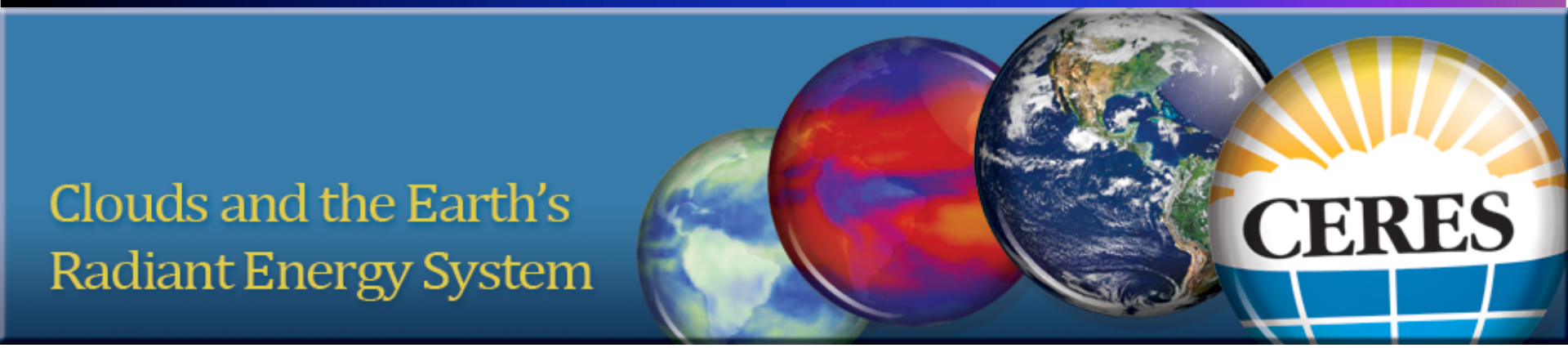
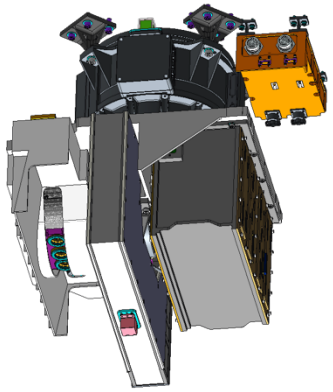


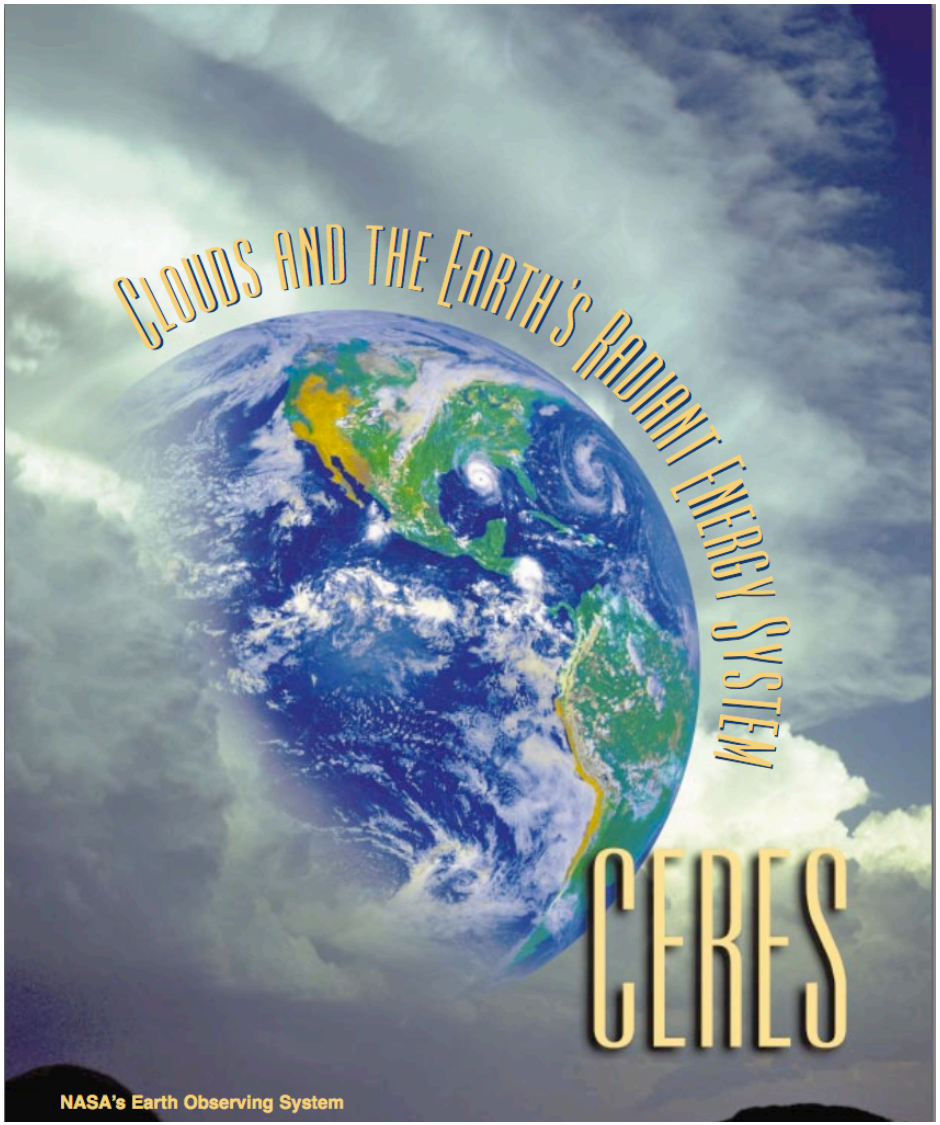
CERES Flight Model 6 & Radiation Budget Instrument (RBI) Status



