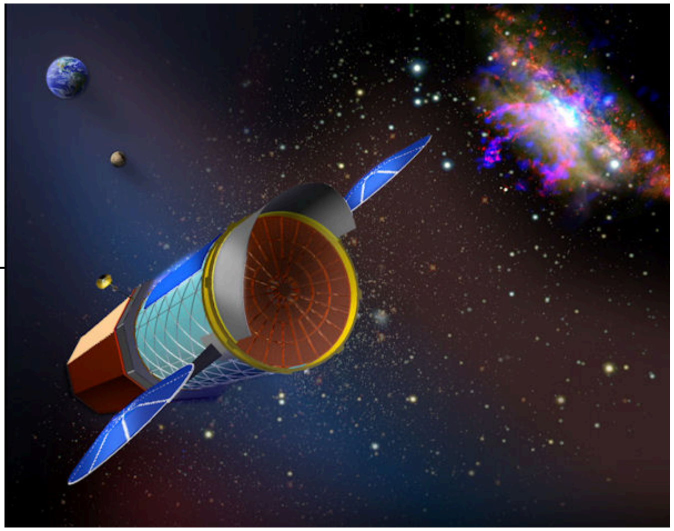
IXO Science Meeting/ January 28, 2009
Goddard Space Flight Center

NASA IXO Mission Concept

Jean Grady / GSFC
IXO NASA Project Manager

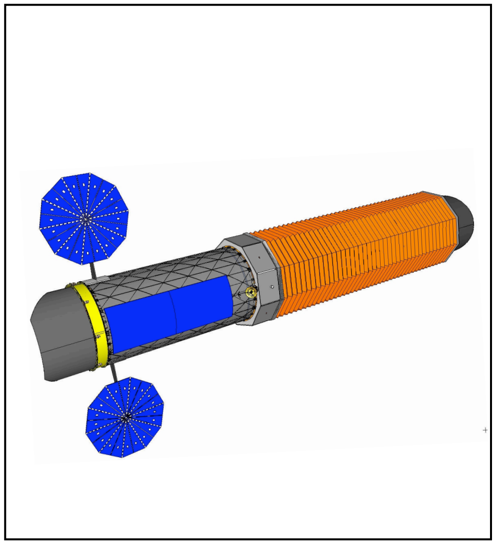


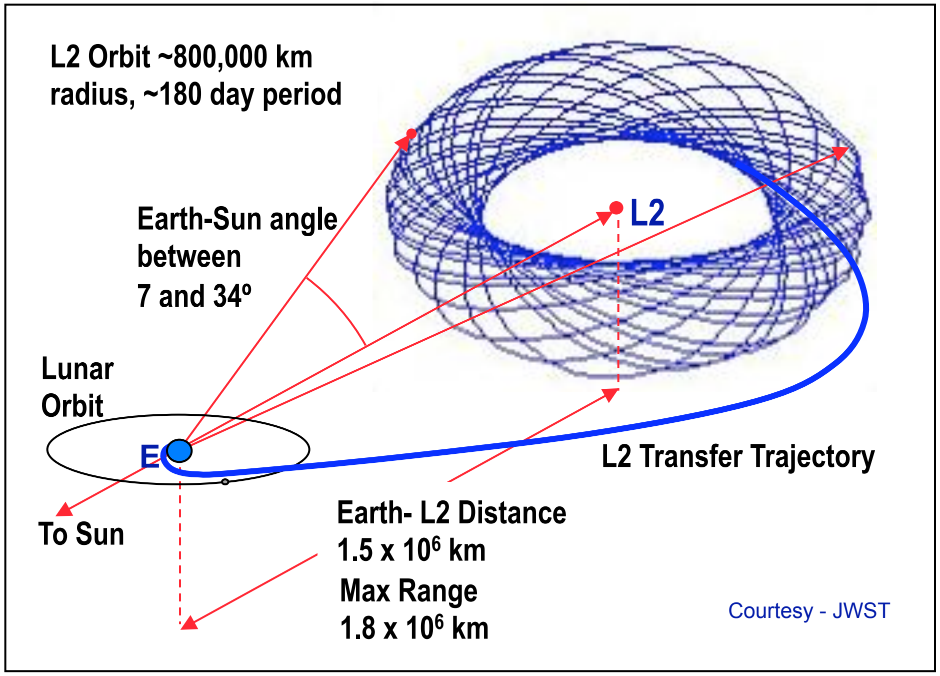
Timeline for IXO Mission Concept Development

- Pre-IXO Mission Studies laid foundation for IXO mission concept development
  - Con-X mission studies, mirror and instrument definition, etc. (1998 – 2008)
  - Large extensible bench studies (2004)
- Preliminary concept studies for single telescope observatory with extensible bench: 3/08 – 7/08
- **ESA and NASA HQ agree on mission study scope: 7/08**
- **Mission Design Lab study at NASA/GSFC: 7/08**
- **IXO Science Team Meetings: 8/08 (GSFC); 9/08 (MPE)**
- **IXO Coordination Group defines instrument set: 11/09**
- Refine and add detail to mission concept: 10/09 – 1/09
  - Payload accommodation update to include all instruments (11/08 – 1/09)
  - Integrated modeling (10/08 – 1/09)
  - NASA Mission Design Lab study update to systems/subsystems (1/09)

Mission Overview

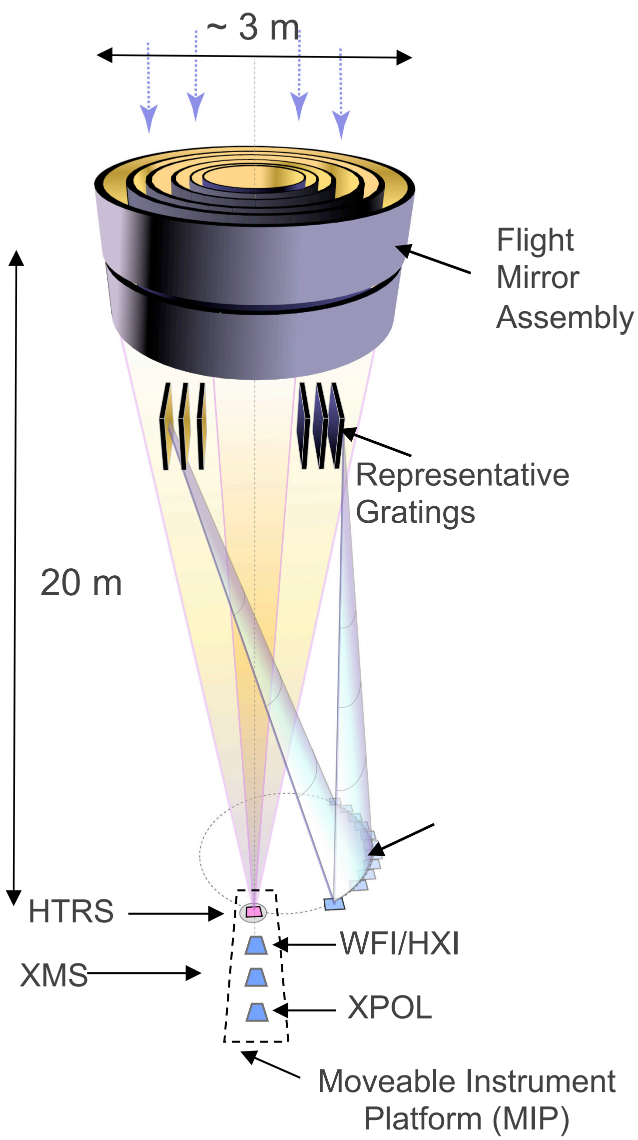
- Single Mirror Configuration
  - 3.4 m dia mirror with a 20 m focal length
  - Part of the metering structure is extensible
- Mission Life and Sizing
  - Class B Mission: no performance degradation w/ single point failure
  - Mission Life: 5 years required; consumables sized for 10 years
- Launch and Orbit Insertion
  - Launch on an Atlas V 551 medium fairing or Ariane 5 in 2020
  - Observatory Dry Mass is ~6100 kg (w/ 30% contingency) within capability of Atlas V or Ariane 5
  - Direct launch into "zero Insertion delta-v" L2 orbit
  - 100 day cruise
- Mission Orbit
  - L2 800,000 km semi-major axis halo orbit





