trunnion Mounts This Side
Constrain in 2 Axes

- **Mass Saving Compared With Original Rotational Mounts**
- **Balanced Load Configuration – Not Cantilevered**
- **Adjustable by Simple Shimming and Pinning**
  - **Not Clear That Previous Arrangement Offered Any Significant Advantages**

Door Latch Mechanism

- Heritage Is Qualified Design From SMEI
  - All Bearings Rulon 123
  - Push-off Spring for Initial Movement



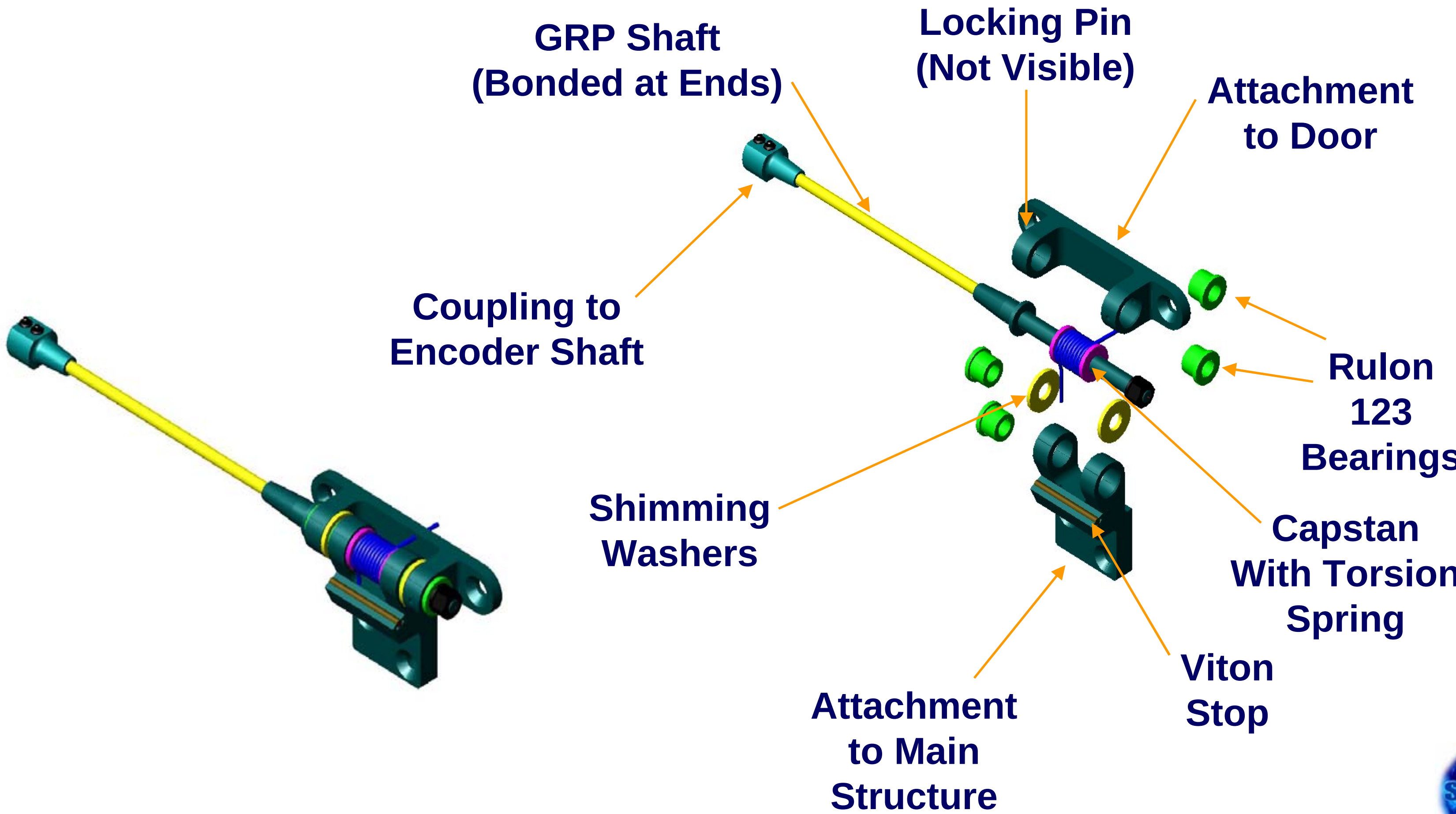


Door Latch Design

- Door Actuator is StarSys Type EP-5025-3
  - Rated Output Force = 50 lb f (minimum) = 225 N
  - Rated Non-Operating Load = 40 lb f (for no motion) = 200 N
- Door Is Restrained by Hinges on One Edge and Clamped by Latch Mechanism on Other Edge
  - Door Is Not Pre-Loaded; Clearance Between Door and Top of Main Structure
- Roller on Locking Arm Is Over-Centre in Latched Position
  - Lifting Action Releases Door
- Mechanical Advantage of 10/3 Between Actuator and Opening Force on Door in Latched Position
  - Safety Factor = 4.0 for 60g Quasi-Static Load on Door Relative to Rated Non-Operating Load of Actuator

Door Hinge

- Design Based on Solar-B EIS Clamshell Door Hinge
  - All Bearings Stainless Steel in Rulon 123
  - Simplified Design for Other Hinge (No Coupling)



Hinge Design Parameters and Margins

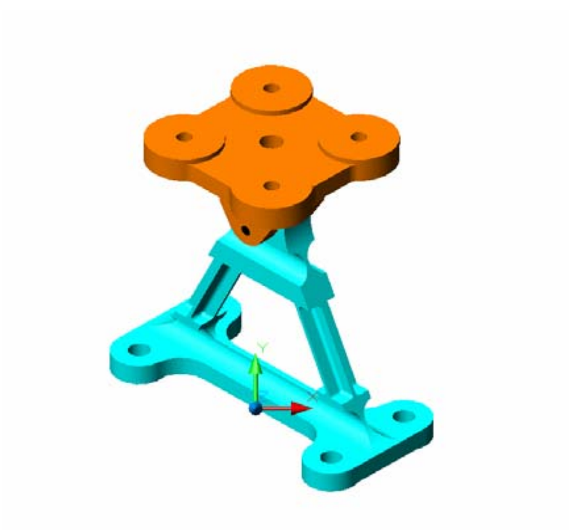
- Door Mass = 0.56 Kg
- Moment of Inertia = 0.033 Kg m^2 (About Hinge)
- Friction Torque $\leq$ 0.05 nm (Per Bearing – EIS Measurement)
- Require Single Spring to Have Design Margin Versus Friction = 2 at End of Motion
- Spring Constant = 1.31 x 10-3 nm Degree^{-1} (Per Spring – Same As in EIS Design)
  - 150 Degrees Pretension; 200 Degrees Opening Angle
- Hinge End Stop Stiffness Constant = 1.55 nm Degree^{-1} (per Hinge – EIS Measurement)

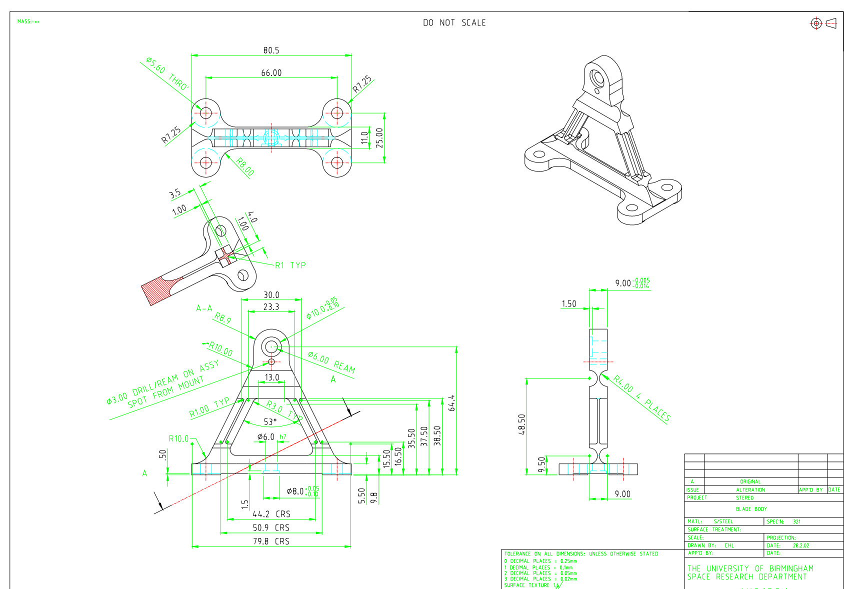
Design Margin Versus Friction	Door Closed ($\theta = 0°$)	Fully Open ($\theta = 200°$)
Two Springs	9.2	4.0
Single Spring	4.6	2.0

Parameters for Impact With Hinge End Stop	Including Friction	No Friction
Angular Velocity at Stop (deg s^{-1})	82	89
Angular Impulse (Kg m^2 s^{-1})	0.047	0.051
Overshoot (deg)	1.1	1.2
Peak Force on Each Stop (Kg f)	11.0	12.0

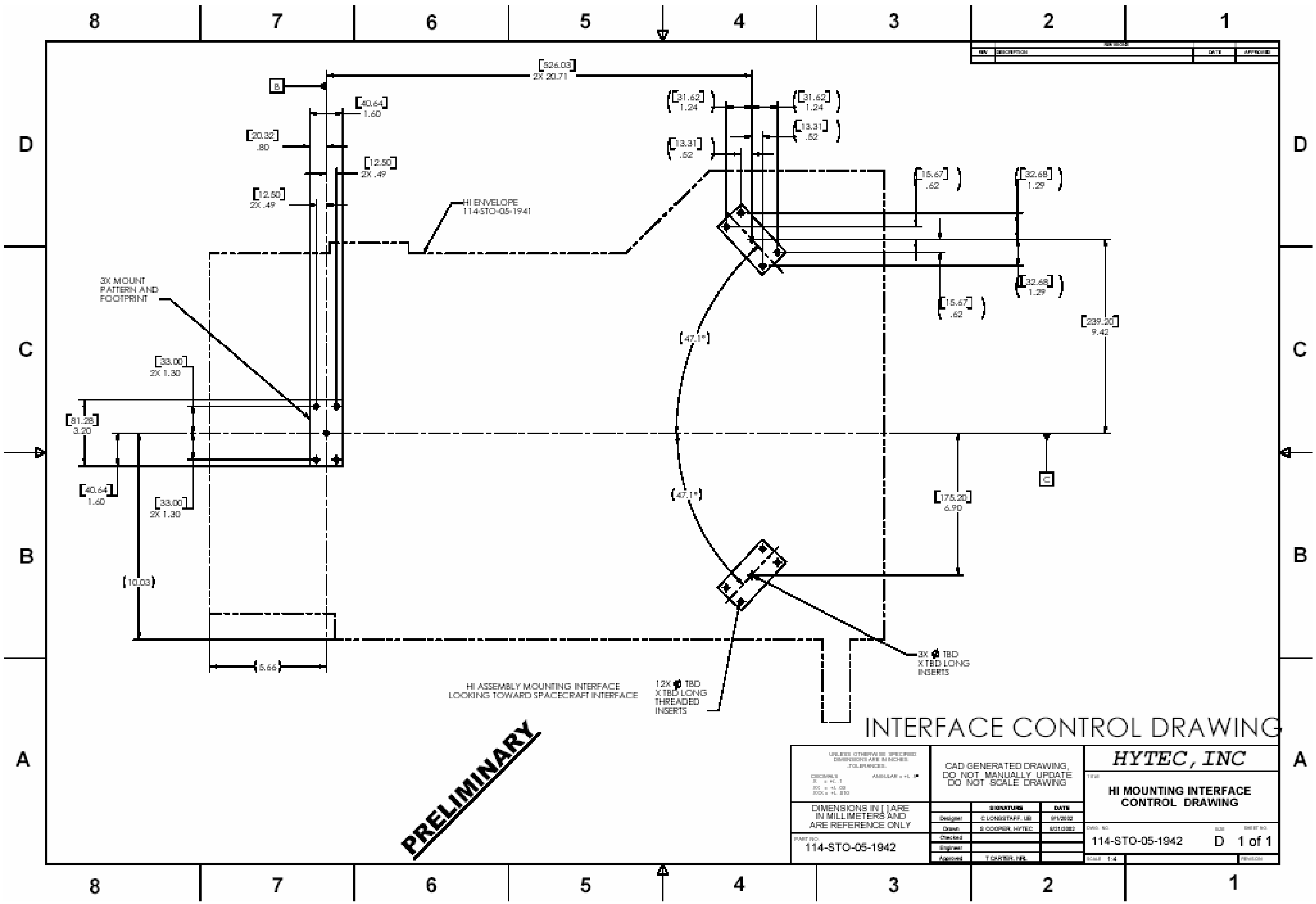
Revised Leg Design

- Heritage is SPIRE Instrument on Herschel Space Observatory
- Material Ti6Al4V (Grade 5 Titanium)
- Significant Mass Saving Compared to Previous LASCO Mounts (Mass = 156g)
- Avoids Concern About Post-launch Change in Pointing Alignment (~ 1-2 Arcmin With LASCO Mounts)
- Good Thermal Isolation (< 0.01 W/K per leg)
- Better Defined Thermal Isolation

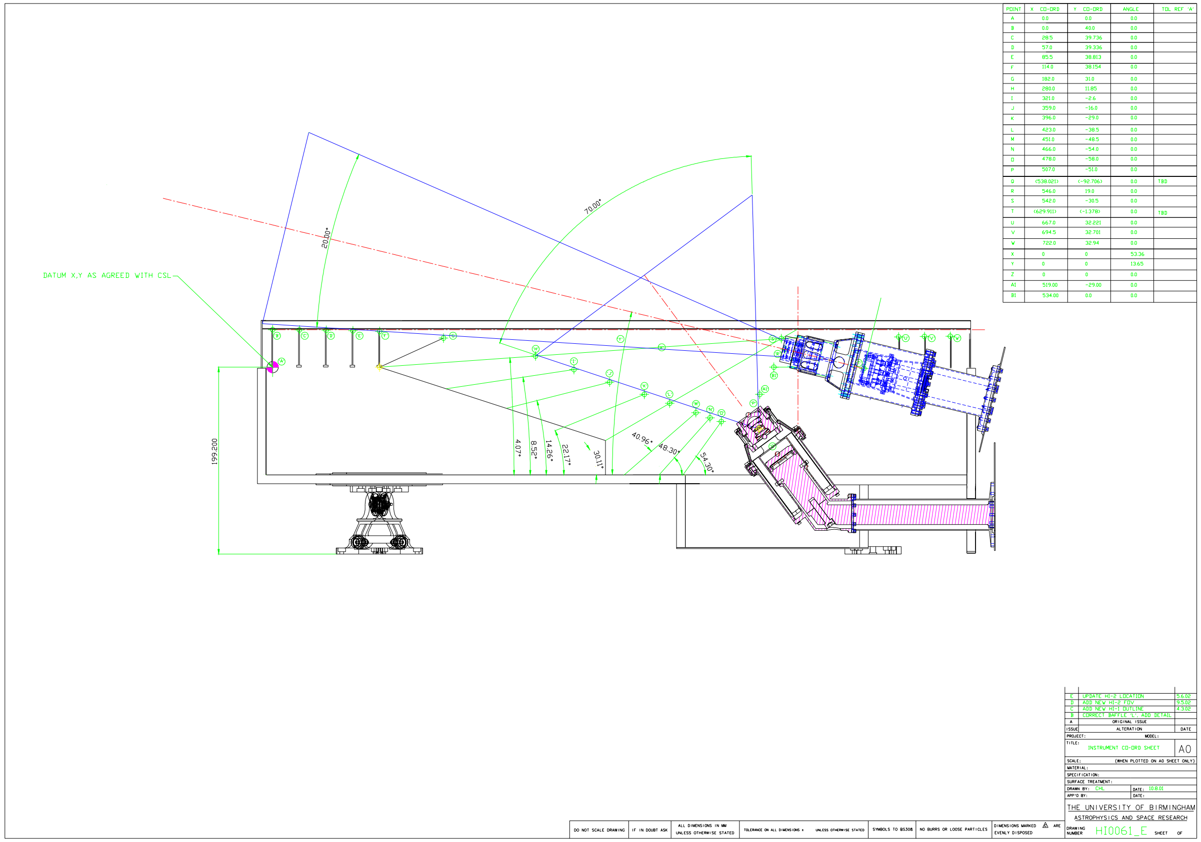




HI – Spacecraft Mounting Interface



HI Field of View Requirements



- Optical Field-of-view (OFOV) of HI-1 and HI-2 Defined by Cones of 20 Degree and 70 Degree As Above
- Unobstructed Field-of-View (UFOV) of HI Relative to by Plane Defined by Extreme Forward and Rear Baffle Vanes
  – UFOV Is Margin of 1.5 Degree Below This Plane (and Similar Plane Defined by Lateral Vanes)