Kory Priestley

CERES Science Team Meeting
Langley Research Center
Hampton, VA
May 5th, 2015

Discussion Topics

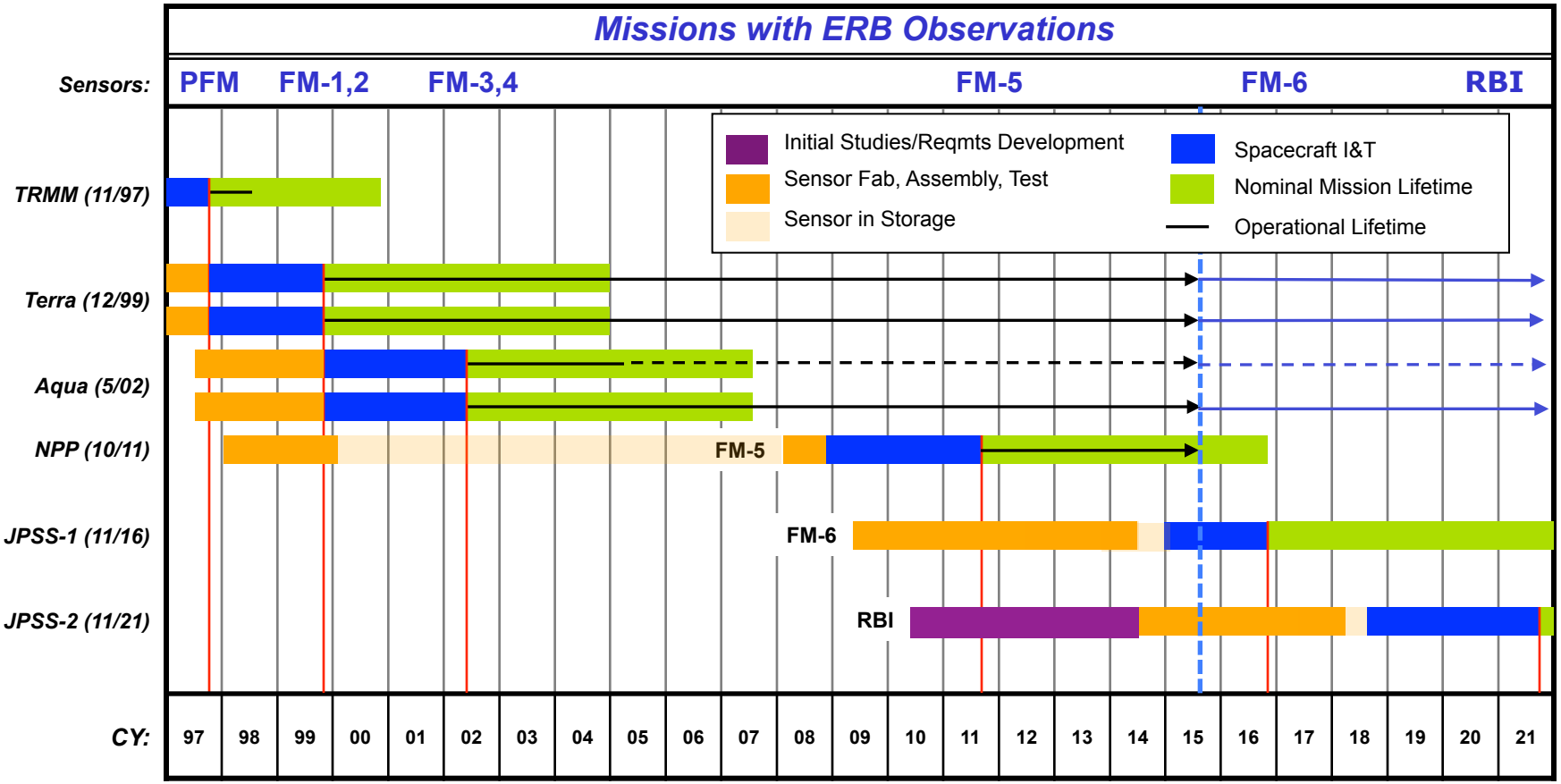


- **ERB missions Overview**
  - Flight history/future
- **Instrument Status**
  - FM-6 on JPSS-1
  - RBI on JPSS-2
- **Summary**

Climate Data Record Continuity

Clouds and the Earth's Radiant Energy System

CERES/RBI Flight Schedule



We now have over 61 years of flight experience with the CERES instruments

CERES FM-6

JPSS-1 Satellite I&T Overview

- **Ball Aerospace & Technologies Corporation (BATC) in Boulder, CO is the JPSS-1 spacecraft provider and satellite integrator**
  - BATC was also NPP S/C provider and integrator
- **NGST will run first Bench Acceptance Test at BATC**
- **NASA LaRC personnel will perform CERES I&T activities at BATC**
- **JPSS will coordinate launch operations through NASA KSC**
  - Launch will be from Vandenberg Air Force Base, CA (same as NPP)
  - Launch vehicle provider has not been selected yet
- **I&T will heavily leverage success accomplished on NPP**
  - Reuse NPP I&T flow & procedures minimizing changes
  - Integrate lessons learned from NPP for JPSS-1 I&T

CERES FM-6 Upcoming Activities

• CERES Delivery to BATC	June 2014
• CERES Bench Acceptance Test	June 2014
• First Instrument Integrated (CERES):	October 2014
• Last Instrument Integrated:	May 2015
• Satellite Pre-Environmental Review:	August 2015
– Dynamics Testing Complete	November 2015
– EMI – EMC Complete	February 2016
– TVAC Complete	March 2016
• Satellite I&T Complete:	May 2016
• Ship to Launch Site:	September 2016
• Launch Readiness Date:	October 2016

CERES FM-6 I&T Team

- CERES I&T Activities for integration to JPSS-1 are being planned
  - Activities and documents are being coordinated with BATC
- CERES Project expects to retain most key I&T personnel from CERES FM5 on NPP