IXO Payload

- **Flight Mirror Assembly (FMA)**
  - Highly nested grazing incidence optics
- **Instruments**
  - X-ray Micro-calorimeter Spectrometer (XMS)
  - X-ray Grating Spectrometer (XGS)
  - Wide Field Imager (WFI) and Hard X-ray Imager (HXI)
  - X-ray Polarimeter (X-POL)
  - High Time Resolution Spectrometer (HTRS)
- **XMS, WFI/HXI, XPOL and HTRS observe one at a time by being inserted into focal plane via a Moveable Instrument Platform (MIP)**
  - 4 Science Operational Modes
  - XGS always operational



Instrument Operation/Science Mode Summary

- 4 Science Modes defined
  - One Science Mode for each instrument location on Movable Instrument Platform (MIP)
  - XGS operates during all Science Modes
  - Instruments that are not conducting science are in placed in Standby

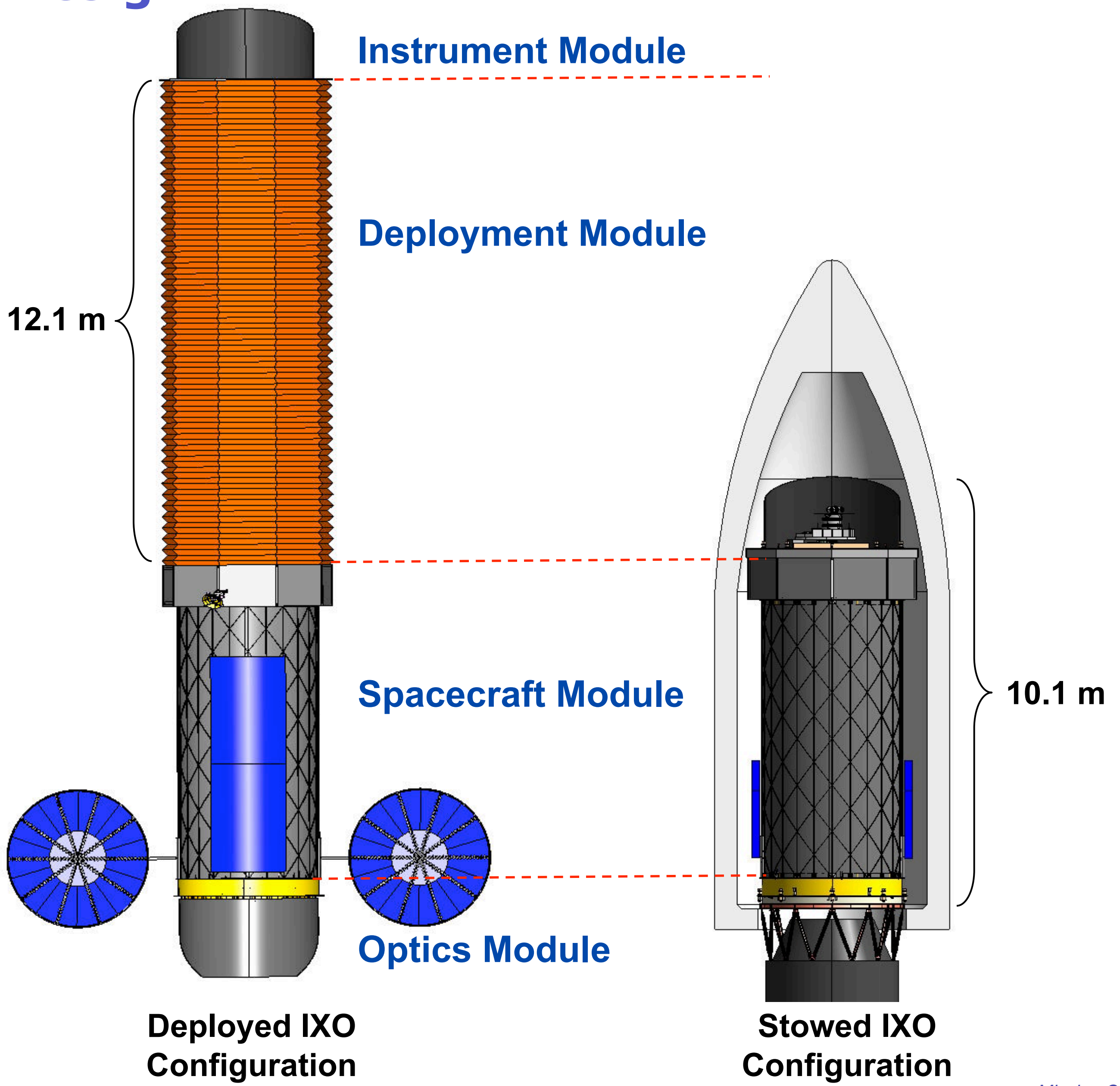
		Science Modes			
		Mode 1	Mode 2	Mode 3	Mode 4
Instrument Operations	Science	XMS, XGS	WFI, HXI, XGS	X-Pol, XGS	HTRS, XGS
	Standby	WFI, HXI, X-Pol, HTRS	XMS, X-Pol, HTRS	WFI, HXI, HTRS, XMS	WFI, HXI, XMS, X-Pol
Percent time for each Mode		40%	40%	10%	10%
Observation Duration (hours)	Average	10 hours			
	Minimum	30 minutes			
	Peak	48 hours			

Payload Mass, Power, and Data Rate Summary

Element	Mass (kg)	Power (W)		Data Rate (kbps)	
		Ave	Peak	Ave	Peak
Flight Mirror Assembly (FMA)	1748	1394	1394	1	1
X-ray Microcalorimeter Spectrometer (XMS)	257	649	703	30	1684
Wide Field Imager (WFI)	75	233	233	45	1000
Hard X-ray Imager (HXI)	24	36	36	11	1001
X-ray Grating Spectrometer (XGS)	82	47	53	151	1501
X-ray Polarimeter (XPOL)	11	37	37	300	1000
High Timing Resolution Spectrometer (HTRS)	25	94	94	50	50
Total	**2221**				

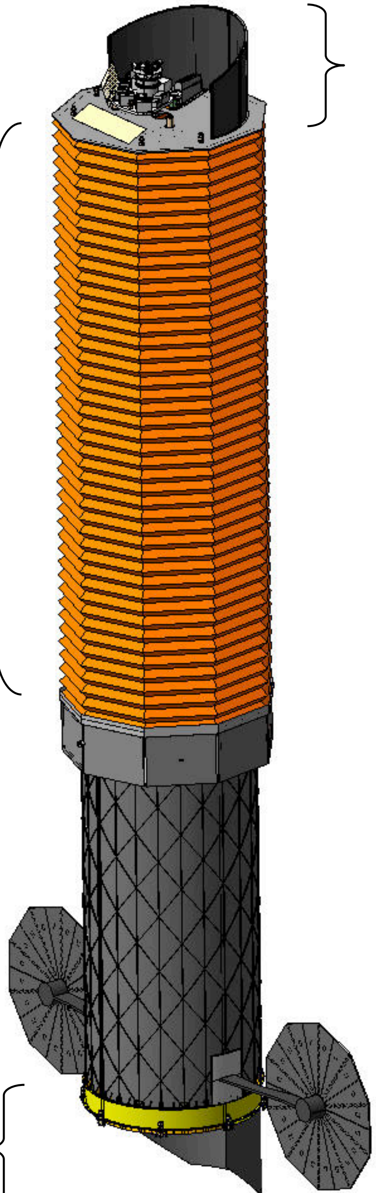
- **Driving Power Science Mode:**
  - Mode 1 (XMS + XGS) is ~2000 average; ~2100 W peak (including FMA heater power)
- **Driving Data Science Modes:**
  - Mode 2 (WFI/HXI +XGS) is ~3500 kbps peak
  - Mode 3 (X-POL+ XGS) is ~450 kbps ave
- **Data Storage Sized for 12 hours of peak plus 60 hours of average data (assuming one missed pass)**
- **Downlink sized to accommodate 2 bright source peak observations (48 hours) per month and meet 72 hour latency on average observations**

NASA Mission Design



Observatory Module Overview

- **Deployment Module**
  - 3.9 m diameter shroud
  - Extensible ADAM-type masts (3) with harness (not shown
  - Two X-ray baffles (not shown)