HI Mechanical Systems Structural Analysis

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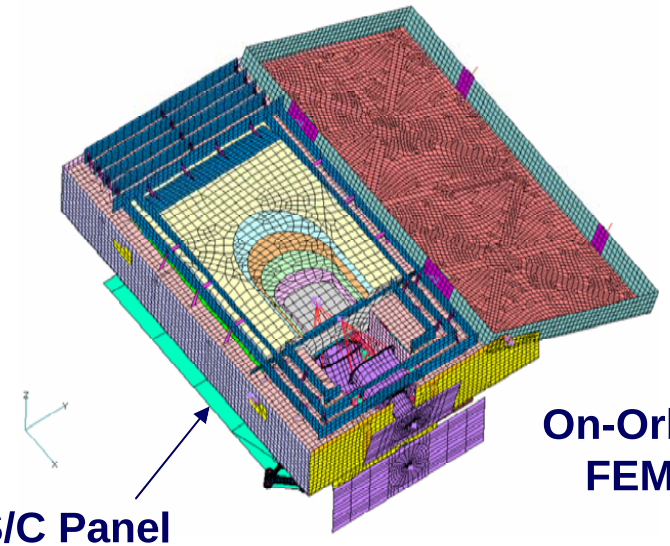
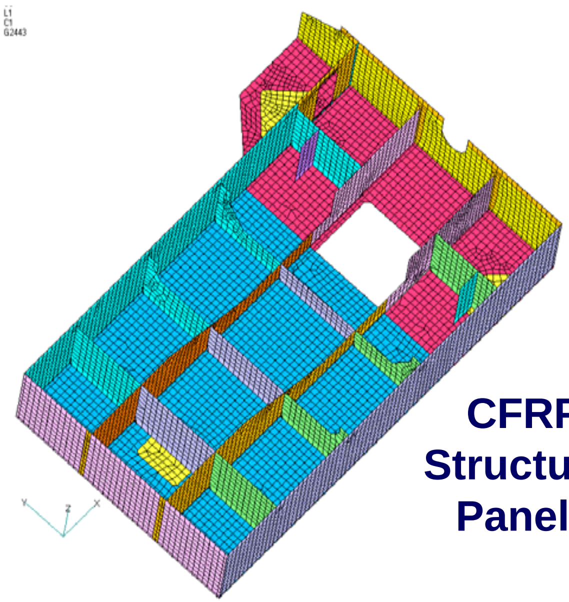
HI Structural Analysis Requirements/Methodology

- Key Requirements (per APL Environmental Specification 7381-9003 Rev. -)
  - Stiffness > 50 Hz
  - 25G Quasi-Static Load, Separately in 3 Orthogonal Axes
    - JPL Mass vs Acceleration Curve Requirements for Components
  - Qualification Vibration Environments for QM, Acceptance for FM
- Analysis Methodology
  - System Level FEM
    - Modal, Static, Thermal Distortion, CME, Dynamic Analyses
  - Internal Loads Recovered for Stress Analysis
  - Thermal Distortion - Mapped Thermal Analysis Results to Corresponding FEM Grids
    - Heat Transfer Used to Determine Temperatures on Remainder of FEM
    - Displacements at Optical Locations of Interest Recovered
  - FPA Vibration Environment Definition at Trunnion/Box Structure Interface

HI Assembly FEM

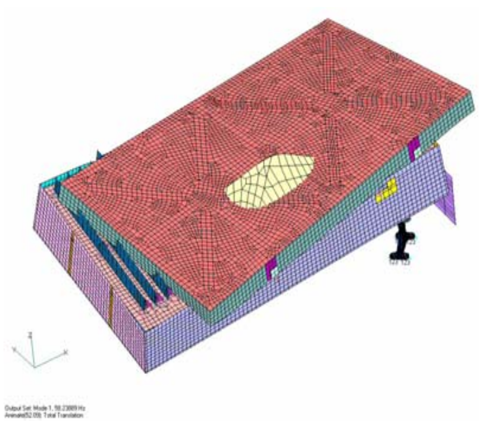
- Initial FEM Created From March 2002 CAD Model
  - Plates for Honeycomb Panels
  - Plates for Linear Baffles/Supports
  - Solid Elements for Mount Legs
- Modifications for CDR FEM
  - Geometry Per Latest Design
    - Transverse Bulkheads Attached by Bonded L Fittings
    - Door - Honeycomb Panel
    - Conservative Hinge/Latch Connections
    - Detailed Internal Baffle Assy
    - Detailed HI-1/2 FEM (Swales), Trunnion Boundary Conditions
    - Updated Linear Baffles, Removed TC1 Cover
    - No Support Leg Hinge (2nd Pin Prevents Rotation)
    - Updated Radiator Sizes Per Thermal Analysis
  - Analysis
    - Launch and On-Orbit (Open Door) FEMs
    - 12.5 Kg FEM Mass (Flight Allocation 12.3 Kg)
    - Performed Thermal Distortion Analyses

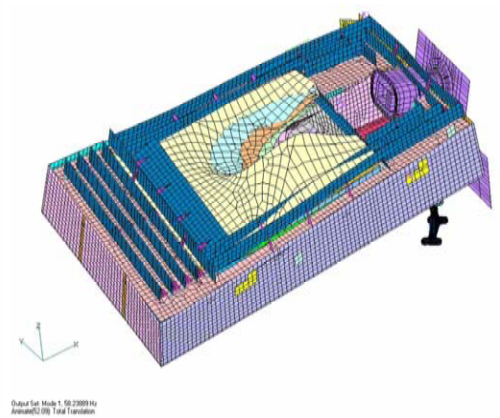


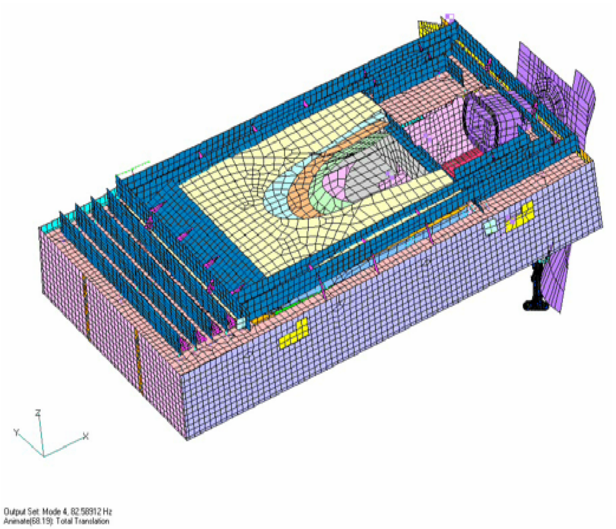


HI Assembly Modal Analysis

- **1st Mode 58.2 Hz : Local Door (Latch Restraint Normal to Door, 2 Places) and Internal Baffle Mode**

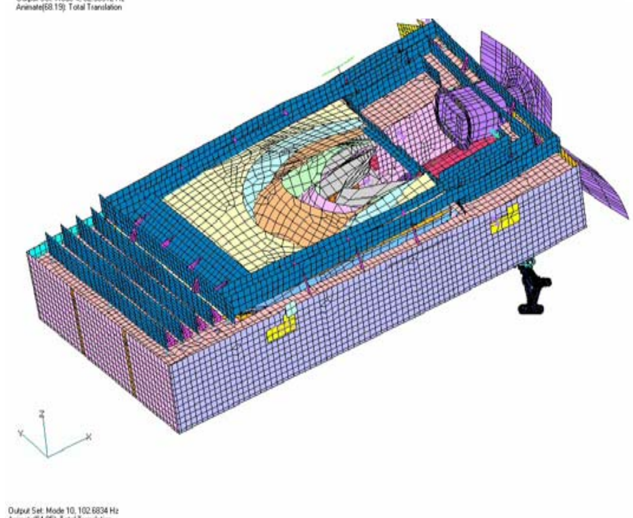






Mode 1: Door Twisting, Top Internal Baffle
Latch Restraint Normal to Door, 2 Places
(Ignore Restraint Due to Friction)

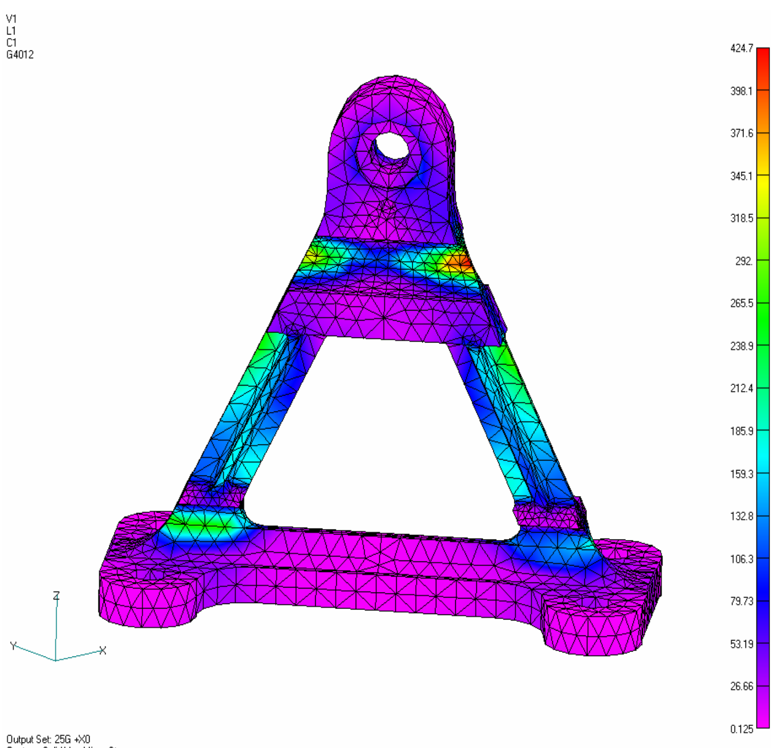
Mode #	Frequency	% Mass Participation					
	(Hz)	T1	T2	T3	R1	R2	R3
		long.	transverse	vertical	12.8		
1	58.2		11.3			20.3	
4	82.6		30.3			28.7	
10	102.7	37.3		14.4		27.0	
12	114.9	35.9		15.2			37.8
20	142.4			28.2			
37	208.8		15.5				
187	497.9						
1 - 187	0-500	98.5	98.0	96.1	84.0	96.0	97.4

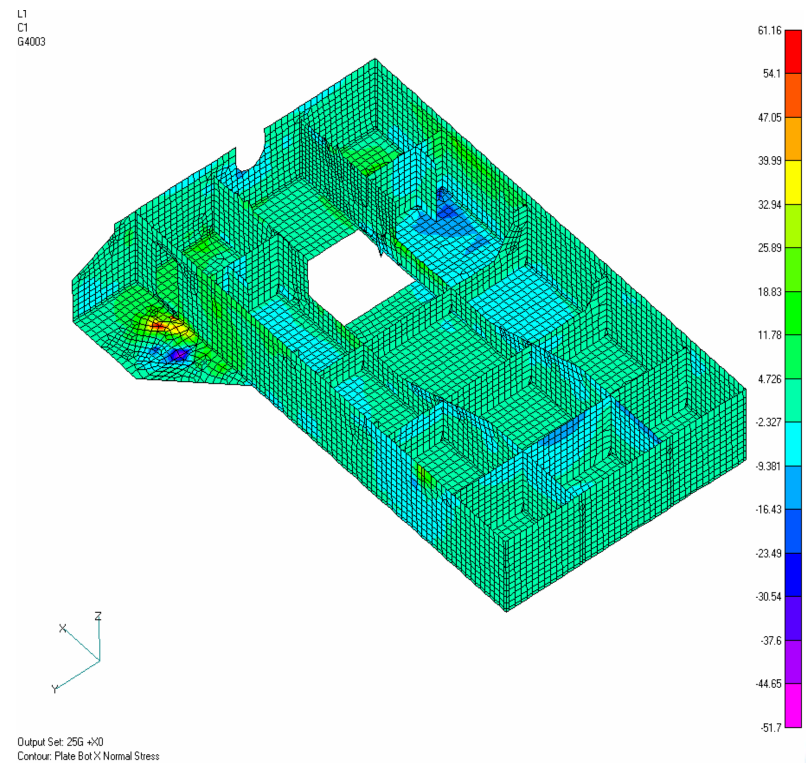


HI Stress Analysis

Maximum Stress and MS Summary								
Component	Material	25G Max Stress	Cold/Hot Op Max Stress	Allowable Stress	FOS	Margin of Safety		Notes
		(MPa)	(MPa)	(MPa)		Launch	On-Orbit	
Structural Panels	M55J/RS-3 Quasi-Iso	61.2	106.0	262.0	2.0	1.14	0.24	Local thermal stress
Door HC Panel	M55J/RS-3 Quasi-Iso	24.1	27.3	262.0	2.0	4.4	3.8	
Door Edges	T300/RS-3	26.1	54.8	551.6	2.0	9.6	4.0	
Panel TC2	M55J/RS-3 Quasi-Iso	44.7	127.5	262.0	2.0	1.93	0.03	Local thermal stress
Instrument Cover	T300/RS-3	58.5	33.2	551.6	2.0	3.7	7.3	
Internal Baffles #1-5	T300/RS-3	20.4	3.7	551.6	2.0	12.5	73.5	
Internal Baffle Supports	T300/RS-3	94.3	11.4	551.6	2.0	1.92	23.2	
Linear Baffles	M55J/RS-3 Quasi-Iso	34.1	123.1	262.0	2.0	2.8	0.06	Local thermal stress
Leg Blade Head	6061-T6	46.9	144.4	241.3	1.3	3.0	0.29	Thermal stress at rigid elements
Leg Blade Body	Ti 6Al-4V	472.4	141.4	827.4	1.3	0.35	3.5	