  - Some new personnel will be added and young team members to be mentored to gain experience for longevity
- I&T staffing levels are planned and conflicts with other LaRC Projects seems manageable
- CERES Team personnel have already been participating in I&T discussions with JPSS and BATC

CERES Team will be ready to support JPSS-1 Satellite I&T

Radiation Budget Instrument (RBI)

National Aeronautics and Space Administration

RBI Instrument Overview

Kory Priestley, *Project Scientist*

Discussion Topics

- RBI Overview and Scope
- RBI project and schedule
- Exelis proposed instrument architecture

RBI Overview and Scope

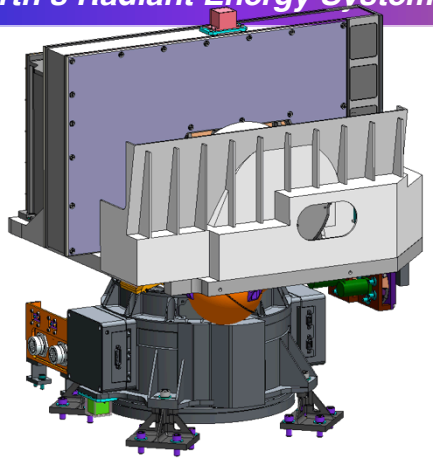
Radiation Budget Instrument (RBI)

Partnerships and Teams

- **NASA/ NOAA Partnership**
  - NOAA provides JPSS-2 satellite for accommodation of RBI
  - NASA provides RBI instrument and support through spacecraft I&T and launch/activation
  - NASA funds radiation budget science data analysis and generation of science products (RBM Project)
- **NASA Langley**
  - Manages prime contractor development of RBI instrument, provides management, technical, and mission assurance insight and oversight; provides support to spacecraft I&T thru launch and early on-orbit checkout (thru Phase D)
  - Hand-over and release of RBI instrument ownership by RBI Project occurs at the JPSS-2 Operational Hand-over Review (OHR). For Phase E, the Langley Science Directorate (SD) Radiation Budget Measurement (RBM) Project assumes responsibility for RBI for mission planning and operations
- **Exelis Inc.**
  - RBI Instrument provider/prime contractor with sub-contractors providing key elements and support (SDL for Calibration, JPL for Thermopile Detectors, Sierra Nevada for Azimuth Rotation Module)
- **JPSS-2 Spacecraft and Mission Interface**
  - -- Interface Control (ICD & MICD) and Data Format