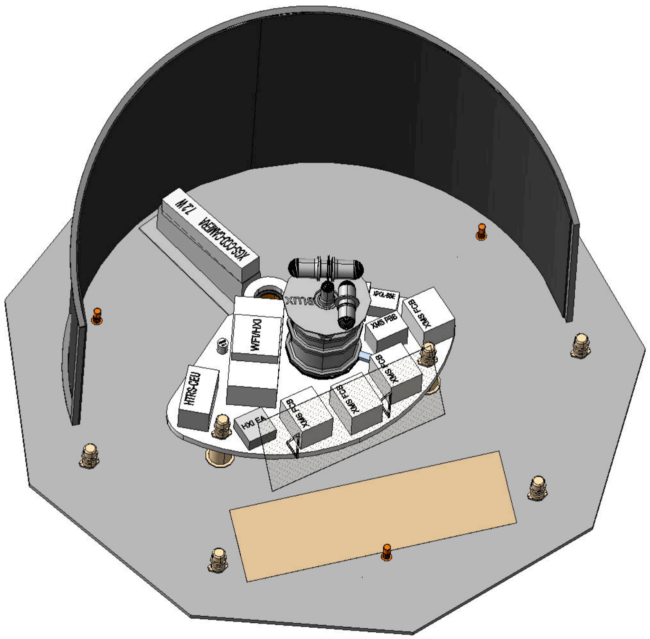
- **Instrument Module**
  - Sunshade
  - Moveable Instrument Platform (MIP) w/ XMS, WFI/HXI, X-POL, HTRS
  - Fixed Instrument Platform (FIP) w/ XGS camera

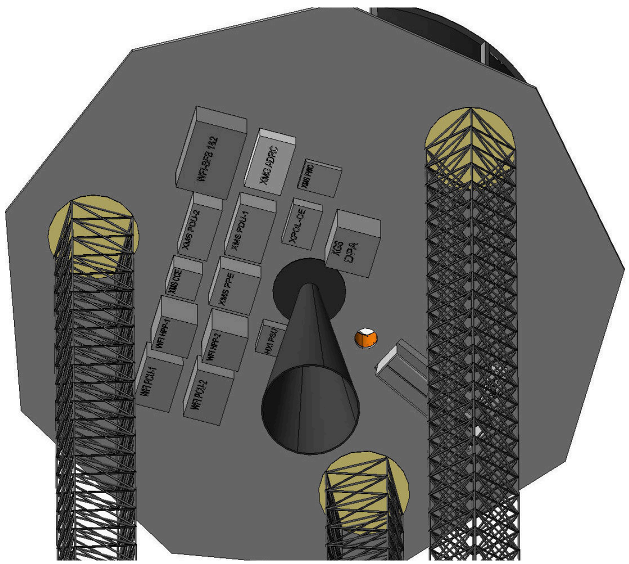
- **Spacecraft Module**
  - 9-sided Bus w/ avionics, power system electronics, battery, propulsion tanks, reaction wheels, etc.
  - Ka- and S-band High Gain Antenna
  - Composite isogrid metering structure
  - Body mounted solar array (not shown)
  - Ultraflex solar arrays (3.4 m dia)
  - Thrusters (14)

- **Optics Module**
  - Flight Mirror Assembly (FMA)
  - FMA deployable covers
  - Deployable Sunshade

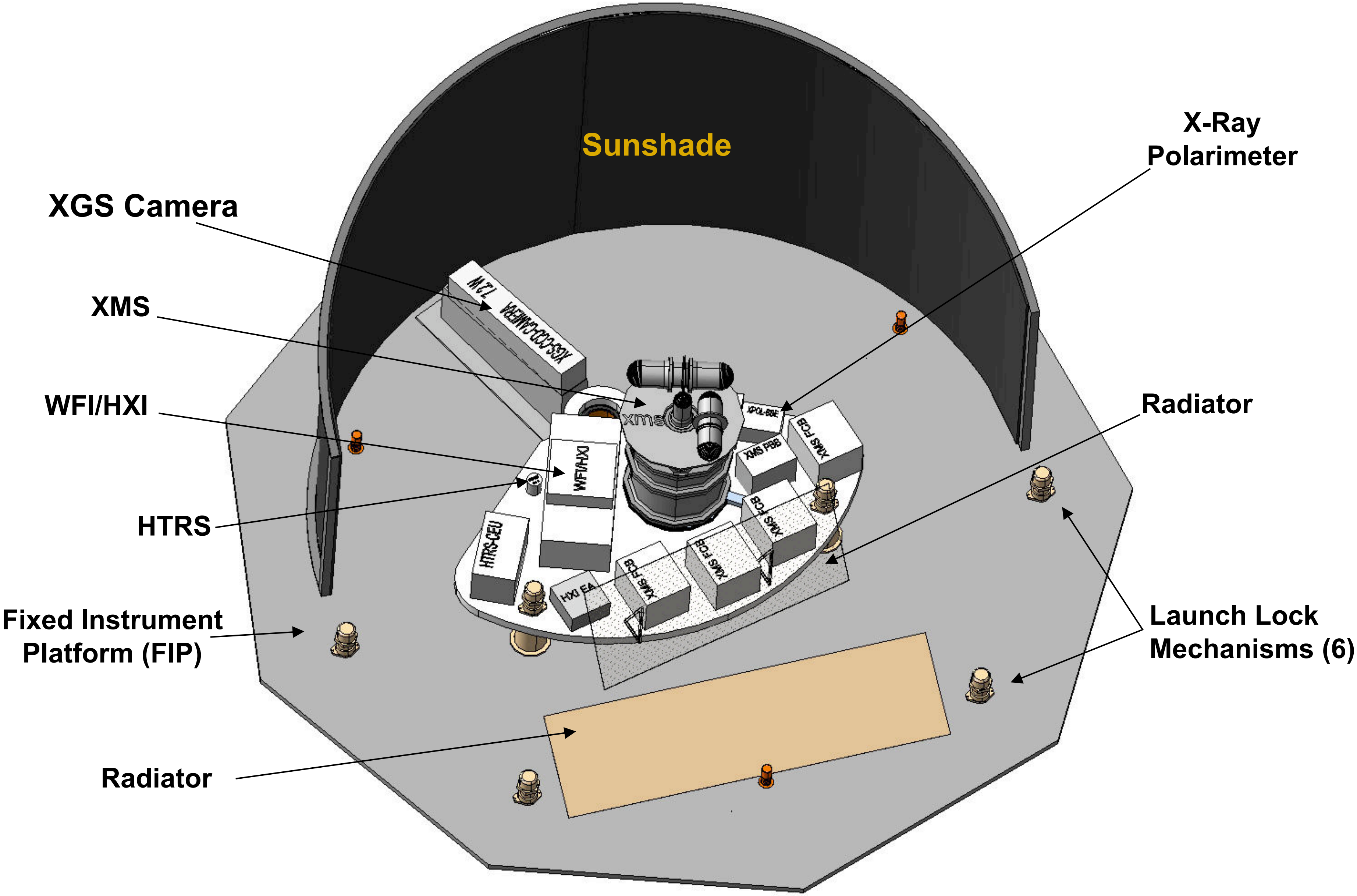
Instrument Module

- XPOL, XMS, WFI/HXI, & HTRS detectors and proximity electronics mount on Moveable Instrument Platform (MIP)
- XGS camera mounts to the Fixed Instrument Platform (FIP)
- Remote instrument boxes mount to the underside of the FIP
- Radiators, VCHPs (variable conductance heat pipes), blankets, heaters on MIP and FIP provide thermal control
- Single Remote Interface Unit on the FIP for instrument command and data interface to spacecraft C&DH, and power distribution
- Large “common instrument baffle” for on-axis instruments on MIP