Allowable stress: compression for CFRP, yield for metals



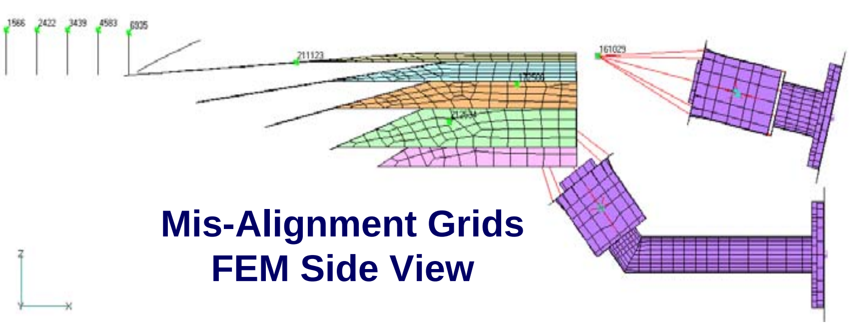


HI Mis-Alignment Analysis

FEM Grid	Grid Description	Relative Disp.	Pitch (Ry) Mis-Alignment		
			Baffle relative to HI-1/2 (due to translations)	HI-1/2 Rotation	Total
			(arcsec)		
1G Off load (+Z0)					
6935	Linear Baffle #5 (aft most, top center)	Linear #5 - HI-1	4.6	-0.2	4.4
161029	HI-1 optics CG				
172506	HI-2 optics CG				
211123	Internal Baffle #1 (top, CL oval cutout)	#1 - HI-2	-103.7	-3.9	-107.6
212534	Internal Baffle #5 (bottom, CL oval cutout)	#5 - HI-2	-92.7	-3.9	-96.6
Cold Operating Temperatures (Behind S/C)					
6935	Linear Baffle #5 (aft most, top center)	Linear #5 - HI-1	22.7	-26.8	-4.2
161029	HI-1 optics CG				
172506	HI-2 optics CG				
211123	Internal Baffle #1 (top, CL oval cutout)	#1 - HI-2	157.9	-42.4	115.5
212534	Internal Baffle #5 (bottom, CL oval cutout)	#5 - HI-2	-20.3	-42.4	-62.7
Hot Operating Temperatures (Ahead S/C)					
6935	Linear Baffle #5 (aft most, top center)	Linear #5 - HI-1	5.3	-32.3	-27.0
161029	HI-1 optics CG				
172506	HI-2 optics CG				
211123	Internal Baffle #1 (top, CL oval cutout)	#1 - HI-2	125.0	-42.1	82.9
212534	Internal Baffle #5 (bottom, CL oval cutout)	#5 - HI-2	-50.1	-42.1	-92.2

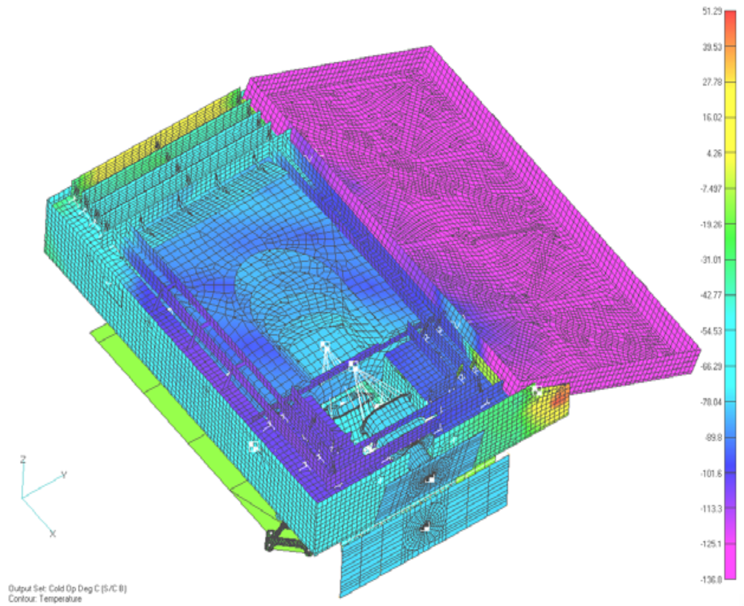
	1G Offload + Cold Operating		
Linear #5 - HI-1	27.2	-27.0	0.2
#1 - HI-2	54.2	-46.3	7.9
#5 - HI-2	-113.0	-46.3	-159.3

	1G Offload + Hot Operating		
Linear #5 - HI-1	9.9	-32.5	-22.6
#1 - HI-2	21.3	-46.0	-24.7
#5 - HI-2	-142.8	-46.0	-188.8



Mis-Alignment Grids
FEM Side View

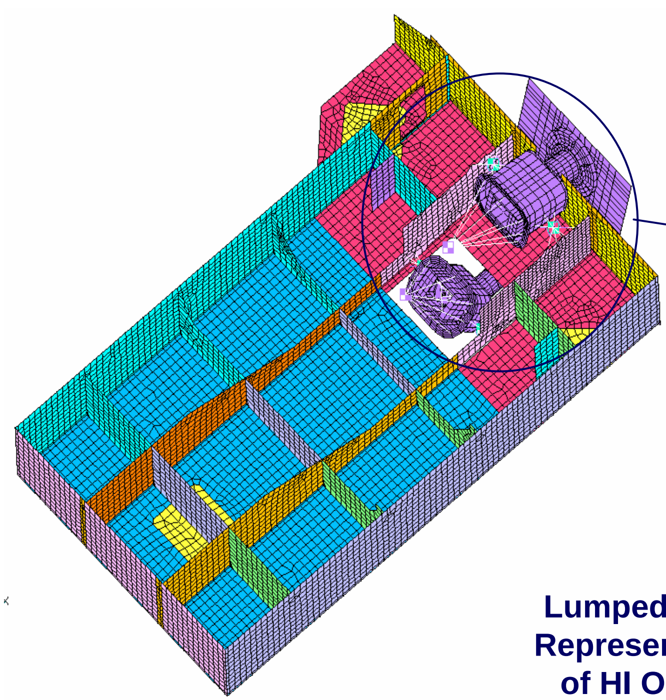
- **Thermal Analysis Temperatures Mapped to Corresponding FEM Grids**
  - **Steady State Heat Transfer Used to Determine Remaining Grid Temperatures Via Material Conductivity**
  - **Apply Resulting Temps to FEM for Thermal Distortion Analysis**
  - **CTE: M55J/RS-3 Quasi-Iso= -0.14 PPM/C, T300/RS-3 Fabric= 3.6 PPM/C**
  - **Spacecraft Panel: -13C Cold Operating, +45C Hot Operating**
- **Relative Rotations Between Optical Elements**
  - **23 Arcsec HI-1 Vs. Aft Linear Baffle (125 Total Budget)**
  - **189 Arcsec HI-2 Vs. Internal Baffles (240 Total Budget)**
- **Relative Linear Baffle Displacements (Center of Top Edge, Adjacent Pairs)**
  - **61 Microns Vertical (66 Total Budget)**
  - **189 Microns Longitudinal Spacing (500 Total Budget)**
- **CME (CFRP Moisture Desorption) Effects TBD (Expected to Be Small)**

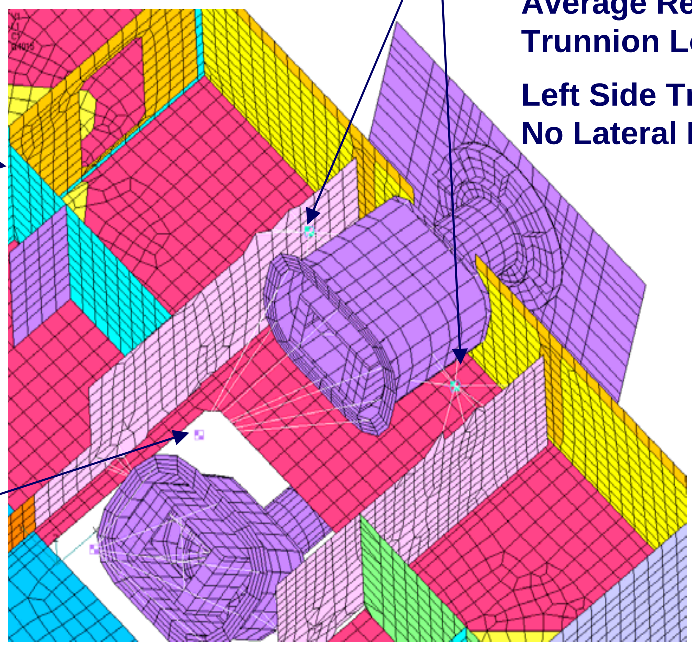


Cold Operating Temperatures (C) - Behind S/C

HI Component Vibration Environments

- **HI-1/2 Lens Barrel and FPA Vibration Environments to Be Specified for Standalone QM Tests**
  - **Recommendation Is to Test Entire Flightlike Telescope With QM Lens Barrel, FPA**
  - **Provide Environments at Major Structural Interface: Telescope Trunnion/Box Structure**
  - **Force Limiting During Testing to Be Addressed**





FPA Vibration Environment Predictions to Be Based on Average Response at FPA Trunnion Locations From FEM

Left Side Trunnion Support: No Lateral Restraint

Lumped Mass Representation of HI Optics

HI Thermal Design and Analysis

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HI Thermal Design Requirements

Temperature Limits

	Operational (°C)		Closed Door (°C)		Survival (°C)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Structure	- 110	+ 90	- 95	+ 95	-120	+ 95
Baffles	- 110	+ 90	- 95	+ 95	-120	+ 95
CCD *****	< - 65		- 120	+ 110	- 120	+ 110
Lenses **	- 25	+ 40	- 30	+ 50	- 30	+ 50
CEB	- 20	+ 30	- 50	+ 50	- 50	+ 50
HOP ***	N/A	N/A	- 50	+ 70	N/A	N/A

*** Operational Goal < - 75 Degree C**

*** Decontamination Goal > +30 Degree C**

(> +10 Degree C Pre-Commission)

**** Operation Goal**

= +5 Degree C

***** Operation at +80 Degree C**

Spacecraft Thermal Interface Requirements †

≥ 20 Degree C/W

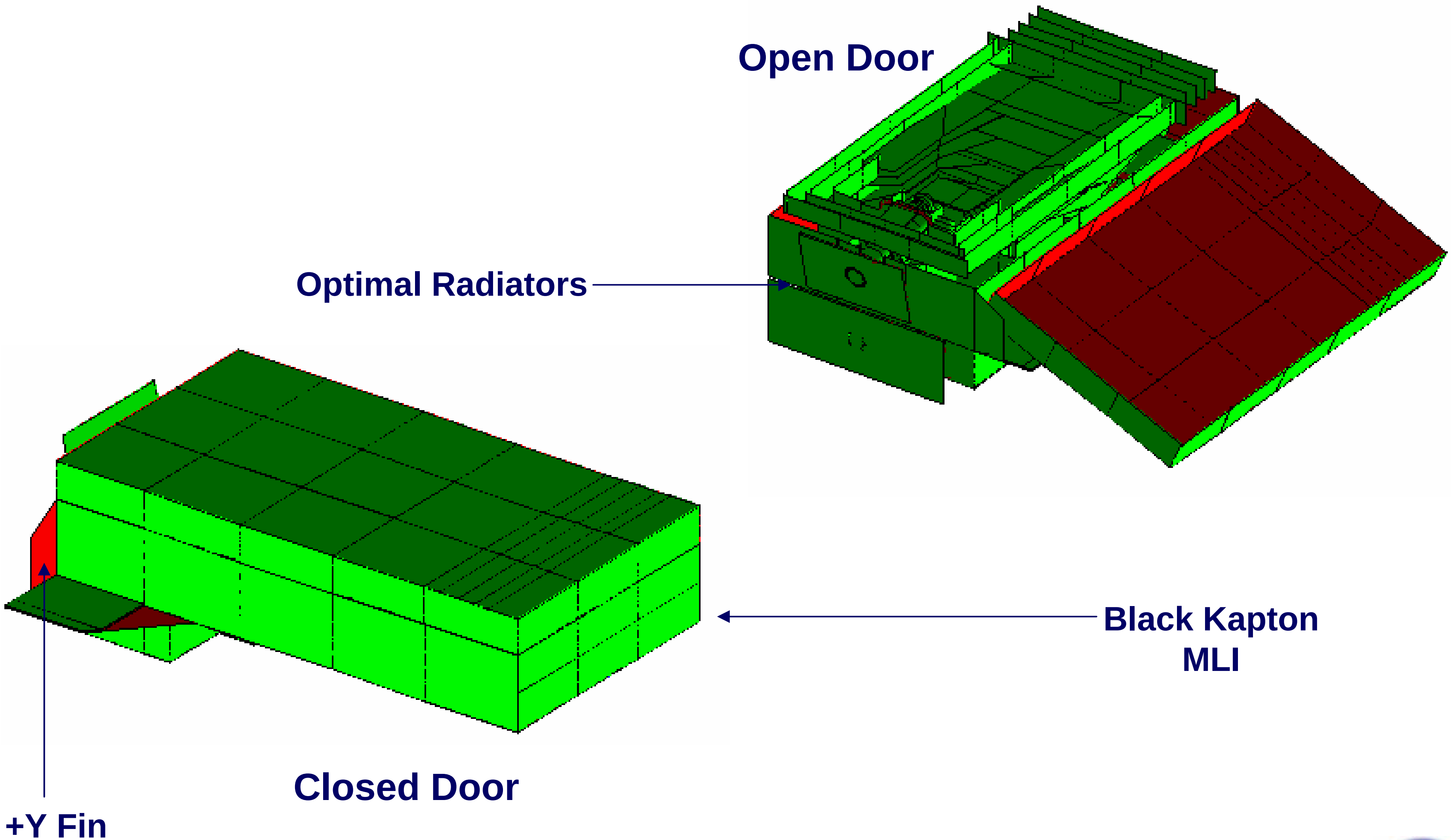
† STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document

HI Thermal Analysis Cases

Case #	Case Name	Orientation	Door Status	Power Status	Max. Heater Power (W)	Transient Duration (min)	Boundary Temperature (°C)	Solar Constant (Wm^{-2})	Optical Properties
1	**HIA Hot Operational**	nominal	open	Operational	4.25	ST-ST	+ 45	1653.8 †	EOL
2	**HIA Cold Operational**	nominal	open	Operational	4.25	ST-ST	- 13	1308.3 †	BOL
3	**HIB Hot Operational**	nominal	open	Operational	4.25	ST-ST	+ 45	1414.2 †	EOL
4	**HIB Cold Operational**	nominal	open	Operational	4.25	ST-ST	- 13	1152.3 †	BOL
5	**HIB Cold Decontamination**	nominal	open	Decontamination	13.00	ST-ST	- 13	1152.3 †	BOL
6	**HIB Cold Operating Emergency**	+ 90	open	Survival	2.75	12.5	- 23	1152.3 †	BOL
7	**HIA Hot Operating Emergency**	- 90	open	Survival	2.75	12.5	+ 55	1653.8 †	EOL
8	**HI Cold Post Launch**	+ 90	closed	Survival	2.75	36	- 23	1382.2	BOL
9	**HI Hot Post Launch**	- 90	closed	Survival	2.75	36	+ 55	1382.2	BOL
10	**HI Cold Phasing Orbit**	+ 45	closed	Survival	2.75	105	- 23	1382.2	BOL
11	**HI Hot Phasing Orbit**	- 45	closed	Survival	2.75	105	+ 55	1382.2	BOL
12	**HI Hot Decontamination**	nominal	closed	Decontamination	20.61	ST-ST	+ 55	1382.2	BOL
13	**HIB Cold Survival**	nominal	open	Survival	2.75	ST-ST	- 23	1152.3	BOL
14	**HI Hot Pre-Comm.**	nominal	closed	Survival	2.75	ST-ST	+ 55	1382.2	BOL
15	**HI Cold Pre-Comm.**	nominal	closed	Survival	2.75	ST-ST	- 23	1382.2	BOL

† STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document

HI Thermal Design and Analysis Overview



HI Thermal Design Features

- Structure
  - Black Kapton MLI (BOL α/ε =0.93/0.78, EOL α/ε =0.95/0.76)
  - Exposed Internal and Linear Baffles, Z307 Paint (α = 0.84 ε = 0.96)
  - Exposed Rear Panel Solar Collector Fin (Collecting Area = 52cm2)
  - Isolating Titanium Legs, 0.0087 W/K (0.026 W/K Total Conductive Link to Spacecraft)
  - Germanium Black Kapton MLI Around Legs and HOP (BOL α/ε =0.5/0.86, EOL α/ε =0.63/0.84)
- Camera
  - Optimised CCD Radiator Areas of 0.230 cm^2 and 0.391 cm^2, for HI1 and HI2
  - Swales FPA and Coldfinger Thermal Model
  - UB Lens Assembly Thermal Model
  - Lens Assembly Isolation (Ti Skeleton + GRP Spacer, 0.01 W/K Link)
  - Operational and Survival HI1 and HI2 Lens Heaters
  - Germanium Black Kapton Radiator MLI
  - Black FPA Housing and Cold Finger Support Structure Outer Surfaces
  - Sun Shield Required for Back of HI2 Radiator

HI Thermal Sensors

- **Sensor Summary Table**

Sensor #	Label	Description	Position	Range (°C)
1	HI_THERM_2	HI Structure Front Thermistor	(x,y,z)	-100 to +100
2	HI_THERM_3	HI Structure Base Thermistor	(x,y,z)	-100 to +100
3	HI_THERM_4	HI Structure Rear Thermistor	(x,y,z)	-100 to +100
4	HI_ACT_T	Wax Actuator Thermistor	(x,y,z)	-100 to +90
5	HI_CEB_BOX_T	HI CEB Enclosure Thermistor	(x,y,z)	-50 to +50
6	HI_1_CCD_T	HI1 CCD Temperature	(x,y,z)	-150 to +50
7	HI_2_CCD_T	HI2 CCD Temperature	(x,y,z)	-150 to +50
8	HI_OPTHR1_T	HI1 Telescope Thermistor	(x,y,z)	-30 to +50
9	HI_OPTHR2_T	HI2 Telescope Thermistor	(x,y,z)	-30 to +50

HI Analysis Temperature Predictions

Case #	Case Name (Final Ts for transients)	Temperature Predictions (°C) [limit exceeds shown in red]									Heater Power (W)
		Baffle min	Baffle max	Structure min	Structure max	CEB	HI1 Lens	HI2 Lens	HI1 CCD	HI2 CCD	
1	HIA Hot Operational	-97.5	54.7	-96.6	88.6	-1.7	3.2	2.9	-72.0	-67.6	3.05
2	HIA Cold Operational	-108.5	15.9	-107.1	51.3	-16.2	6.8	4.5	-79.5	-77.0	3.45
3	HIB Hot Operational	-108.1	42.1	-105.9	-1.0	-16.8	3.7	4.9	-82.5	-82.3	3.45
4	HIB Cold Operational	-108.5	15.9	-107.0	51.3	-16.1	6.9	6.6	-79.4	-76.8	3.50
5	HIB Cold Decontamination	-100.1	16.8	-104.1	55.3	-9.3	49.5	30.6	35.6	35.6	18.5,21.2
6	HIB Cold Operating Emergency	-146.0	-117.1	-143.4	-68.3	-95.8	-28.7	-29.9	-103.5	-104.8	2.70
7	HIA Hot Operating Emergency	-97.4	54.4	-96.5	87.6	-1.7	3.3	3.0	-72.1	-67.7	2.00
8	HI Cold Post Launch	-66.9	-62.6	-81.5	-40.7	-58.8	-0.7	-3.5	-77.5	-84.1	2.70
9*	HI Hot Post Launch	11.8	24.2	-10.3	64.2	21.3	26.1	18.9	-17.4	-44.6	1.00
10	HI Cold Phasing Orbit	-69.1	-64.8	-83.2	-83.2	-61.4	-1.9	-4.8	-78.9	-85.3	2.70
11	HI Hot Phasing Orbit		TBD / Not Worst Case								
12	HI Hot Decontamination	-7.3	-0.1	-8.0	100.5	4.3	26.2	23.0	23.8	10.7	21.61
13	**HIB Cold Survival**	-116.6	15.0	-114.1	39.8	-70.8	-19.1	-17.6	-90.8	-87.9	2.70
14	**HI Hot Pre-Com.**	-32.8	-29.7	-35.3	93.9	-18.8	7.0	2.9	-56.4	-61.2	2.00
15	**HI Cold Pre-Com.**	-47.7	-44.1	-48.7	90.5	-34.4	-2.4	-6.7	-64.5	-68.4	2.00

*** STEREO Steady-State Temperatures**

HI Contamination Control Requirements

- **HI Has Stringent Stray Light Rejection Requirements**
  - **B / B0 < 10-13 for HI-1**
  - **B / B0 < 10-14 for HI-2**
- **Particulate Contamination Is a Major Concern –**
  - **Scattering From Particulates on Critical Forward Baffle Edges Would Degrade Rejection of Solar Flux**
  - **Particulates on Other Baffle Surfaces or Objective Lenses Degrade Stray Light Rejection**
  - **Particulates on CCD Cause Pixel Blocking**
- **Also Non-Volatile Residue (NVR) Condensed Molecular Contamination on Optical Elements Could Constitute a Secondary Source of Diffuse Stray Light**
- **HI Will Conform to Project Contamination Control Documents –**
  - **STEREO Contamination Control Plan (7381-9006)**
  - **SECCHI Contamination Control Plan (7906-PLN-0-0007)**

HI Contamination Control for Composites

- HI Structure and Baffles Use Carbon Composites
  - Draw on Heritage/Experience From Solar-B EIS
- Materials/Processes Selected on Basis of Low Outgassing
  - M55J/RS3 Unidirectional Carbon Fibre Prepreg System (for Panels)
  - T300/RS3 Woven Carbon Fibre Prepreg System (for Solid Inserts)
  - Adhesives and Potting Compounds Selected on Basis of TML < 1%, CVCM < 0.1%
- Carefully Attention Paid to Panel, etc Finishing to Avoid Particulates Due to Exposed Fibres
  - Resin Coating or Taping of Exposed Edges
  - End-Capping or Taping of Honeycombe Panel Edges
  - Inserts for All Fasteners in CRFP Solids
  - Specifications to Ensure Surfaces Are Resin-Rich With No Exposed Fibres
  - No Silicone Release Agents
- Multi-Stage Cleaning for CFRP Panels
  - Panel Coarse and Fine Cleans
  - Panel Stress Relief Bake, Also Used for Preliminary Clean-Up
  - All-Up Structure Bake

HI Purging and Venting Design

- HI Will Have Purge Inlet Connector Adjacent to Interface Connector Plate
- Manifold With Three Individually Sized Orifices to Meter Gas to –
  - HI-1 Telescope / FPA Volume
  - HI-2 Telescope / FPA Volume
  - Main Structure Volume
- Inlet to Each Telescope / FPA Volume Is Via Telescope Lens Carrier Into Volume Between Final Optical Element and CCD Decontamination Cup
  - Common Design for All SECCHI FPAs
  - FPA Has Molecular Vent Which Also Acts As Ascent Vent (TBC)
- For Main Structure Volume, Gas Inlet Near Base of Structure
  - Gas Will Vent From Main Structure Around Door Perimeter and Clearance Holes Around FPA/Cold Fingers
- Whenever Practical During AIT, HI Will Be Enclosed in a Sealed Llumalloy Bag ('Red Tagged') With Breather Valve
- Alternatively, Prior to Integration on Spacecraft a Dedicated Purge / Clean Cover Box Will Be Used
- Purge Rate of 4 Changes Per Hour
- Filtered CP Grade N2 Shall Be Used for Purging

HI Purge GSE

- **HI Will Use Either SOHO LASCO or CDS Purge GSE**
  - **Regulator**
  - **Flow Control Needle Valve**
  - **Relief Valves**
  - **Flow Meter and Gas Pressure Gauges**
  - **Hygrometer and Alarm**
  - **7-Micron Particulate Filter**

HI Housekeeping and Control - SEB

SEB Control of –

- **HI-1 / HI-2 CCD Decontamination Heaters**
- **HI-1 / HI-2 Optics Operational Heaters**
- **HI-1 / HI-2 Red / Blue / Green Calibration LEDs**

SEB Monitoring of –

- **HI-1 / HI-2 CCD Thermistors**
- **HI-1 / HI-2 Optics Thermistors**
- **HI CEB Thermistor**
- **HI Structure Thermistors – 3 off**
- **HI Door Encoder**

Total of 8 Thermistors Monitored by SEB

HI Housekeeping and Control - Spacecraft

- Spacecraft Control of Wax Actuator –
- Actuator is Starsys EP-5025-3
  - 78 Ω Redundant Heaters
  - No Over-Heating Protection in Actuator
- Spacecraft Control of Survival Heaters –
- Survival Heaters are TBD
  - CEB, HI-1 and HI-2 Survival Heaters
- Spacecraft Temperature Monitoring –
- Wax Actuator Thermistor
- Structure

HI Electrical Interface Connectors

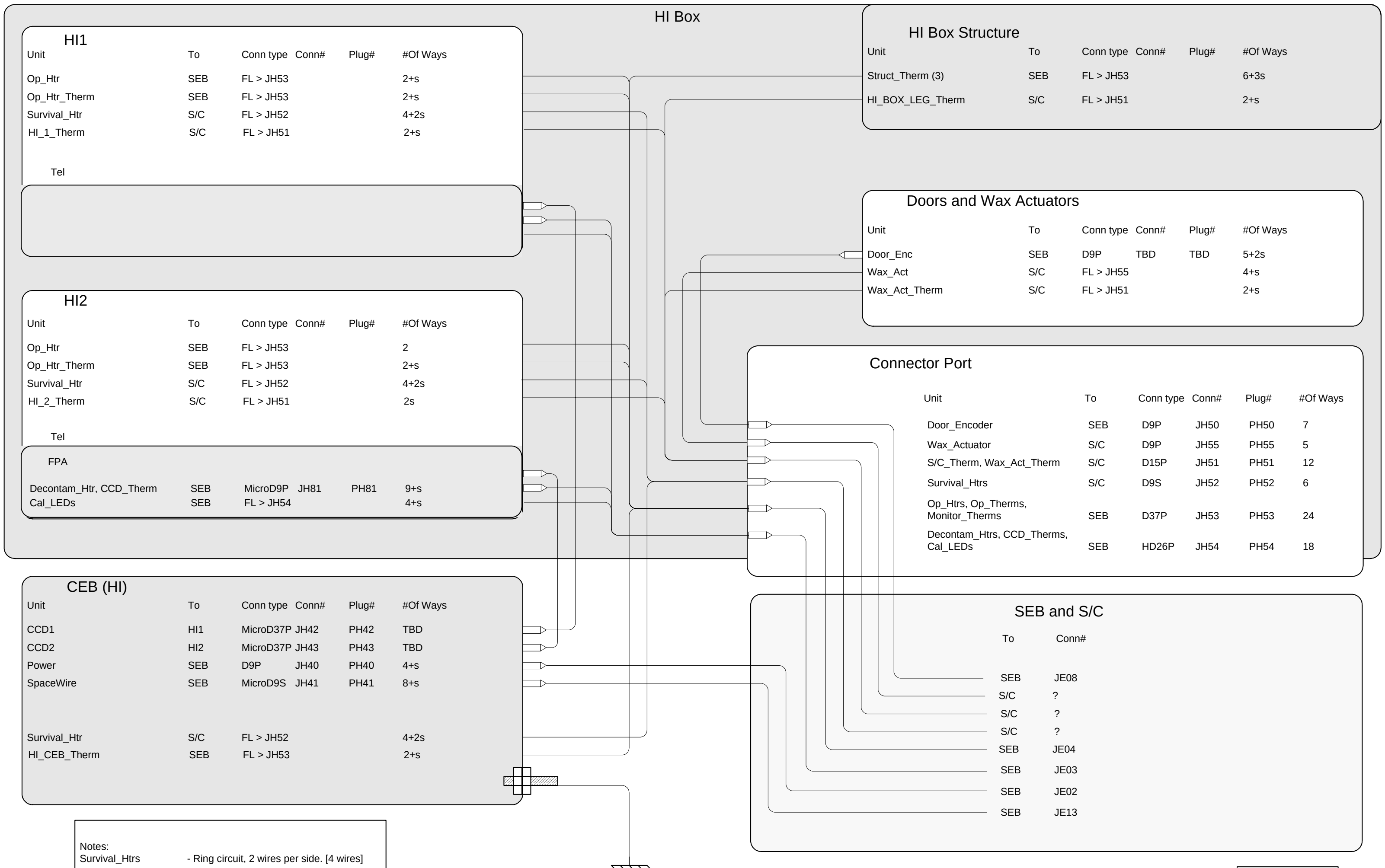
Connectors on CEB –

- **CEB Power Input (9-Way Male Standard D)**
- **SpaceWire Interface (9-Way Female Micro-D)**

Connectors on Connector Panel –

- **SEB Operational Heaters & Thermistors, Monitor Thermistors (37-Way Male Standard D)**
- **SEB De-Contam Heaters & CCD Thermistors, Cal LEDs (26-Way Male High Density D)**
- **SEB Door Encoder (9-Way Male Standard D)**
- **Spacecraft Survival Heaters (9-Way Male Female D)**
- **Spacecraft Thermistors (15-Way Male Standard D)**
- **Spacecraft Wax Actuator Control (9-Way Male Standard D)**

HI Harnessing Diagram



Notes:
Survival_Htrs - Ring circuit, 2 wires per side. [4 wires]

Draft
17-Sept-02

Environmental Test Requirements

Environmental Test Requirements Documents -

- **STEREO Environmental Definition, Observatory, Component and Instrument Test Requirements Document (APL 7381-9003)**
- **SECCHI Environmental Test Plan (NRL 7906-PLN-9-0-0004)**
- **STEREO EMC Control Plan and EMC Performance Requirements Specification (APL 7381-9030)**