RBI scanning radiometer measuring three spectral bands at top of Atmosphere (TOA)

- Total 0.3 to > 50+μm
- Shortwave 0.3 to 5.0 μm
- Longwave 5.0 to 50 μm



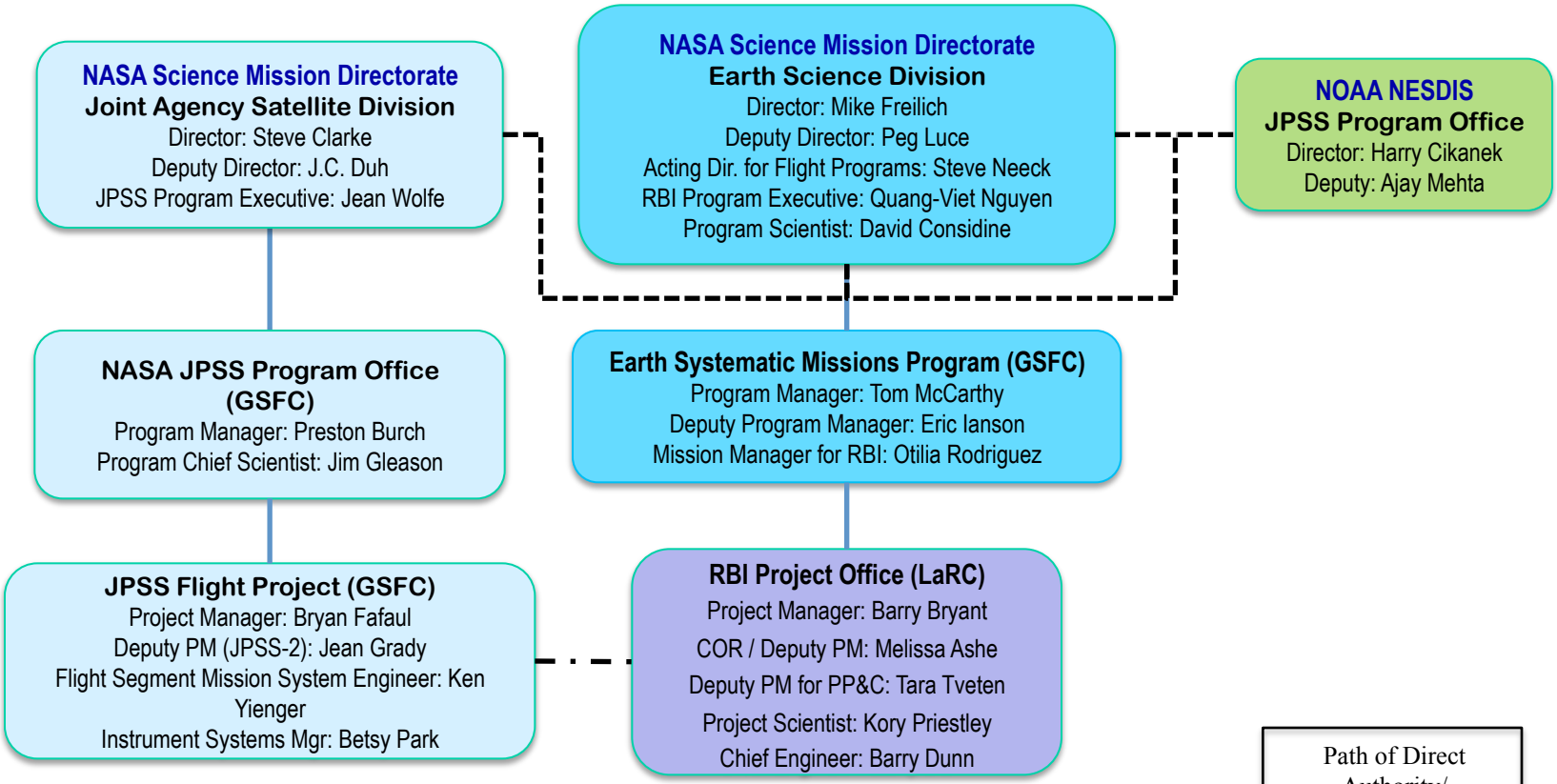
Science Goal

- To continue the measurements from the last two decades in support of global climate monitoring.
- RBI extends the Earth radiation budget measurements of the Earth Observing System (EOS) and Joint Polar Satellite System (JPSS)