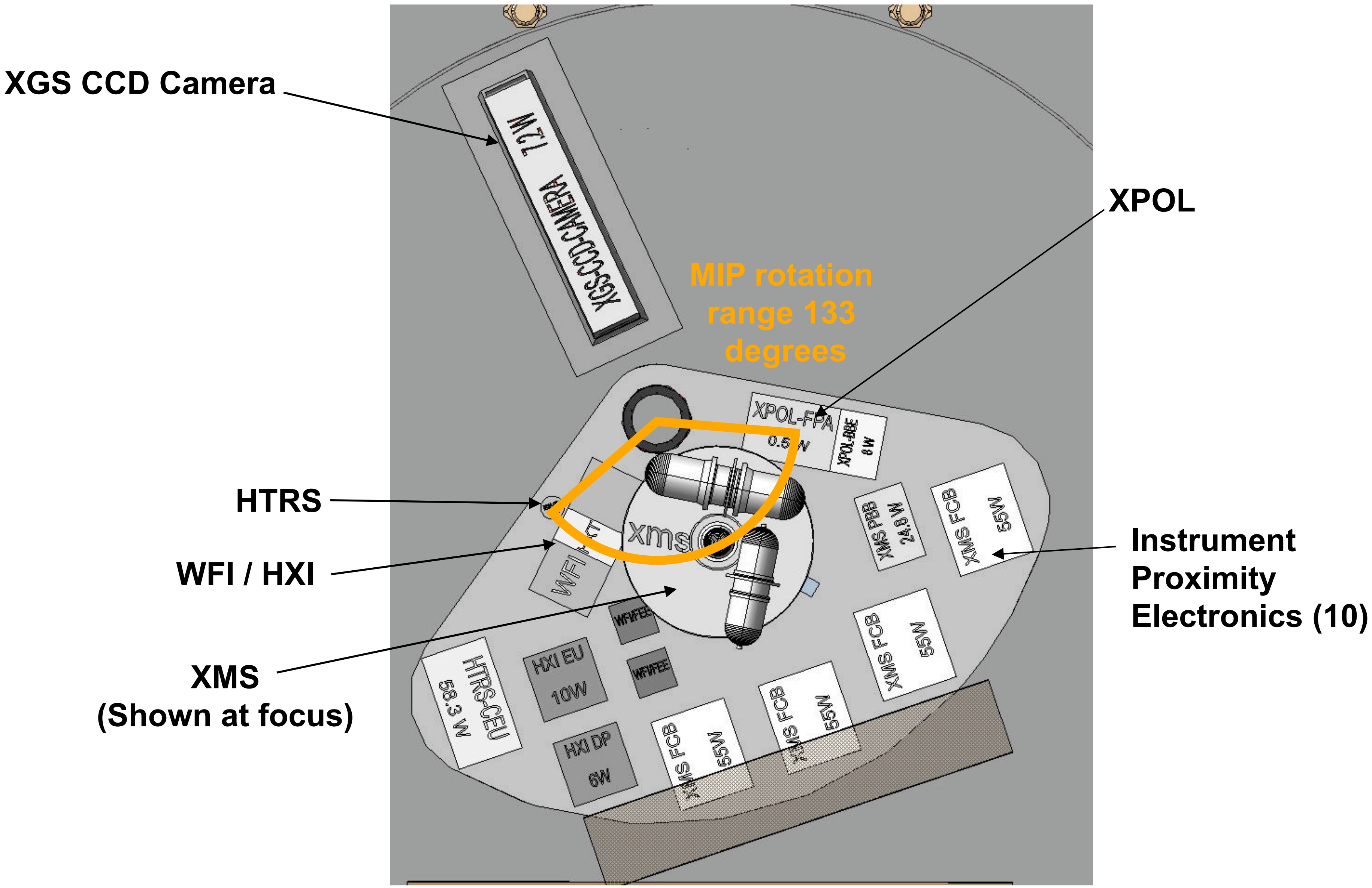




Instrument Module

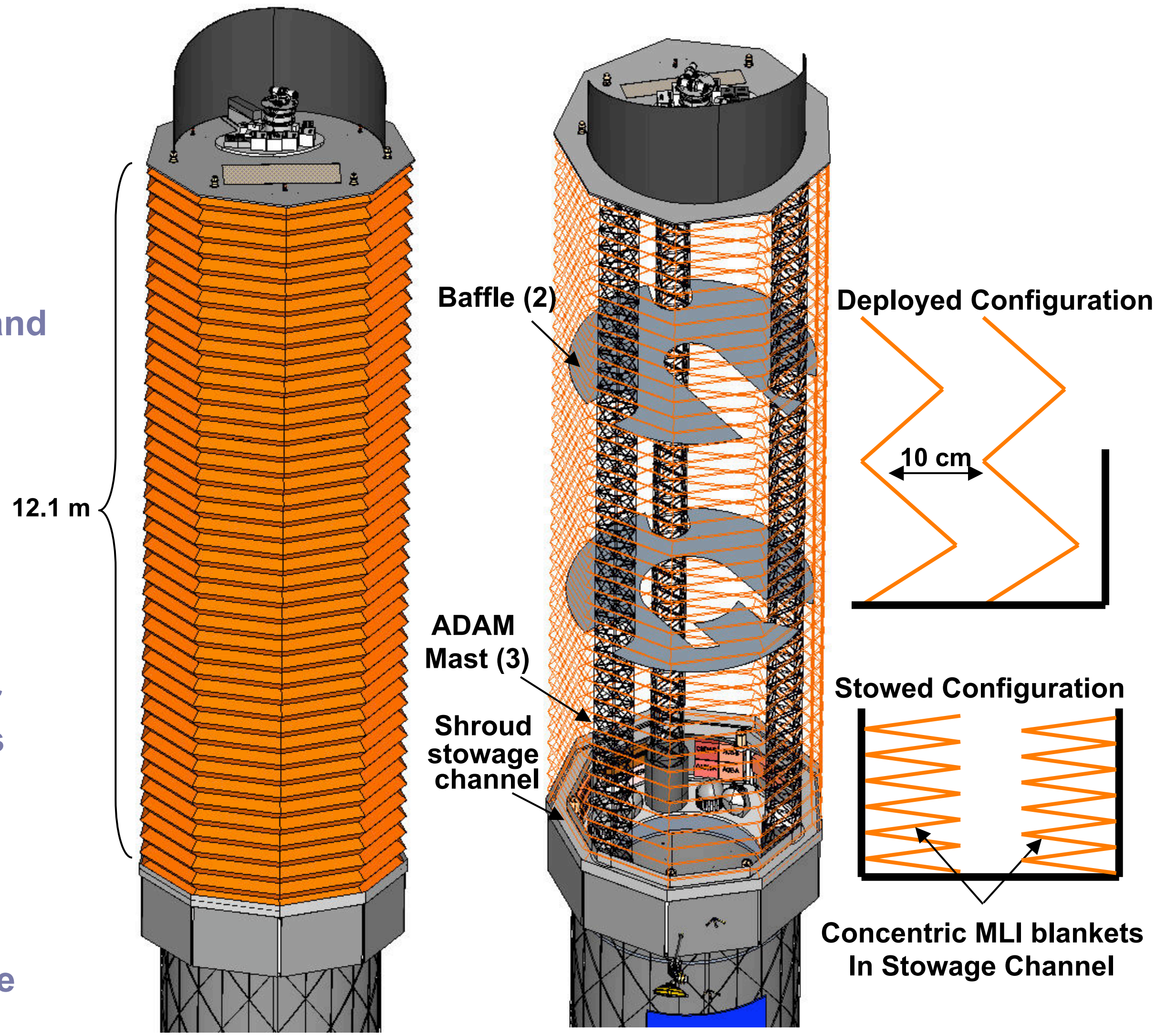


Instrument Suite Layout



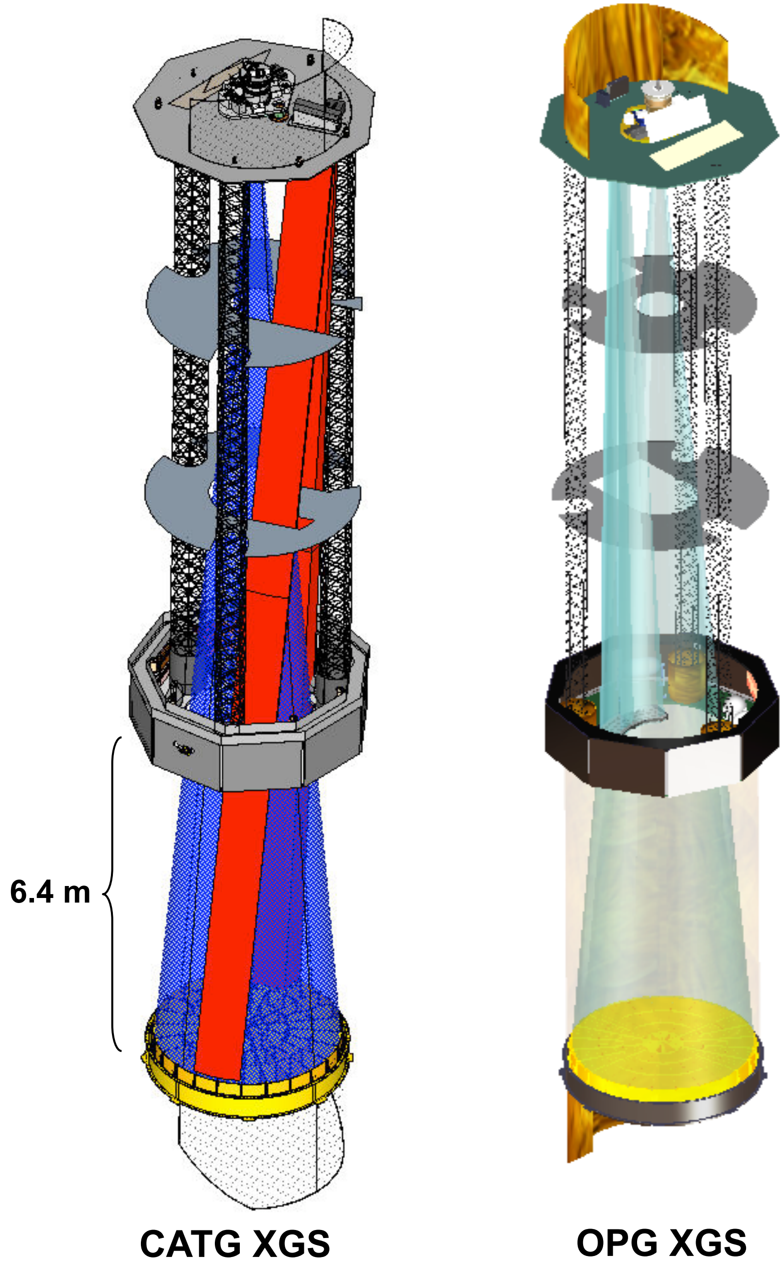
Deployment Module

- 3 ADAM masts deploy the IM, shroud, baffles and harness
  - Provides on-orbit alignment stability between optics and detectors
  - First modes: 1.8 Hz bending and 4.1 Hz torsion
  - Proven technology
  - Mast and harness stows into canister
- Shroud blocks light and supports baffles
  - Accordion-pleated multi-layer insulation blanket assemblies
  - Two concentric blanket assemblies form a “Whipple shield” to minimize micrometeorite penetrations