Instrument Test Requirements -

- **APL 7381-9003 Sect 3.4.2, Instrument Dynamic Test Requirements:**
  - **"Instruments Shall Be Vibrated As Given in Sections 3.4.2.1 and 3.4.2.2. The Test Requirements Are for Protoflight Hardware, That Is Qualification Levels (Max Expected Level + 3 Db for Acceptance Duration)".**
  - **Section 3.4.2.2 Gives Random Levels Overall Amplitude 10.4 and 7.4 G RMS, Perpendicular and Parallel to Mounting Panel (Mass < 22.7 kg)**

HI Sub-Assembly Test Matrix

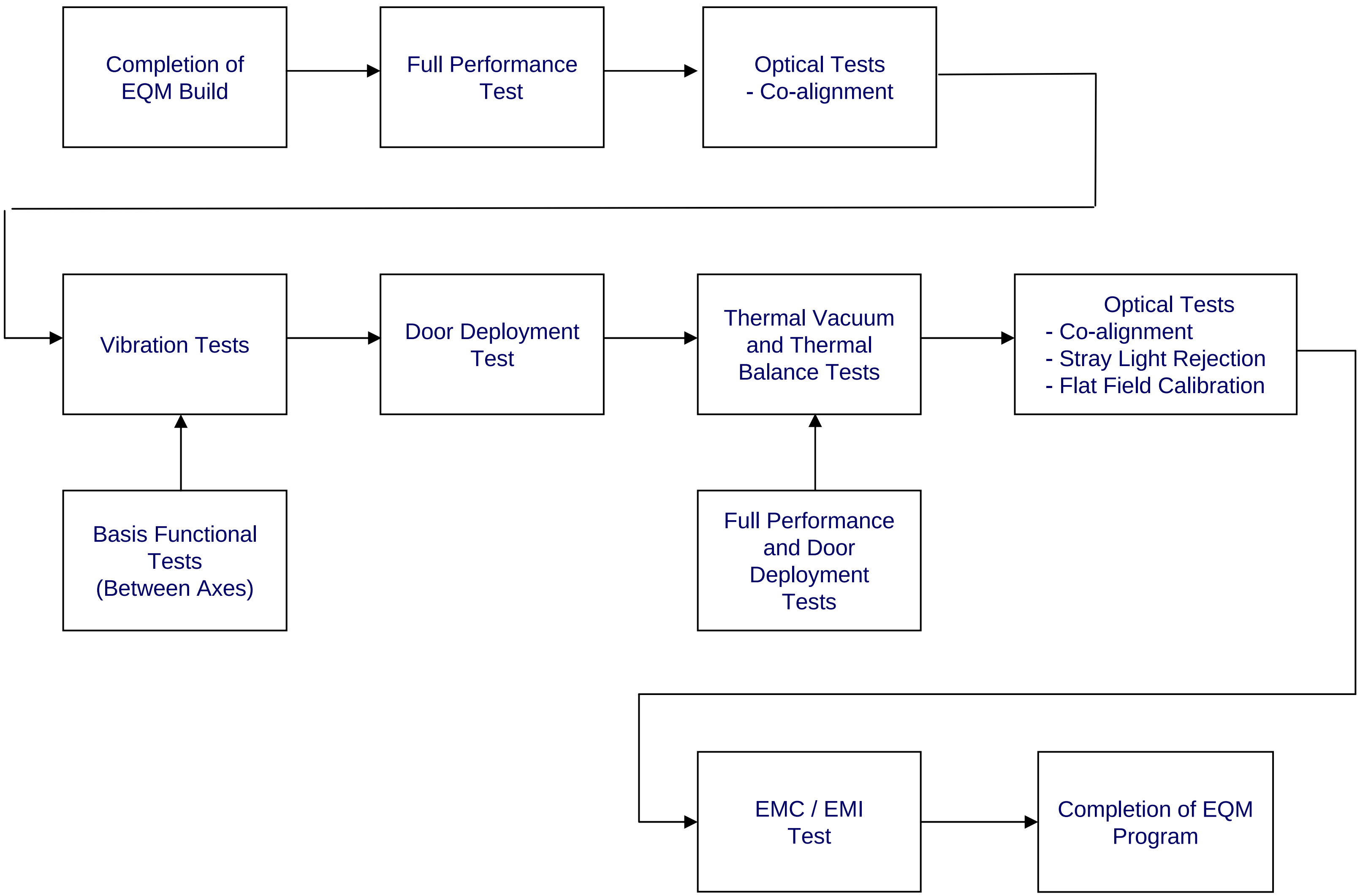
Subsystem	EQM Baffle	EQM FPA	EQM Optics	EQM CEB
Random Vibration	No	Qualification Levels	Qualification Levels	Qualification Levels
High-Level Sine Sweep	No	Qualification Levels	Qualification Levels	Qualification Levels
Sine Survey	No	Yes	Yes	Yes
Modal Survey	No	No	No	No
Thermal Vacuum	No	Yes	Yes	Yes
Thermal Balance	No	Yes	No	No
Shock	No	No	No	No
Acoustic	No	No	No	No
EMC/EMI	No	No	No	No
Functional Testing	No	Yes	No	Yes
Straylight Rejection	Yes	No	Yes (TBC)	No
Optical Performance	No	No	Yes	No

HI Instrument Test Matrix

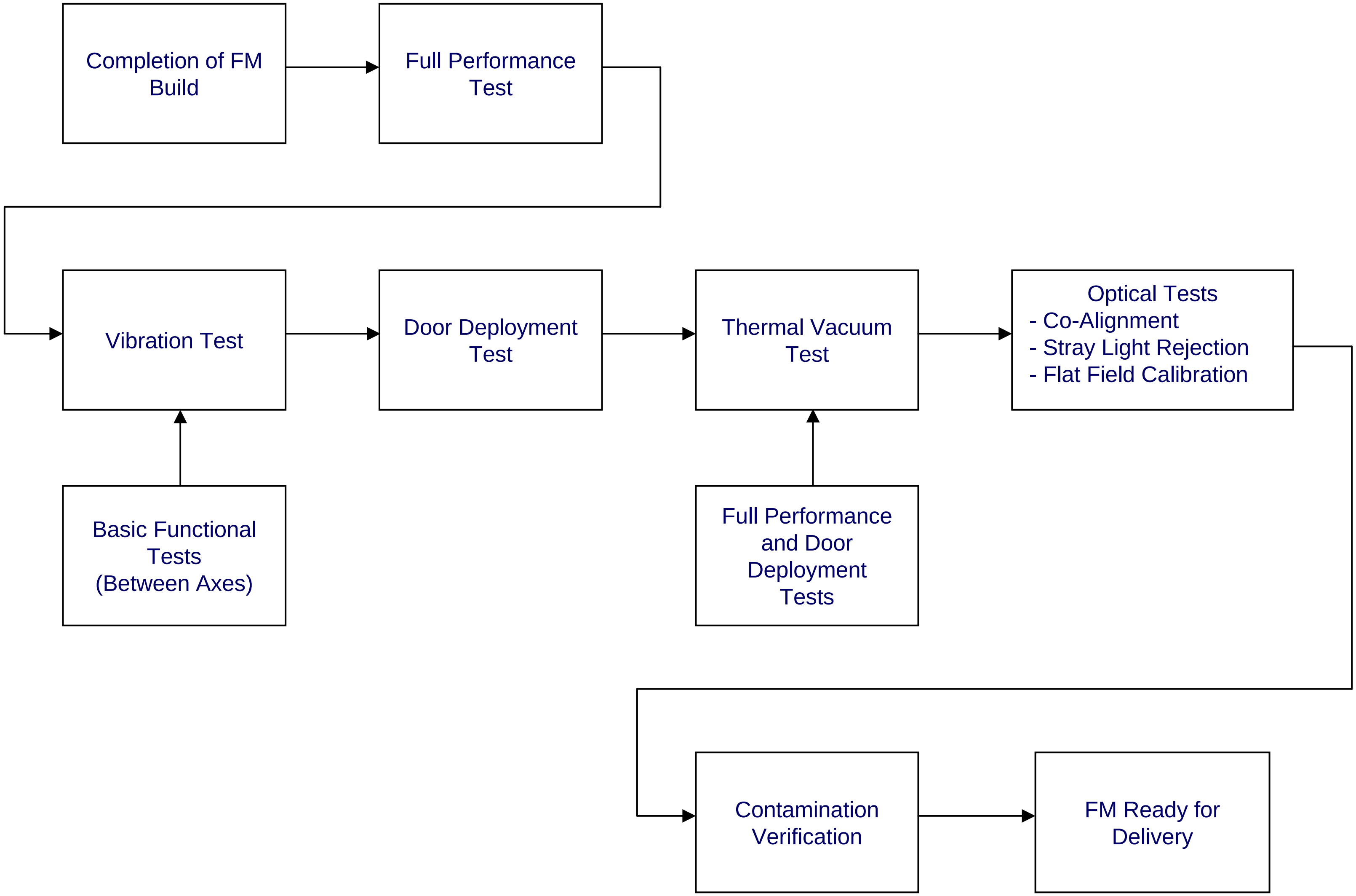
Test	EQM	FM
Random Vibration	Qualification Levels	Acceptance Levels
High-Level Sine Sweep	Qualification Levels	Acceptance Levels
Sine Survey	Yes	Yes
Pull Tests	Yes	No
Quasi-Static	Yes	TBD
Thermal Vacuum	Yes	Yes
Thermal Balance	Yes	No
Shock	No [1]	No [1]
Acoustic	No [1]	No [1]
EMC/EMI	Yes	No
Functional Testing	Yes	Yes
Straylight Rejection	Yes [2]	Yes [3]
Co-Alignment Verification	Yes [2]	Yes [3]
Optical Performance	Yes [2]	Yes [3]

Notes:
1. Shock and Acoustic Testing at Observatory Level
2. Co-Alignment Testing Before and After Qualification Testing, Straylight and Optical Testing After Qualification Testing
3. Straylight, Co-Alignment and Optical Testing After Acceptance Testing

EQM Test Flow



FM Test Flow


Completion of FM Build
Full Performance Test
Vibration Test
Door Deployment Test
Thermal Vacuum Test
Optical Tests
- Co-Alignment
- Stray Light Rejection
- Flat Field Calibration
Basic Functional Tests (Between Axes)
Full Performance and Door Deployment Tests
Contamination Verification
FM Ready for Delivery

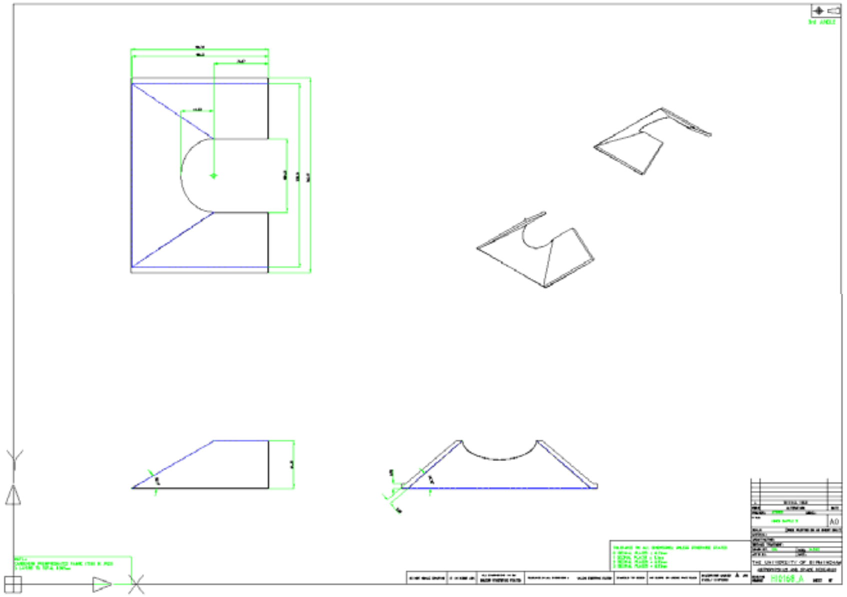
HI EQM Structure

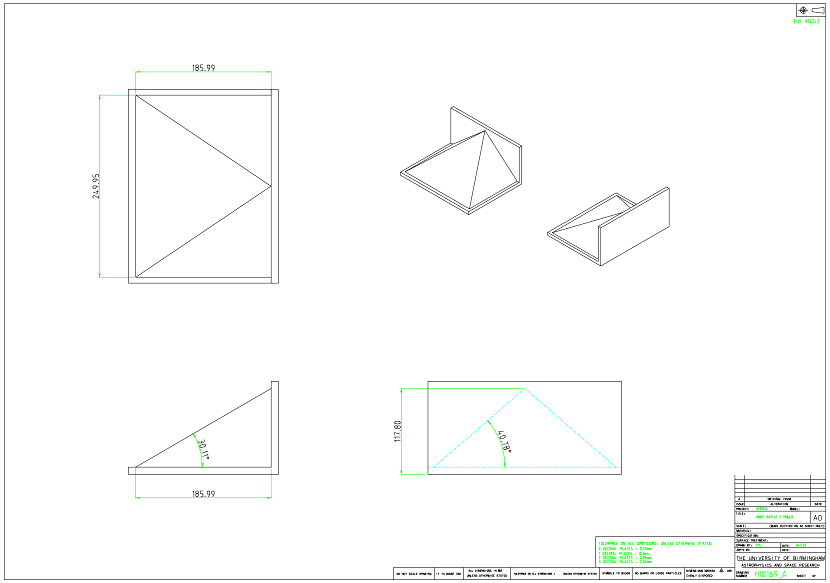
Design and Testing Backup

HI Responses to PDR Action Items

RFA #	Concern / Action	HI Response
5	Justify Why Only First Lens of HI Optics Needs to Be Radiation Resistant Glass	Technical Note by Jean-Marc Defise (27-Nov-01) Shows for HI-1 Dose in Front Lens is 0.59 krad/yr, Other Lenses 0.13 krad/yr. Figures for HI-2 are 5.5 krad/yr and 0.12 krad/yr. Shows That Baselined Glasses Have Adequate Radiation Resistance
8	HI Instrument's Plan for Using Z306 Black Paint May Be Inconsistent With Spacecraft Charging and Surface Conductivity Requirements. Analysis Should Be Performed to See If There Is a Problem.	Baseline Is Now Aeroglaze Z307 Paint Which Is Conducting and Designed to Avoid This Problem (Conductivity Is Typically 10^2 – 10^5 ohm/iN2 for 0.75 – 1.5 mil Coating Thickness) Tests Performed by CSL Have Confirm That BRDF (Bi-Directional Reflectance Distribution Function) of CFRP Samples Painted With Z307 Is Acceptable (Very Similar to Z306) Thermal Cycling Tests of Samples –100 to +100°C by UBham Have Confirmed No Peeling, Cracking, Flaking or Other Degradation
11	Heliospheric Imager Has a Door With Perimeter Seal Against Viton O-Ring. There Have Been Numerous Recent Door Failures Where the Viton O-Ring Have Had Very High Stiction After Cold Storage. This Effect Is Due to the Migration of Water Out of the O-Ring to the Interface	Use of a Viton O-Ring Around Door Has Been Abandoned. Instead a PTFE (Teflon) Strip Has Been Incorporated, Trapped in a Similar Way to the O-Ring O-Ring Was Never Intended to Provide a Hermetic or Vacuum Seal. Its Function Was to Minimise the Flow of Purge Gas Around the Edge of the Door, and to Minimise the Risk of Ingress of Particulate Contamination Around the Door Edges. These Functions Can Equally Well Be Achieved by Means of a Teflon Strip, Although the System May Need Rather More Careful Setting up to Ensure That When the Door Is in the Latched Position the Gap Between the Door Edge and the Teflon Is Minimised