- Category 3 Mission per NPR 7120.5E
- Risk Classification B per 8705.4
- Follow-on instrument to the Clouds and the Earth's Radiant Energy System (CERES)
- Flight Instrument Complete – Exelis CBE is May 2018
- Flight Instrument Delivery – NLT April 2019 (per NOAA/NASA IAA)
- "Notional" JPPS-2 on-dock delivery date – Nov 2018 (TBR after JPSS-2 spacecraft is awarded, April 2015)

NASA-NOAA Partnerships

Clouds and the Earth's Radiant Energy System



RBI funded by NASA thru SMD/ESD/ESMP
Radiation, Ozone, & Atmospheric Measurements (ROAM)
(WBS 852671)

The RBI Project is being implemented by the Earth Systematic Missions Program (ESMP) within the Earth Science Division (ESD) of the Science Mission Directorate (SMD)

RBI & RBMP Organizational Relationships

Clouds and the Earth's Radiant Energy System

NASA Science Mission Directorate
Earth Science Division
Director: Mike Freilich
Deputy Director: Peg Luce
Acting Dir. for Flight Programs: Steven Neeck
RBI Program Executive: Quang-Viet Nguyen
RBM Program Executive: Cheryl L. Yuhas
Program Scientist: David Considine

Earth Systematic Missions Program (GSFC)
Program Manager: Tom McCarthy
Deputy Program Manager: Eric Ianson
Mission Manager for RBI: Otilia Rodriguez

JPSS Flight Project (GSFC)
Project Manager: Bryan Fafaul
Deputy PM (JPSS-2): Jean Grady
Flight Segment Mission System Engineer: Ken Yienger
Instrument Systems Mgr: Betsy Park

Flight Projects Directorate (LaRC)
RBI Project Office (LaRC)
Project Manager: Barry Bryant
COR / Deputy PM: Melissa Ashe
Deputy PM for PP&C: Tara Tveten
Project Scientist: Kory Priestley

Science Directorate (LaRC)
RBM Project Office
Principal Investigator: Norman Loeb
Project Scientist: Kory Priestley
Data Management Team Lead: Jonathan Gleason

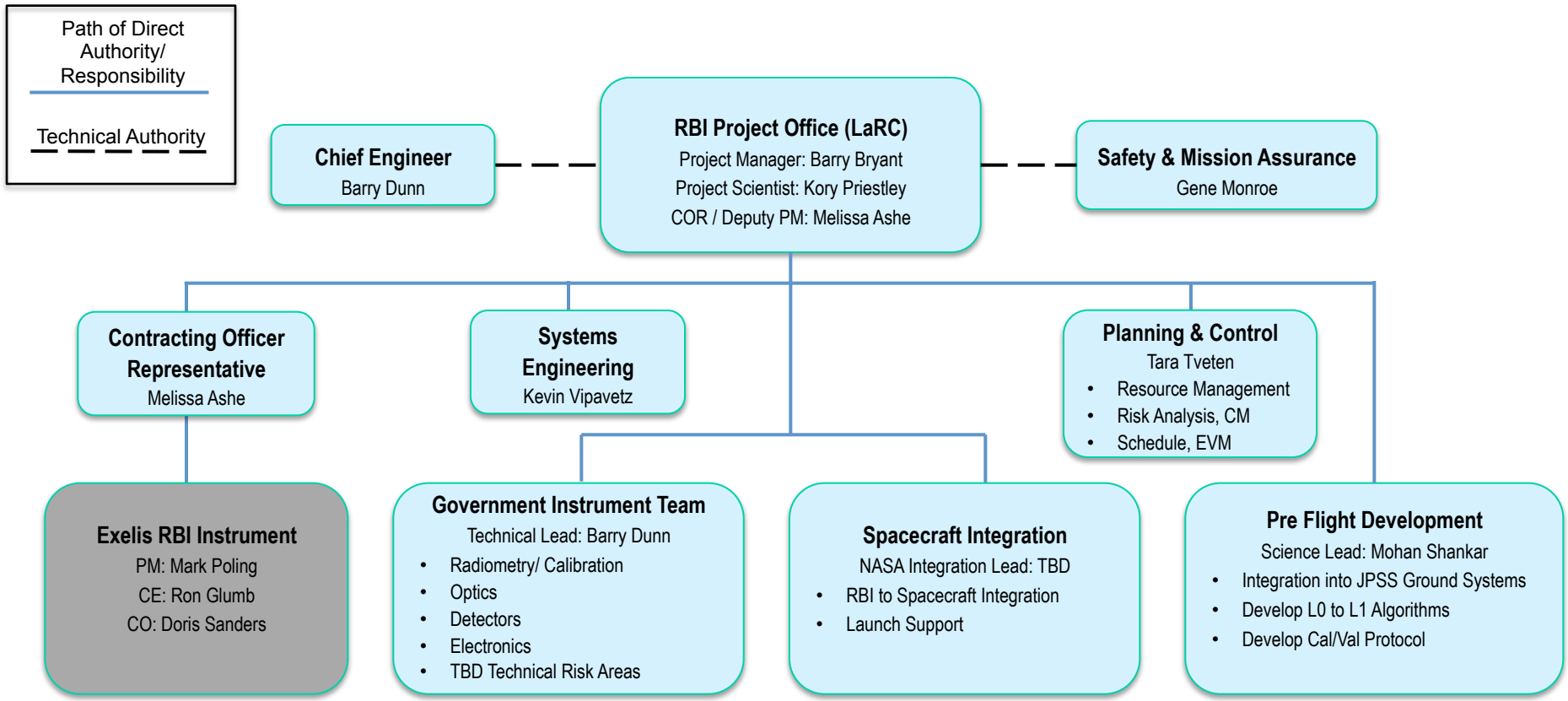
RBI funded by NASA thru SMD/ESD/ESM Radiation, Ozone, & Atmospheric Measurements (ROAM) (WBS 852671)