  - Stows in channel on top of the spacecraft bus



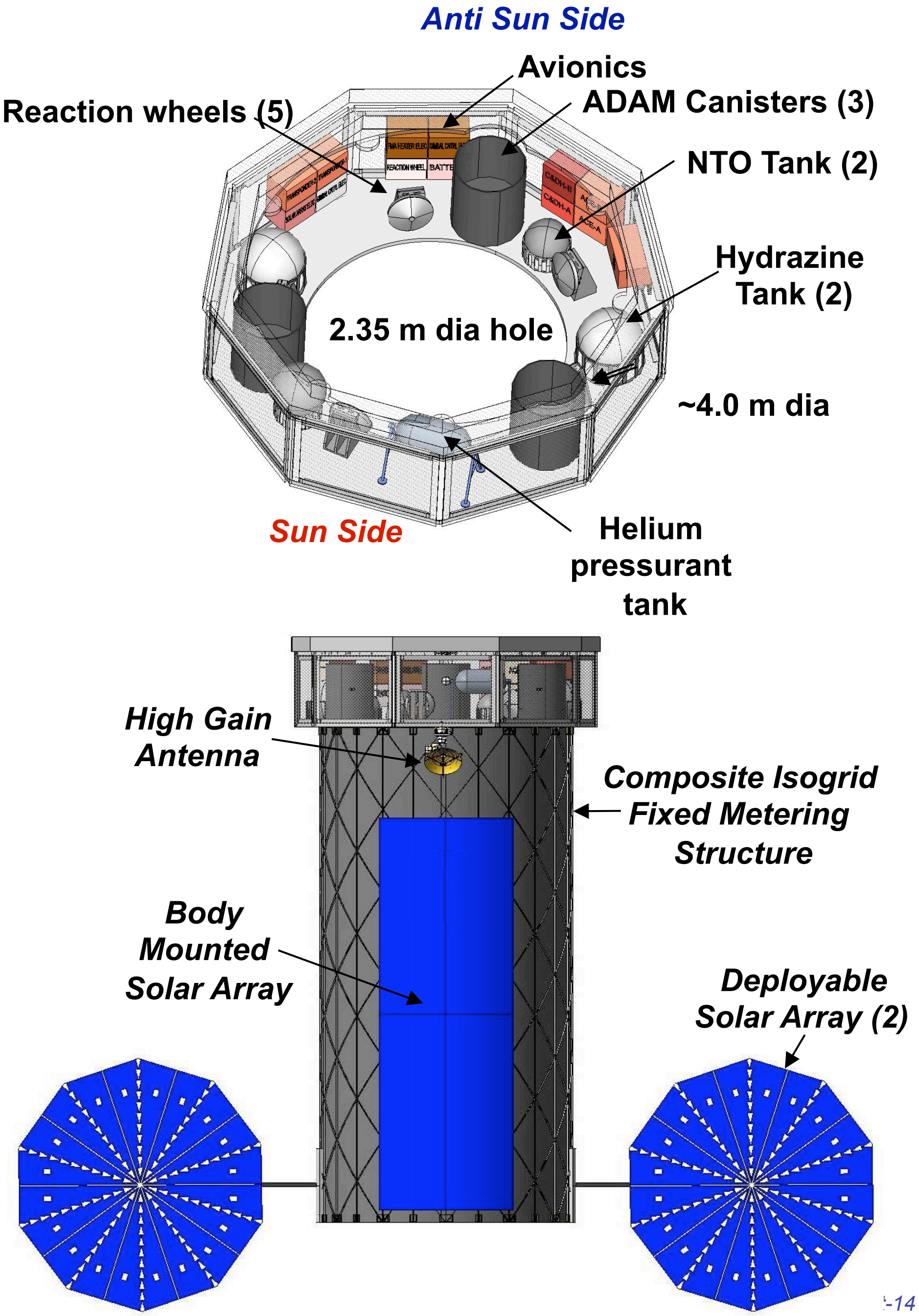
X-ray Trace

- The X-ray traces of the FMA and XGS traverse nearly the entire length of the observatory
- Either Critical Angle Transmission Grating (CATG) or Off-Plane Grating (OPG) XGS can be accommodated
- The x-ray beams drive the size, shape and placement of the spacecraft bus "ring"
  - Needs to be forward of the FMA for sufficient volume for bus components
  - Distance between the bus and the FMA limited to fit in the Atlas V 5 medium fairing
  - (CG, mass propellant lines are additional considerations)