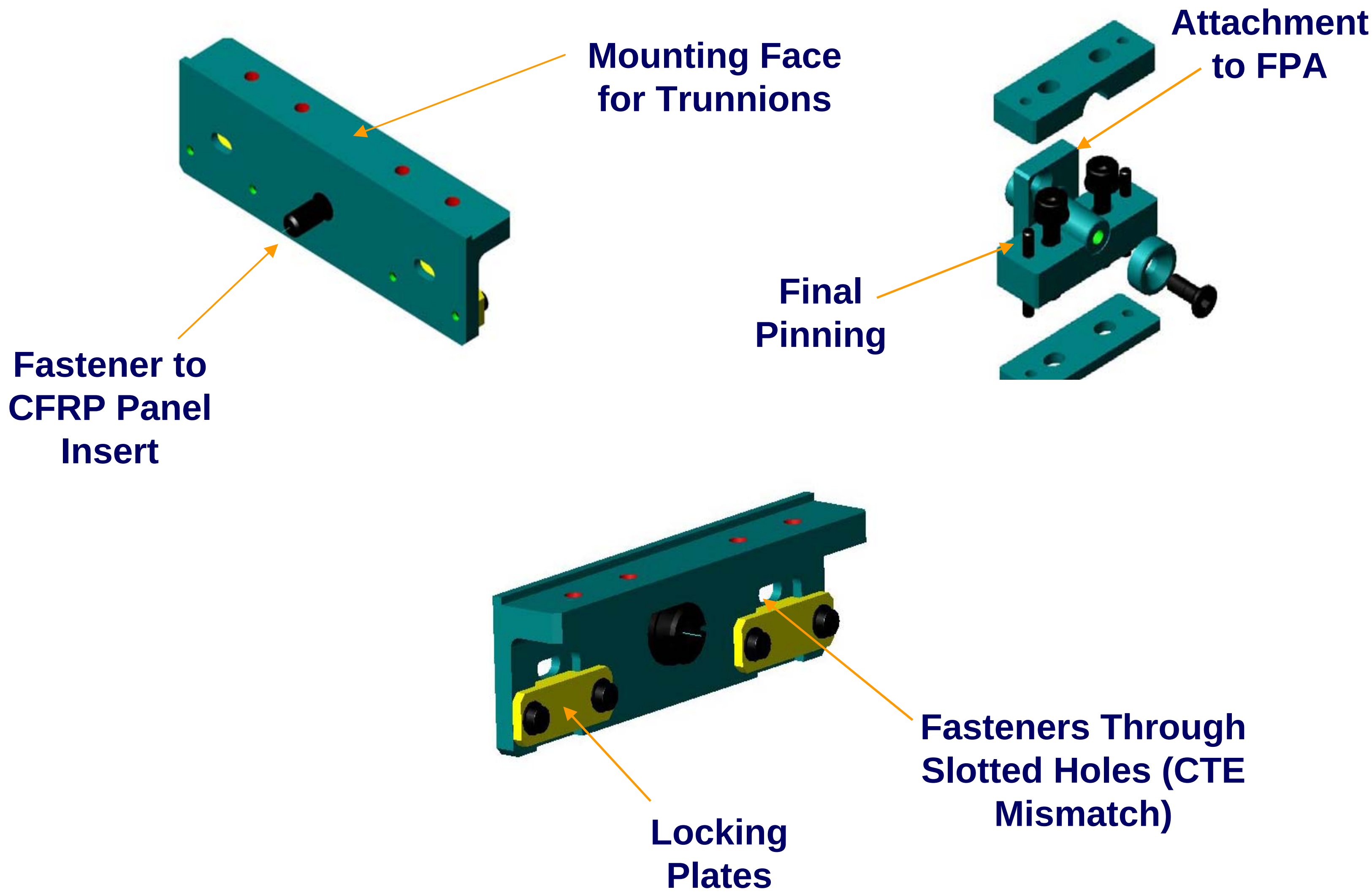
Internal Baffle Fabrication





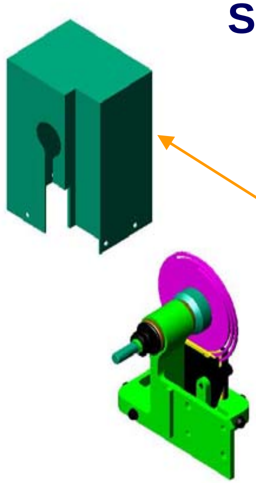
- **Example of Fabrication Drawing of Typical Internal Baffle and Drawing for CFRP Panel Mould for Lay-Up**

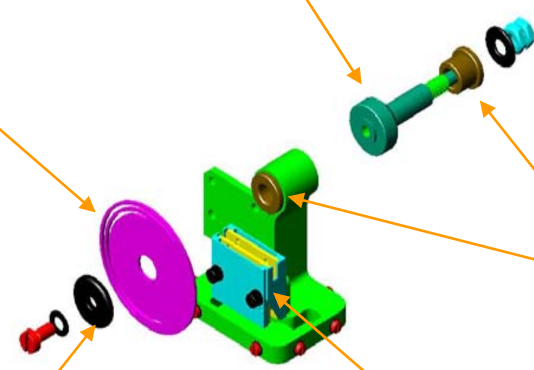
FPA Trunnion Mounts



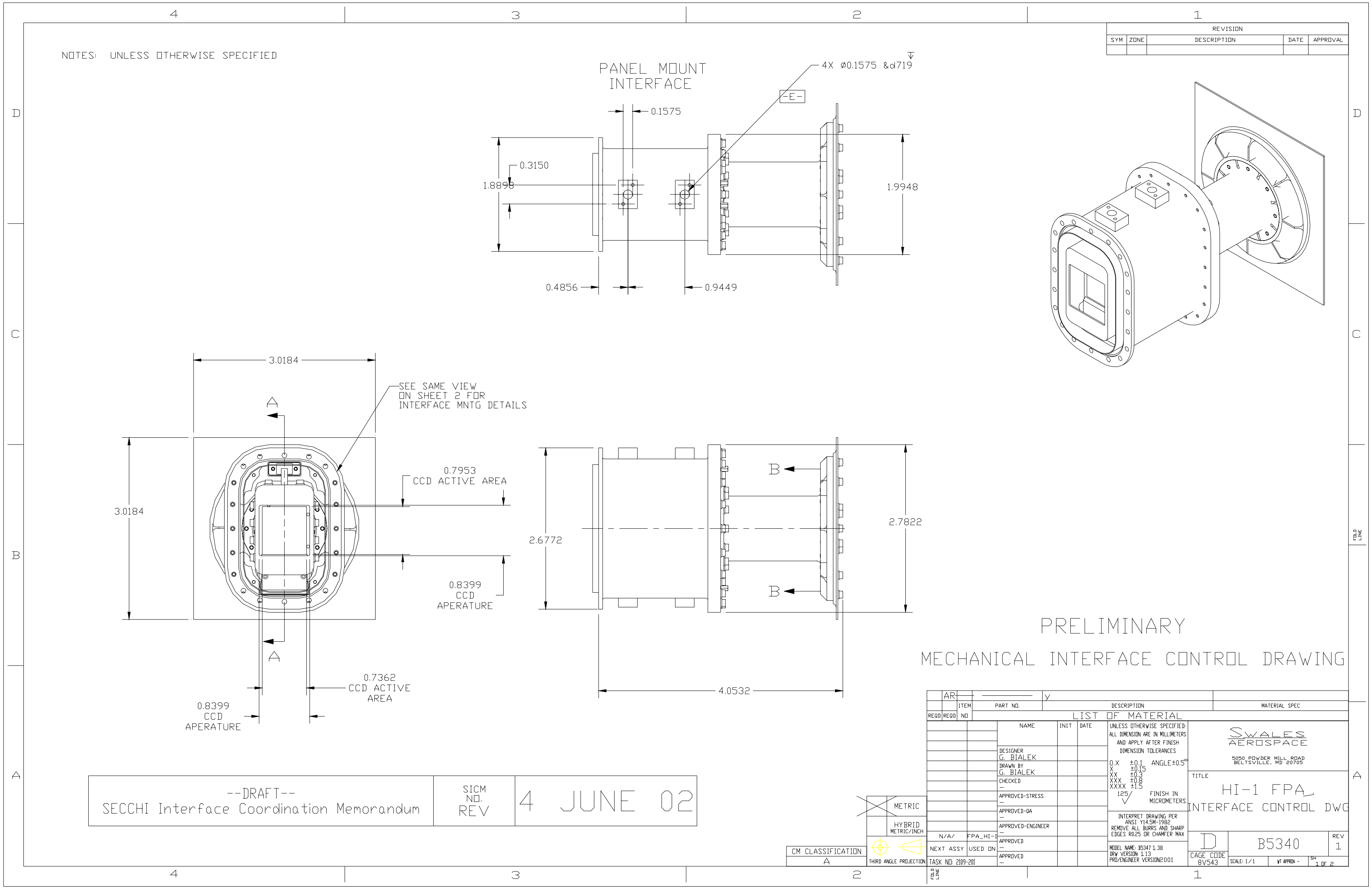
Door Encoder

- **Encoder Disc, PCBs Etc As Used for SCIP Door Encoders**
  - **Based on LASCO Design**

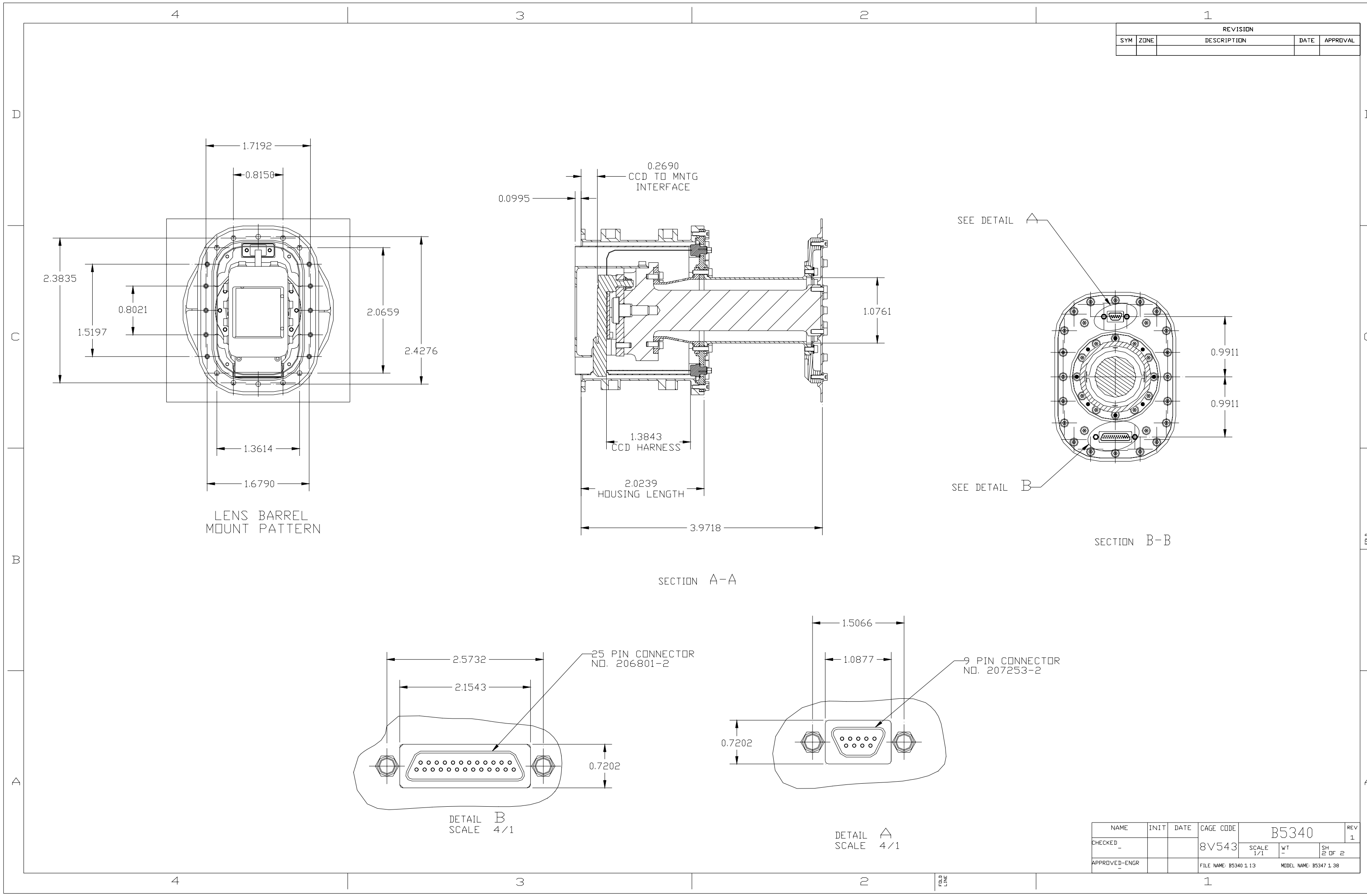




HI-1 FPA Interface Drawing (1 of 2)