RBM Project funded by NASA thru SMD/ESD/ESM ESM Research (WBS 652528)

Langley has been designated as the lead center for stewardship of the Earth Radiation Budget Climate Data Record

LaRC RBI Organization

Clouds and the Earth's Radiant Energy System

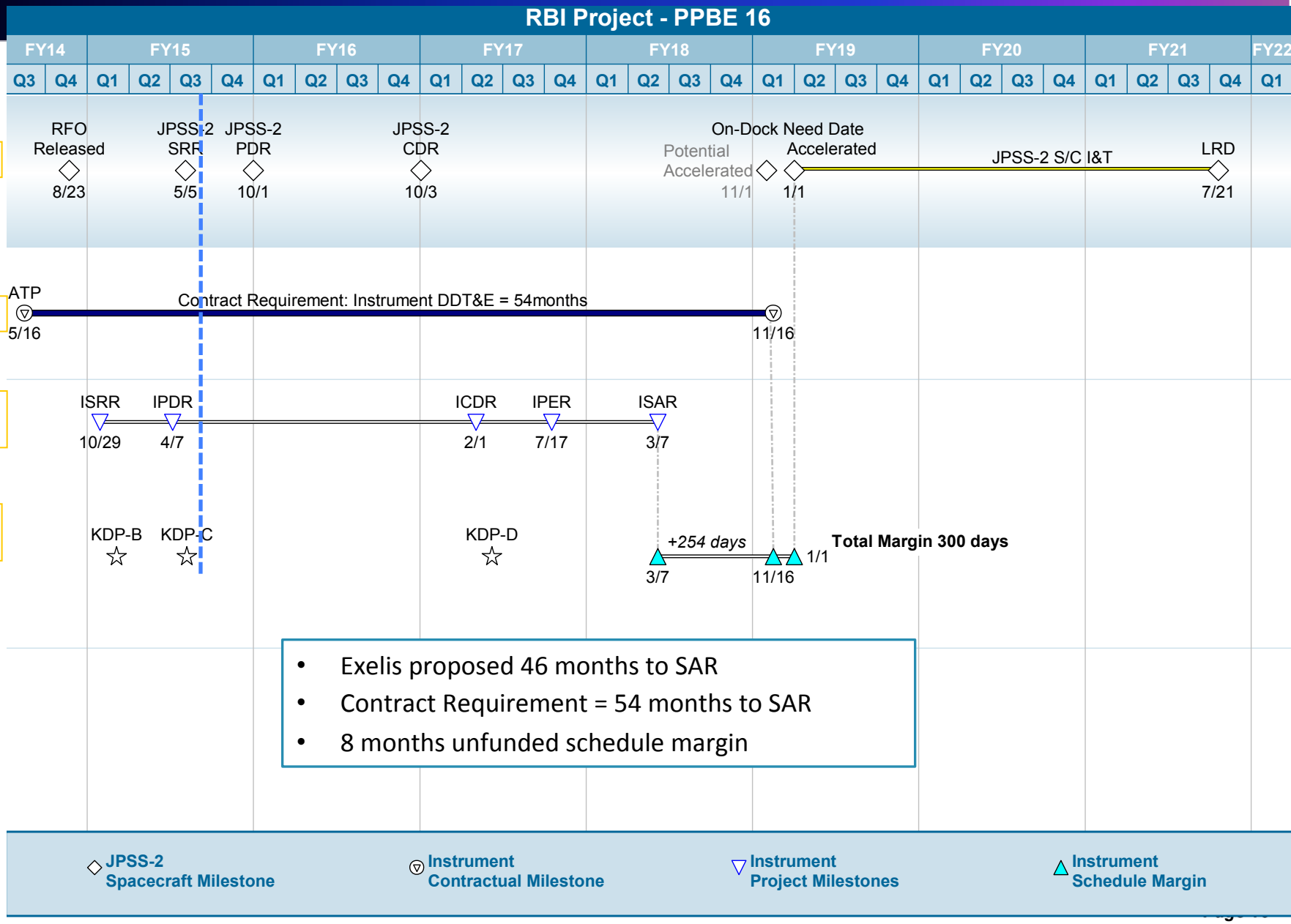


Programmatic Driver - Schedule

- **NASA / NOAA Inter-Agency Agreement (from draft):**

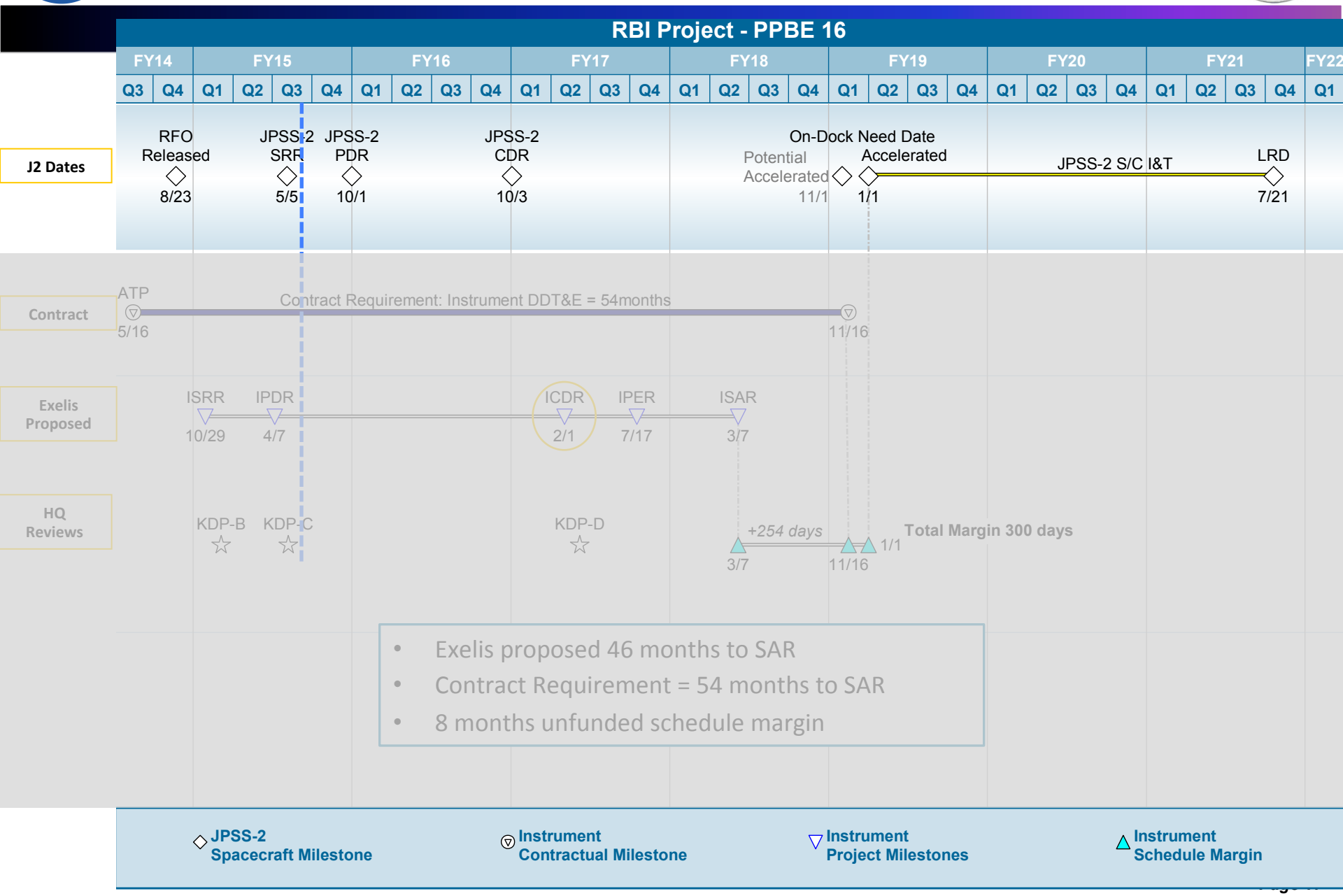
- NASA will develop and deliver the RBI on a timeline that is tied to JPSS-2 mission milestones as documented in the JPSS Program Integrated Master Schedule (IMS), however it evolves over time, and ***in a manner that does not interfere with, or add consequential risk to the overall JPSS-2 mission development and timely launch***
- RBI considerations ***shall not drive any JPSS planning or baselined schedules*** other than to allow for nominal integration to the spacecraft if RBI is delivered prior to the last weather instrument delivered plus nominal integration time.