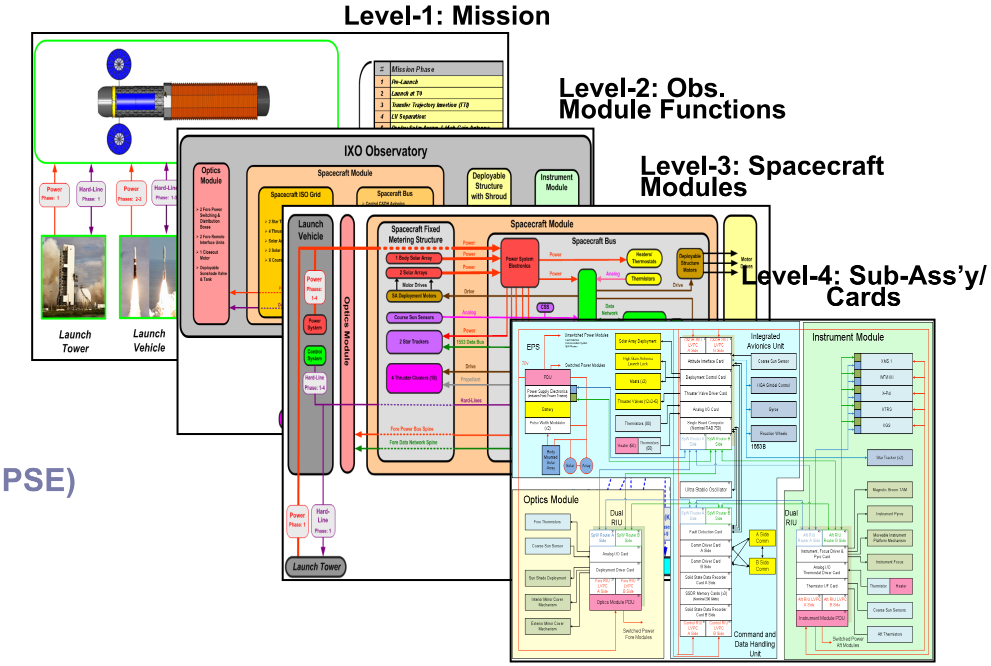
Spacecraft Module Overview

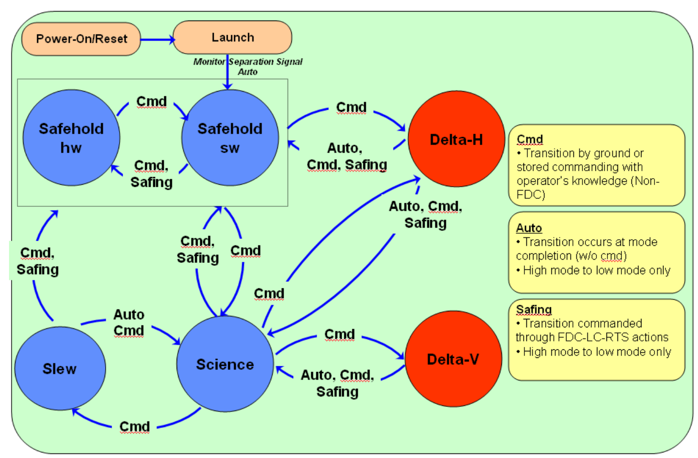
- GN&C
  - Pointing Requirements: 10 arcsec control, 1 arcssec knowledge, 0.2 arcsec jitter
  - AST-301 star trackers (2), HR-16 reaction wheels (5), Course and Fine Digital Sun Sensors, IRU, Distributed Telescope Aspect Determination System (TADS)
  - Solar Pressure Torque @ 1.5m CM/CP offset compensated with 0.9 N monoprop pulse every ~18 minutes
- Propulsion
  - NTO/Hz Bi-prop pressure regulated
  - Tanks sized for 10 years+; placed to minimize CG migration over life of mission
  - 22 N thrusters (16), 0.9 N thrusters (2)
- Electrical Power
  - 19.5 m^2 Solar Array for 5000 W (Beginning of Life)
    - Body mounted solar array allows for indefinite safe mode
    - Ultra-flex deployable arrays help reducing Center of Mass-Center of Pressure offset
  - S/A output routed to PSE for regulated 28V DC
  - 50 AH LiIon battery sized for Launch only
  - Electrically independent FMA power system for thermal control



Spacecraft Module Overview (cont.)

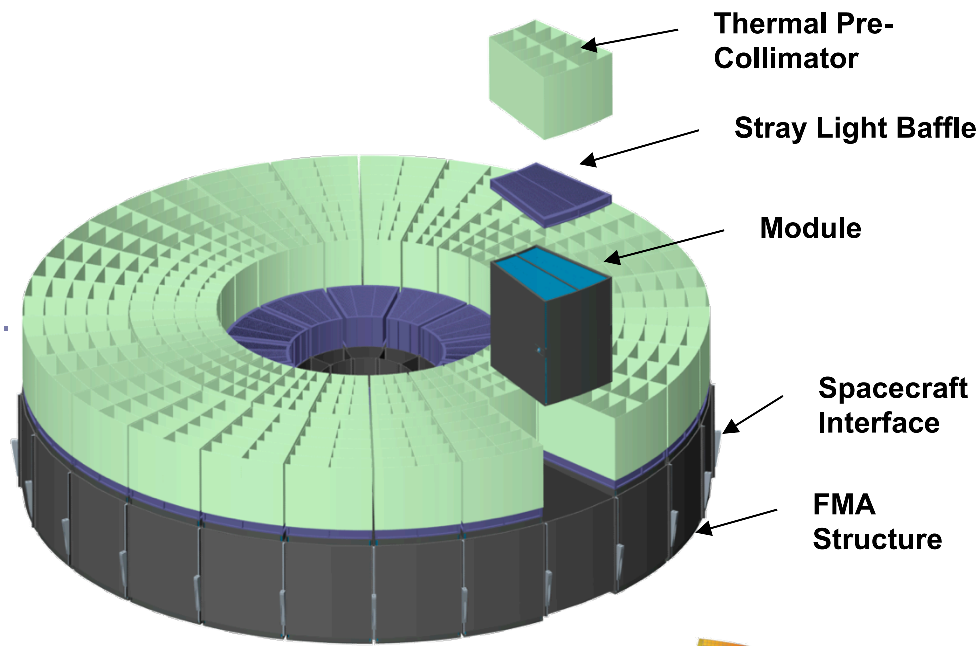
- **C&DH**
  - Networked highly redundant Spacewire architecture
  - 400 Gbit storage
  - BAE RAD 750 SBC (6U) processor
- **Flight Software**
  - C&DH/FSW provides:
    - Commands and time distribution
    - ACE and PSE functions (no separate ACE, PSE)
    - Mechanisms control
  - Instruments provide any data compression, packetization and time stamping
  - Re-use of existing C&DH FSW
- **RF Communication**
  - Ka-band for science data and TT&C via gimbaled HGA to Deep Space Network 34 meter antenna
  - S-band for TT&C via HGA to DSN 34 meter, via omni to DSN 34m, and via omni to TDRSS for launch/LEO critical events
  - Contacts: one 30 minute contact/day nominal; 3 hr contact twice/month for peak data; Two contacts / day during Cruise
  - Observe/range/orbit determination during downlink