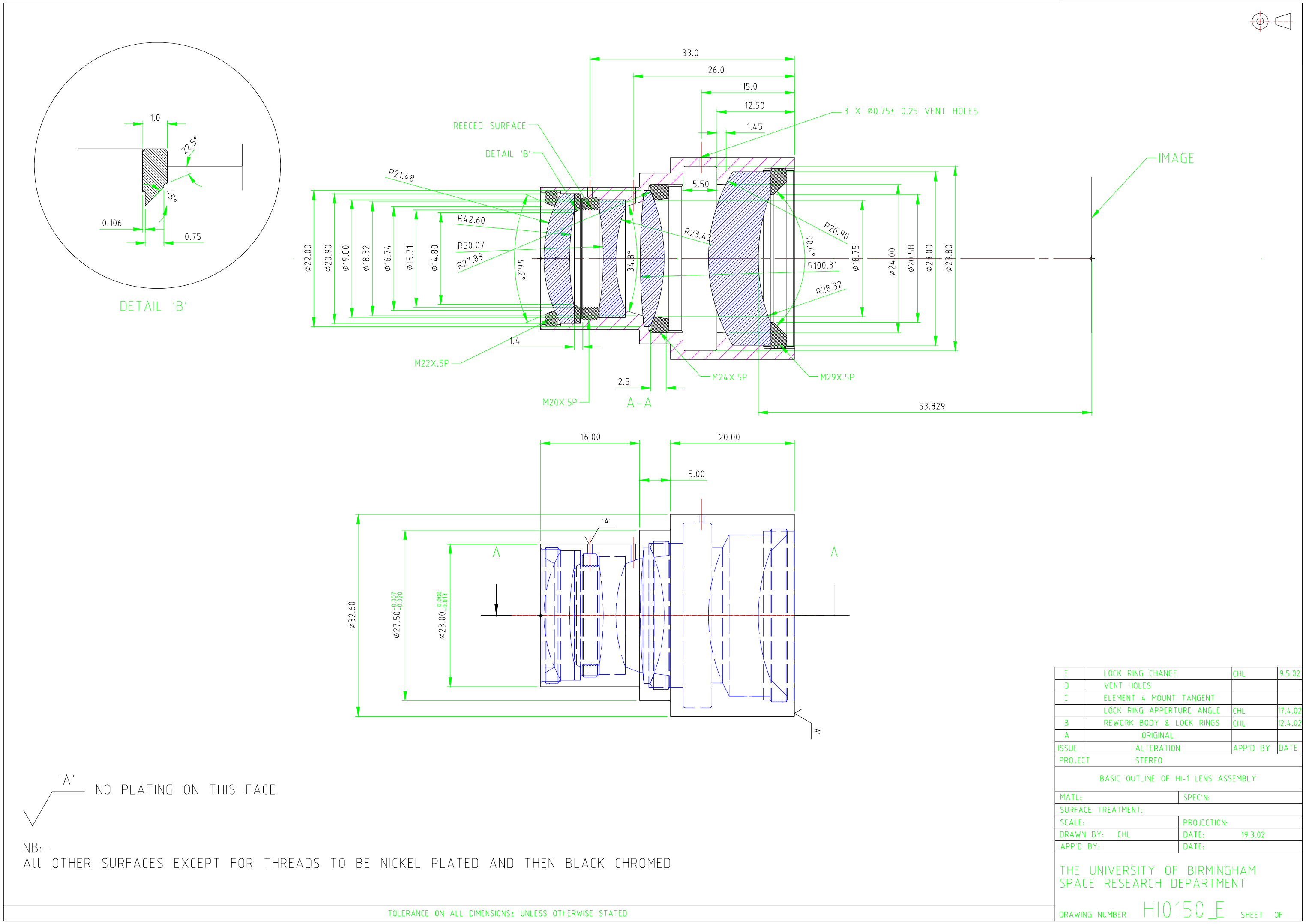
HI-1 FPA Interface Drawing (2 of 2)



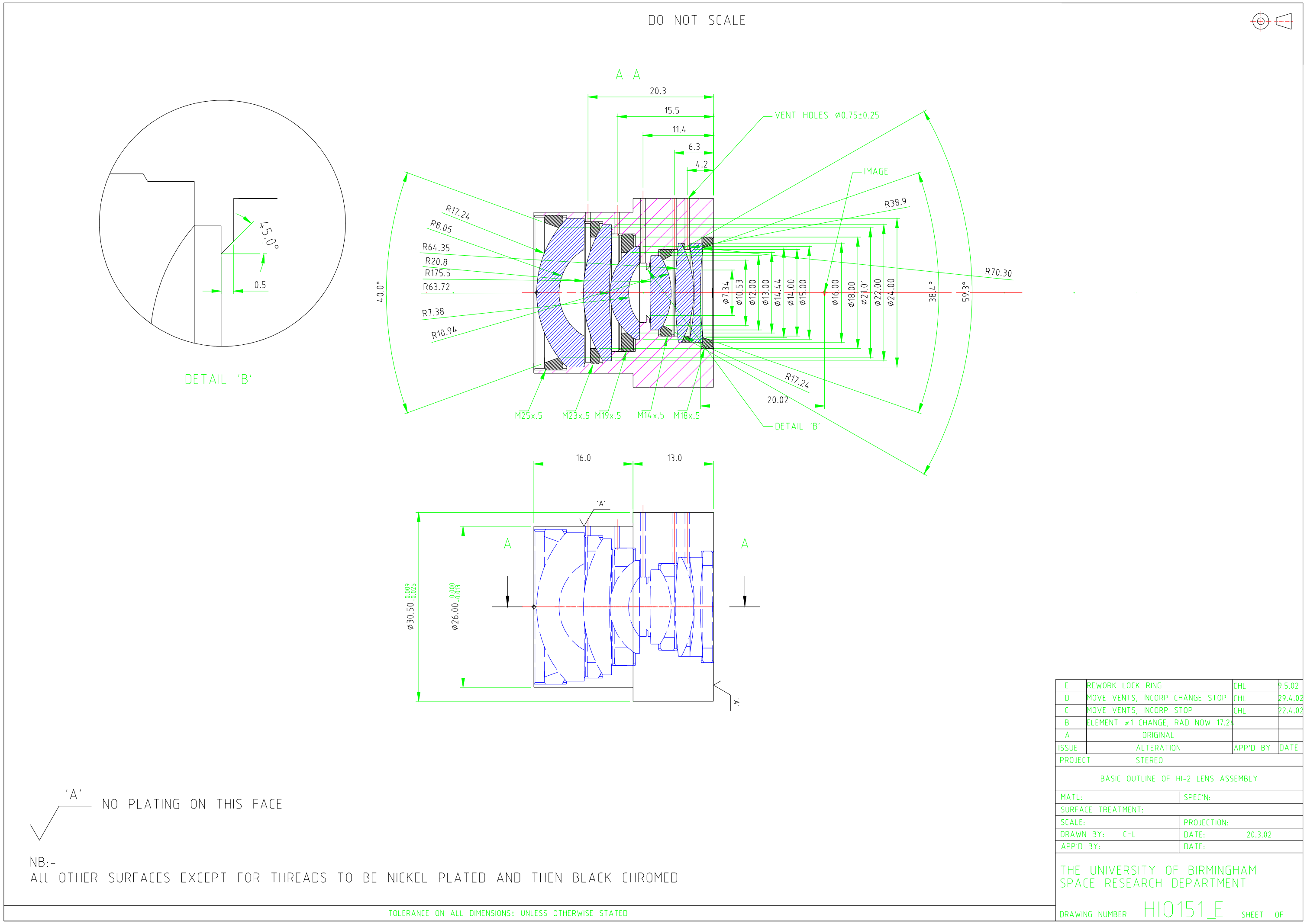
HI Optics Status and Barrel Design

- **Contract Placed With ICOS Ltd for Fabrication of HI Optics (June 2002)**
- **ICOS Procured Stocks of ‘Old’ Spec Glasses – Known Rad Tolerance**
- **CSL, UBham and ICOS Have Iterated the Barrel Designs**
  - **Provide Straylight Traps As Requested by CSL As Far As Possible**
- **Barrel Material Is Grade 2 Titanium**
  - **Good Match to CTE of Glasses**
- **Lens Clamping Rings Ground to Same Curvature As Lenses**
  - **Avoid Line Contacts**
- **Preliminary Tightening Torques Calculated by CSL Are Very Low**
  - **HI-1 range 10 to 73 N.mm; HI-2 range 3 to 28 N.mm**
  - **Include Conservative Safety Factors, E.G. 50g Loading, SF=1.25 on Preload, SF=3 on Coefficient of Friction**
- **Induced Stresses, *Even Including 150K Temperature Change*, Are Very Low**
  - **HI-1 Worst Case 1.2 N.mm^{-2}; HI-2 Worst Case 0.7 N.mm^{-2}**
  - **Max BK7 Tensile Stress is 6.9 N.mm^{-2}**
  - **Max Compressive Stress Without Birefringence Change is 3.4 N.mm^{-2}**
- **Polishing of HI-1 Elements Almost All Finished; Starting HI-2 Very Soon**
  - **Will Supply Parameters of Lenses As Finished for CSL to Optimise Spacings**

HI-1 Optics Barrel Design



HI-2 Optics Barrel Design



ISSUE	ALTERATION	APP'D BY	DATE
E	REWORK LOCK RING	CHL	9.5.02
D	MOVE VENTS, INCORP CHANGE STOP	CHL	29.4.02
C	MOVE VENTS, INCORP STOP	CHL	22.4.02
B	ELEMENT #1 CHANGE, RAD NOW 17.24		
A	ORIGINAL		

PROJECT: STEREO

BASIC OUTLINE OF HI-2 LENS ASSEMBLY

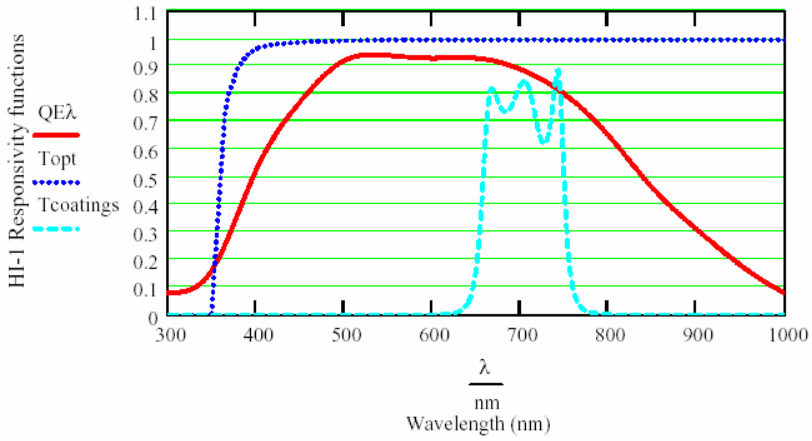
MATL:	SPEC'N:
SURFACE TREATMENT:	
SCALE:	PROJECTION:
DRAWN BY: CHL	DATE: 20.3.02
APP'D BY:	DATE:

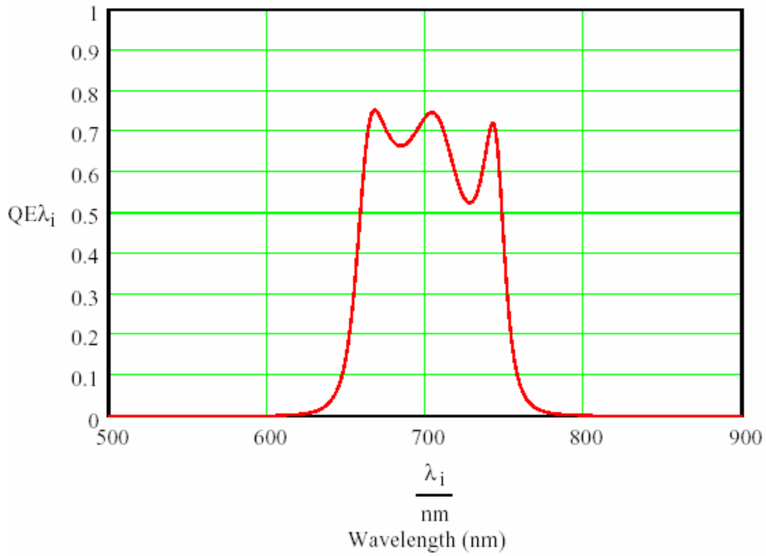
THE UNIVERSITY OF BIRMINGHAM
SPACE RESEARCH DEPARTMENT

DRAWING NUMBER HI0151_E SHEET OF

HI Optics Coatings

- **Front Surfaces First Element of HI-1 and HI-2 Have λ/4 SiO^2 Coating**
- **Elsewhere λ/4 MgF2 Anti-Reflection Coating Used**
- **HI-1 High-Pass Filter Is 25 Layers of ZrO^2 and SiO^2 on N-LAK9**
- **HI-1 Low-Pass Filter Is 25 Layers of ZrO^2 and SiO^2 on BK7**





HI Contamination Control Documents

Applicable Project Documentation:

- **STEREO Contamination Control Plan (7381-9006)**
- **SECCHI Contamination Control Plan (7906-PLN-0-0007)**
- **EIS (Solar-B) Contamination Control Plan (MSSL/SLB-EIS/PA/003.01)**

Other References:

• **MIL-STD-1246C**	**Product Cleanliness Levels and Contamination Control Program**
• **NASA-JSC-SN-C-0005C**	**Contamination Control Requirements for Space Shuttle Program**
• **PSS-01-701**	**Data for Selection of Space Materials**
• **NASA-RP-1124**	**Outgassing Data for Selected Spacecraft Materials**
• **FED-STD-209E**	**Federal Standard Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones**
• **MIL-PRF-27401**	**Propellant Pressurizing Agent, Nitrogen**
• **ASTM-E-595**	**Methods of Test for Total Mass and Controlled Volatile Condensible Materials from Outgassing in a Vacuum Environment**

- **Also ASTM-E-1216 (Tape Lift Monitoring), ASTM-E-1234 (NVR Handling, Installation, etc) and ASTM-E-1235 (NVR Evaluation)**

HI Contamination Control Approach (1 of 3)

- Materials and Processes Selection
  - Low Outgassing Material Selection; TML < 1% and CVCM < 0.1% per ASTM-E-595
  - Materials Selected From PSS-01-701or NASA-RP-1124 Where Possible
  - Materials and Processes Lists Submitted to the Project for Approval
- Minimum Cleanroom Requirements

Instrument Configuration	Minimum Requirement
Contamination Critical Sub-Assemblies	Class 100
HI Door Open	Class 100
HI Unbagged + Door Closed	Class 1000
HI Double-Bagged + Door Closed	Class 10,000

- Cleanroom Protocols
  - Appropriate Cleanroom Clothing Regime Enforced for Each Cleanroom
  - Rigorous Cleanroom Entry and Exit Procedures Enforced for Personnel, Equipment and Materials
  - Each Entry, Exit and Major Activity in the Cleanroom Will Be Logged
  - Training Given to Relevant Personnel Regarding HI Contamination Requirements
  - HEPA-Filtered Vacuum Cleaner Available in Each Cleanroom
  - All Support Equipment and Materials Used in Cleanrooms Shall Be Non-Shedding

HI Contamination Control Approach (2 of 2)

- Cleanroom Monitoring
  - Validation of Cleanroom to Federal Standard by External Test House
  - PMS Particle Counter for Continuous Monitoring
  - NVR Plates And/or Surface Acoustic Wave (SAW) Detector Used to Monitor Rates of Molecular Deposition
- Component and Subassemblies Cleaning
  - Extensive Use Will Be Made of Solar-B EIS Heritage and Procedures
  - Typical EIS Contamination Control Plan Cleaning Procedure Uses Series of Solvents, e.g.
    - Analytical Grade Acetone
    - Surface UN65 in Demineralised Water
    - Demineralised Water
    - Analytical Grade Propan-2-ol
  - Followed by Bake-Out in Dry N2 and/or Vacuum Bake As Appropriate
  - Cleaned Components, Subassemblies, etc Bagged/Stored in Llumalloy HSC Antistatic Film As Far As Practical to Limit Exposure to Contamination

HI Contamination Control Approach (3 of 3)

- Contamination Monitoring on HI Flight Hardware
  - White Light (Dark Room Grazing Incidence) and Black Light (UV) Inspection
  - Tape Lift for Particle Fallout Monitoring
  - An Optical Witness Plate Will Be Designed Into the HI Door Close to the Forward Baffles
  - TQCM and RGA Used for Thermal Vacuum and Bake-Out Chambers
- Solvent and Gas Purity
  - Analytical or Spectral Grade Solvents and Cleaning Agents Used Throughout
  - Filtered CP Grade N_2 (99.9992% Pure) Used for Cleaning Particulates From Flight Hardware Surfaces
  - Filtered CP Grade N_2 Used for Venting Vacuum Chambers

Birmingham Cleanroom Facilities

Summary of Cleanroom Facilities Which Will Be Available for HI Flight Model Program:

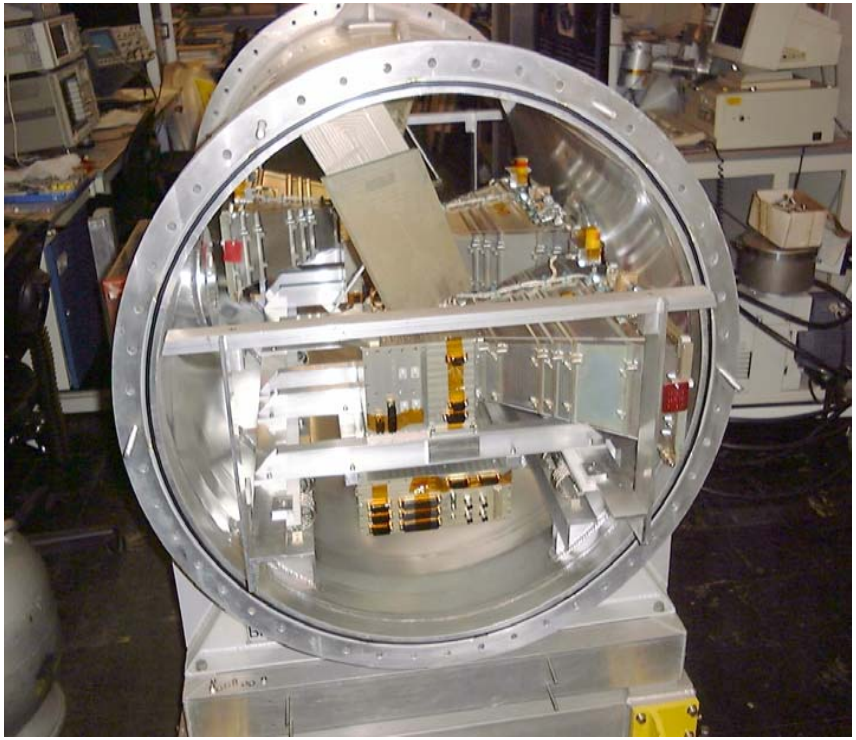
- **High-Grade Assembly Cleanroom**
  - **FED-STD-209E Class 1000; Locally Class 100**
  - **All HEPA Filters Non-DOP Tested; In-Line Carbon Filters**
  - **Environment Low Outgassing; Silicone and Vinyl Free**
  - **Walls Powder-Coated Steel; Floor Conductive Epoxy**
  - **Relative Humidity 50 ± 5%; Temperature 21 ± 1 Degree C**
- **Electronics Assembly Cleanroom**
  - **FED-STD-209E Class 100,000**
  - **Other Specs As Above (Except Temperature 21 ± 2 Degree C)**
- **CFRP Lay-Up Cleanroom**
  - **FED-STD-209E Class 100,000**
  - **Other Specs As Above (but Lower RH)**
- **Tank Room**
  - **Unclassified Cleanroom But Controlled and Maintained to at Least Class 100,000 Standard**
  - **Local Class 100 Vertical Laminar Flow Tent (3m x 4m)**

Typical Component Cleaning Procedure

- **Summary of a Typical Cleaning Schedule (Derived From Solar B - EIS) for Critical Metal Components:**
- **Preliminary Clean (in Laboratory or Workshop)**
  - **Remove Visible Surface Debris, Contamination, etc Using Wipes and/or Vacuum Cleaner**
  - **Scrub Wash With Detergent Solution Then Wipe Dry**
- **Degrease**
  - **Wash in Acetone Then Allow to Dry**
- **Final Cleaning (in Class 10,000 Cleanroom, or Better)**
  - **Wash in Ultrasonic Bath With Approved Detergent in De-mineralised Water**
  - **Flow Wash With Large Quantity of Tap Water**
  - **Flow Wash With De-Mineralised Water**
  - **Check Cleanliness by Water Break Then Allow to Drain and Dry**
  - **Flow Rinse With Isopropyl Alcohol Then Allow to Dry**
  - **Store in Class 100 Flow Bench If Necessary**
  - **Transfer to Vacuum Bakeout Chamber**
  - **Vacuum Bake at 100 Degrees C for TBD Days at Better Than 1 X 10^{-5} Torr; Monitor Cleanliness Levels Using 2-100 AMU Mass Spectrometer and Cooled TQCM**
  - **Bag in New Llumalloy Bag and Attach “Cleaned Component” Tag**
  - **Record Operation in Component Cleaning Log**

HI Transportation Container

- Baseline Is to Use LASCO Transportation Vessel (Also Used for SMEI)
- Sealed Pressure Vessel Filled With GN2



HI Handling GSE

- **Two Frames – One Attached at Front and One at Rear**
- **Attach to Fasteners for Longitudinal Bulkheads in Main Structure**
  - **Double-Threaded Fasteners**
- **Provide 4 Lifting Points for Horizontal Handling**
- **Provide 2 Lifting Points for Vertical Lifting**

CEB Qualification Test Matrix

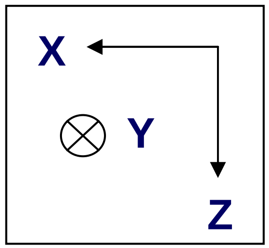
Model	Configuration	EMC	Vibration	Thermal Vac	Notes
DM4	2-Shooter		(Qualification)	(Yes)	Used for HI Qualification Testing but Not Fully Flight Representative
EQM	2-Shooter	Yes	Qualification	Yes	Fully Flight Representative. May Be Used for HI Qualification Testing (in Event of Problem With DM4). Will Be Delivered to NRL to Facilitate Early Testing With Fully Flight Representative CEB.
FM1	3-Shooter		Protoflight	Yes	Similarity of Design to 2-Shooter Justifies Protoflight Qual Approach for 3-Shooter
FM2	2-Shooter (TBC)		Acceptance	Yes	
FM3	3-Shooter (TBC)		Protoflight	Yes	
FM4	2-Shooter		Acceptance	Yes	
FM5	3-Shooter		Protoflight	Yes	Flight Spare Is Built As 3-Shooter. If Necessary Reconfigured As 2-Shooter (Spare Housing Available) and Re-Qualified If Schedule Permits. Alternatively Change Cards

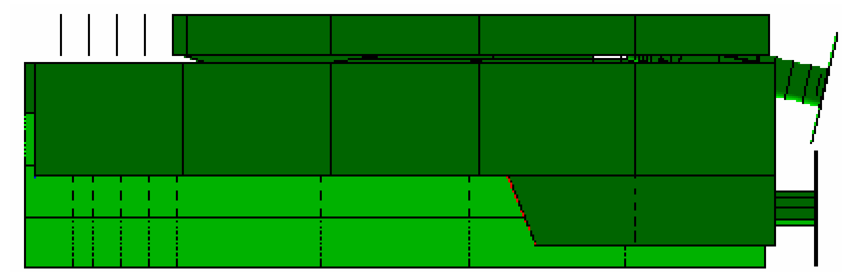
HI Thermal Design and Analysis Backup

HI Thermal Analysis Case Descriptions (1 of 3)

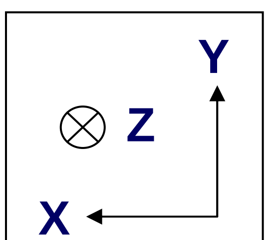
- **Nominal Orientation**
  - **Case 1**
  - **Case 2**
  - **Case 3**
  - **Case 4**
  - **Case 5**
  - **Case 12**
  - **Case 13**
  - **Case 14**
  - **Case 15**

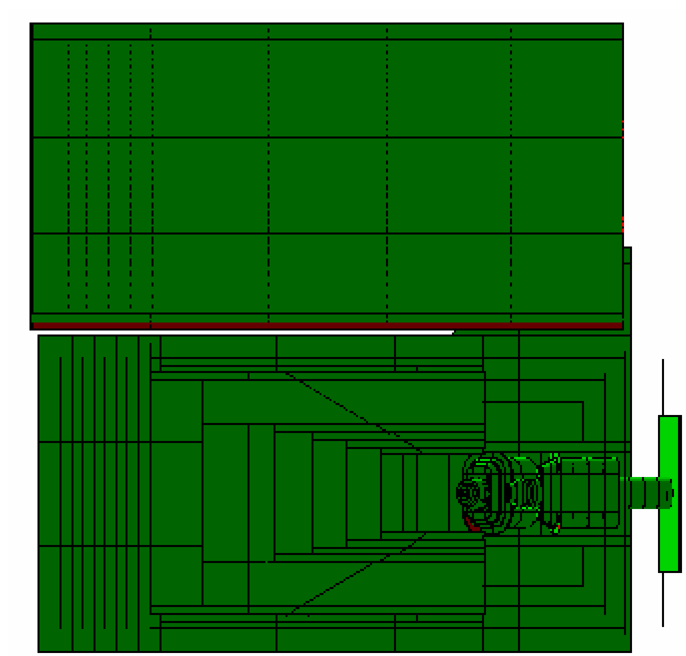
Side View





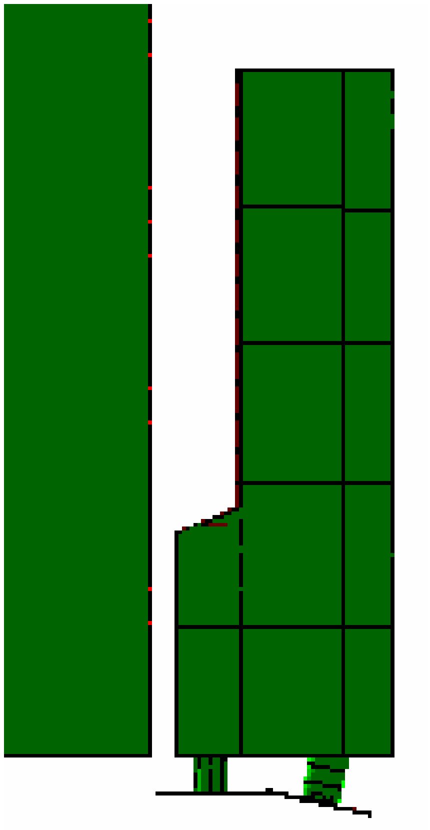
Top View



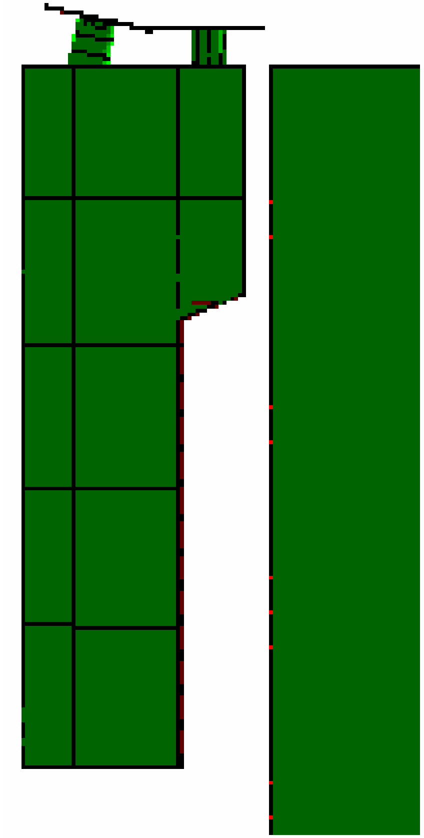


HI Thermal Analysis Case Descriptions (2 of 3)

- + 90 Degree Orientation
  - Case 6
  - Case 8

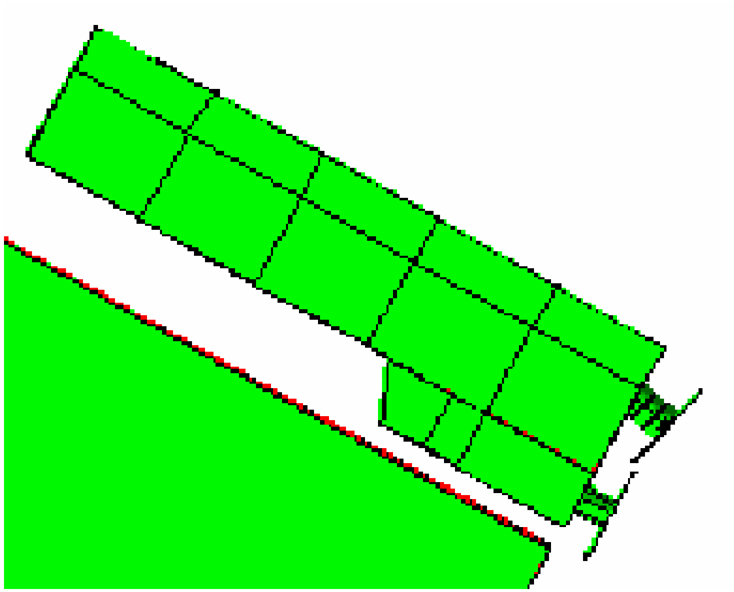


- - 90 Degree Orientation
  - Case 7
  - Case 9

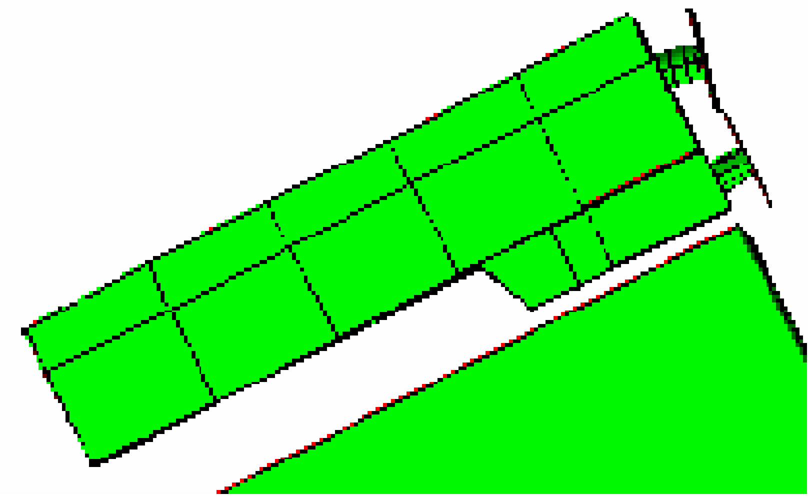


HI Thermal Analysis Case Descriptions (3 of 3)

- **+ 45 Degree Orientation**
  - **Case 10**



- **- 45 Degree Orientation**
  - **Case 11**



HI Thermal Design - Extra Details

- **Solar Power Collected by Legs = 0.05 W Each in Worst Case. Assumed Negligible**
- **Actual Fin Area = 106cm2. ~50% Coverage by Harness and MLI Assumed**
- **Hi1 and Hi2 FPA Cold Cups Are Colder Than CCDs in All Cases**
- **Worst Case "Small" MLI Assumed in All Cases. Effective Conductivity Ranges From ~0.0004 W/K to ~0.002 W/K in Operational Cases. This Is Equal to an Effective Emissivity of 0.0008 to 0.0002.**
- **Sensitivity of CCD Temperature to Lens Assembly Heater Power Is Generally ~ 5 Degree c/w (Varies for Hi1, Hi2 and Different Cases)**