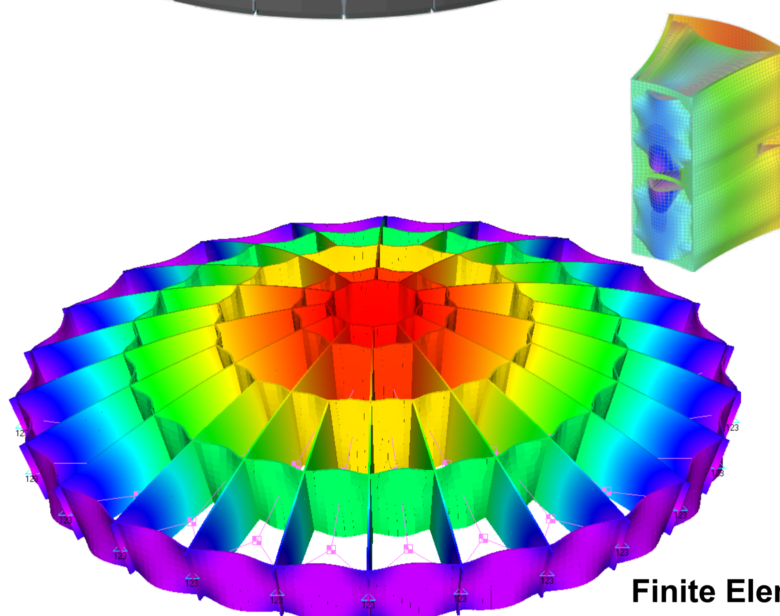




NASA FMA Concept

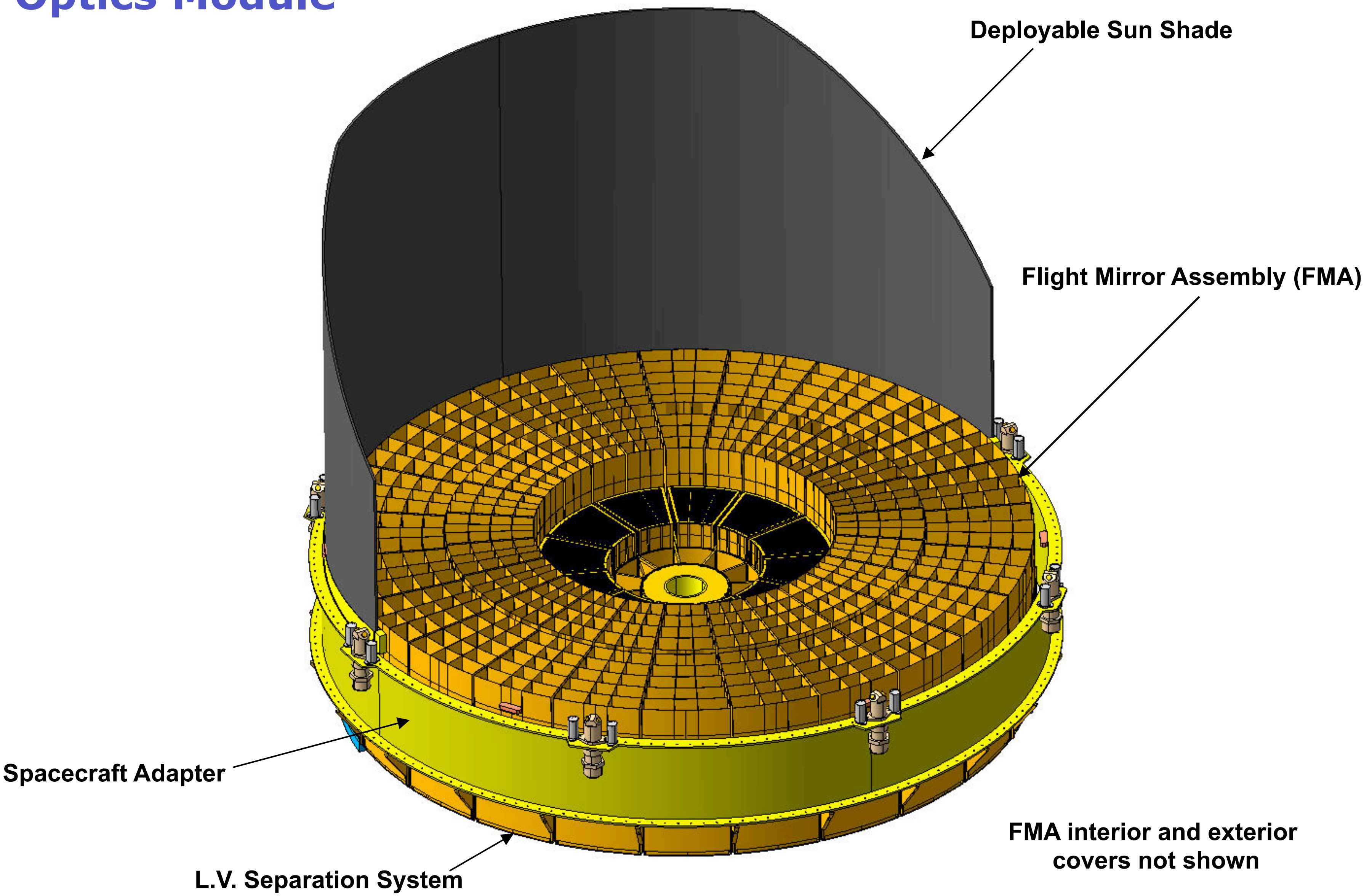
- **Key requirements:**
  - Effective area /Resolution:
    - ~3 m^2 @ 1.25 keV; 0.65 m^2 @ 6 keV with 5 arcsec angular resolution
    - ~150 m^2 @30 keV with 30 arcsec ang. res.
- **Overall dimensions: 3.4 m dia x 0.8 m**
- **Segmented Wolter I optical design**
- **Slumped glass mirror segments**
- **60 modules: 24 outer, 24 middle, 12 inner**
- **60 mirror modules each with 200-300 segments**
- **Hard X-ray mirror module, with multi-layer coated mirrors, in the center provides high energy response**
- **Total FMA mass is ~1750 kg (current best estimate, no contingency)**
- **Power is ~1400 W to maintain 20 C**
- **Finite Element Analyses support design concept**





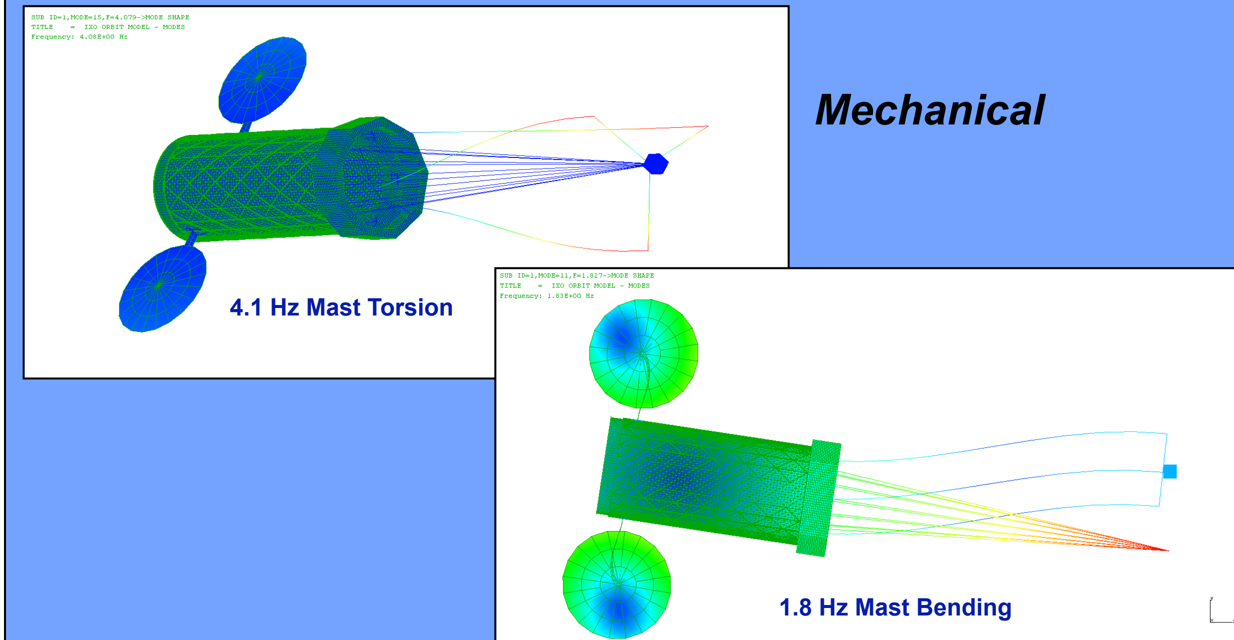
Finite Element Model of FMA Structure

Optics Module

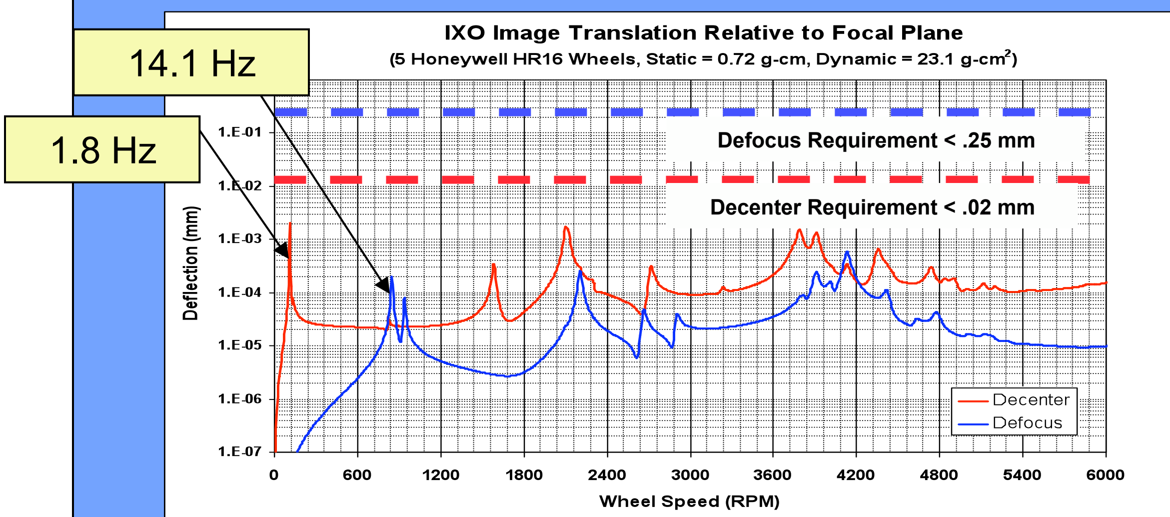


Initial Integrated Modeling Supports Configuration

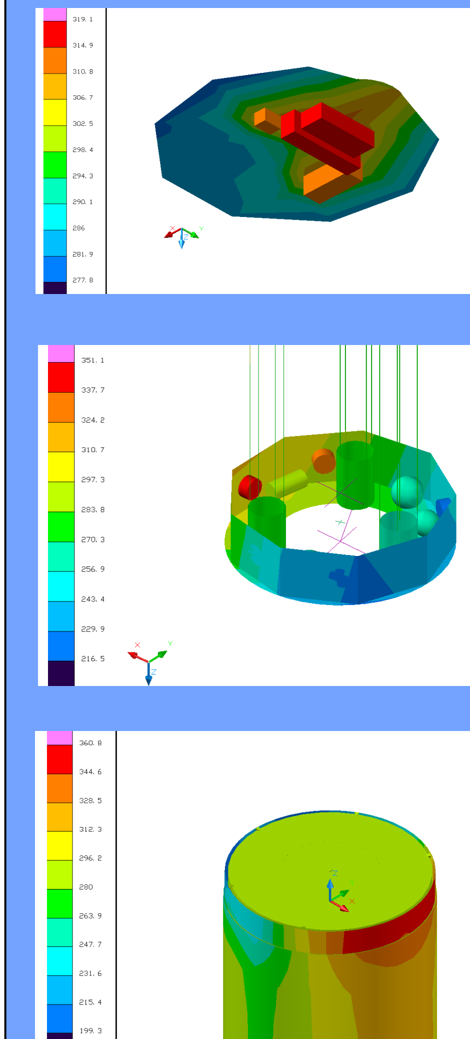
Mechanical



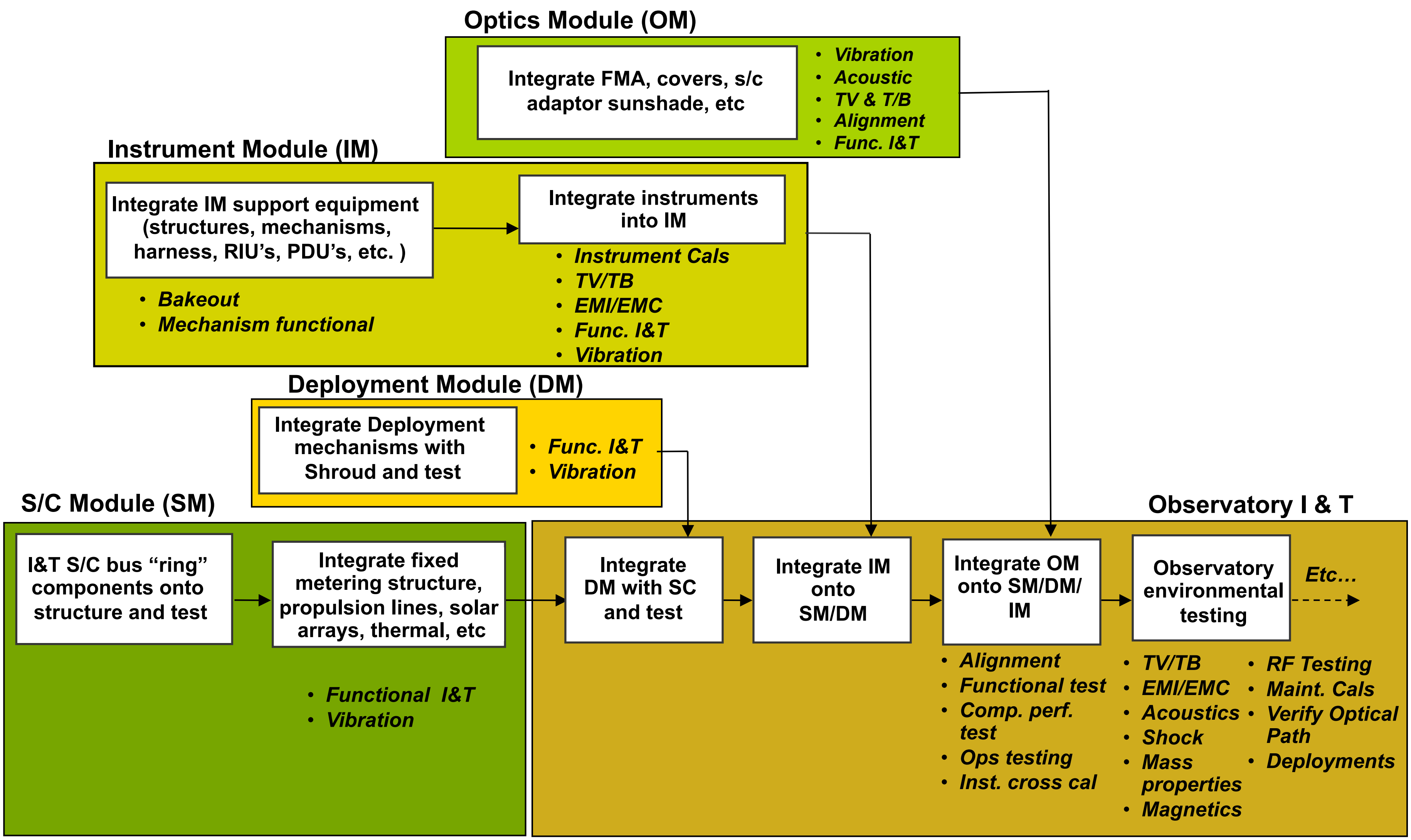
Jitter



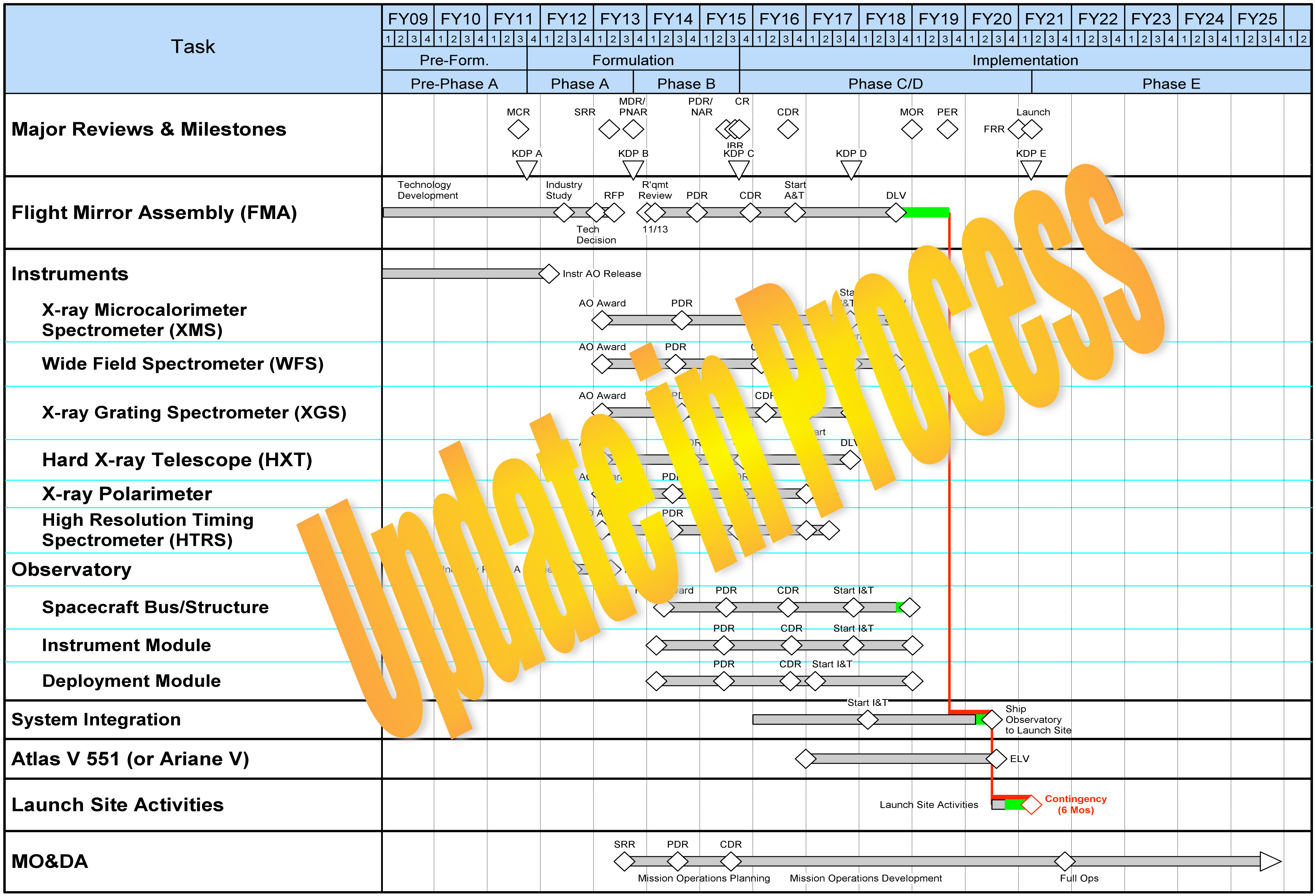
Thermal



DRAFT IXO High Level I&T Flow



DRAFT Mission Schedule



Next Steps Preparing for Decadal

- Finalize observatory system & subsystem updates from MDL: 1/09 – 2/09
  - Observatory system & subsystem updates from MDL
- Update Payload Definition Document: 1/09 input – 2/09 draft – 3/09 final
- Update Technology assessments and plans: 2/09 draft – 3/09 final
- Perform Independent Cost and Schedule Estimates: 2/09 – 4/09
- Receive Request for Information (RFI) from Decadal: 2/09
- Prepare and submit RFI response: 2/09 – 3/09
- Receive Request for Programmatic Information from Decadal: 4/09
- Prepare/submit Mission Programmatic response to Decadal: 4/09 – 5/09
  - Cost and schedules to be reviewed by NASA HQ prior to submittal
- Mission presentations to Decadal: 6/09