RBI PPBE16 Schedule and Review Plan

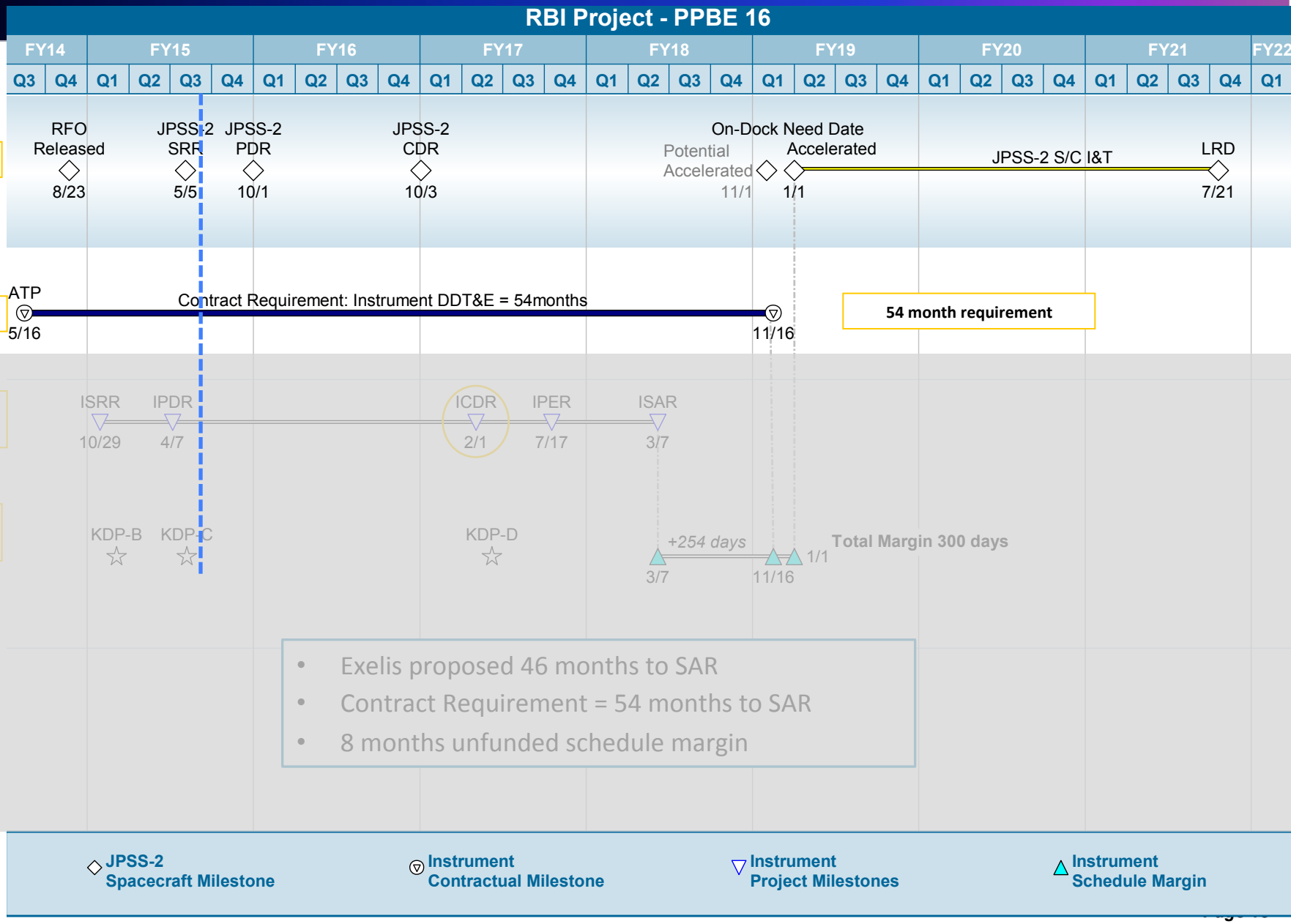


- Exelis proposed 46 months to SAR
- Contract Requirement = 54 months to SAR
- 8 months unfunded schedule margin

RBI PPBE16 Schedule and Review Plan



RBI PPBE16 Schedule and Review Plan



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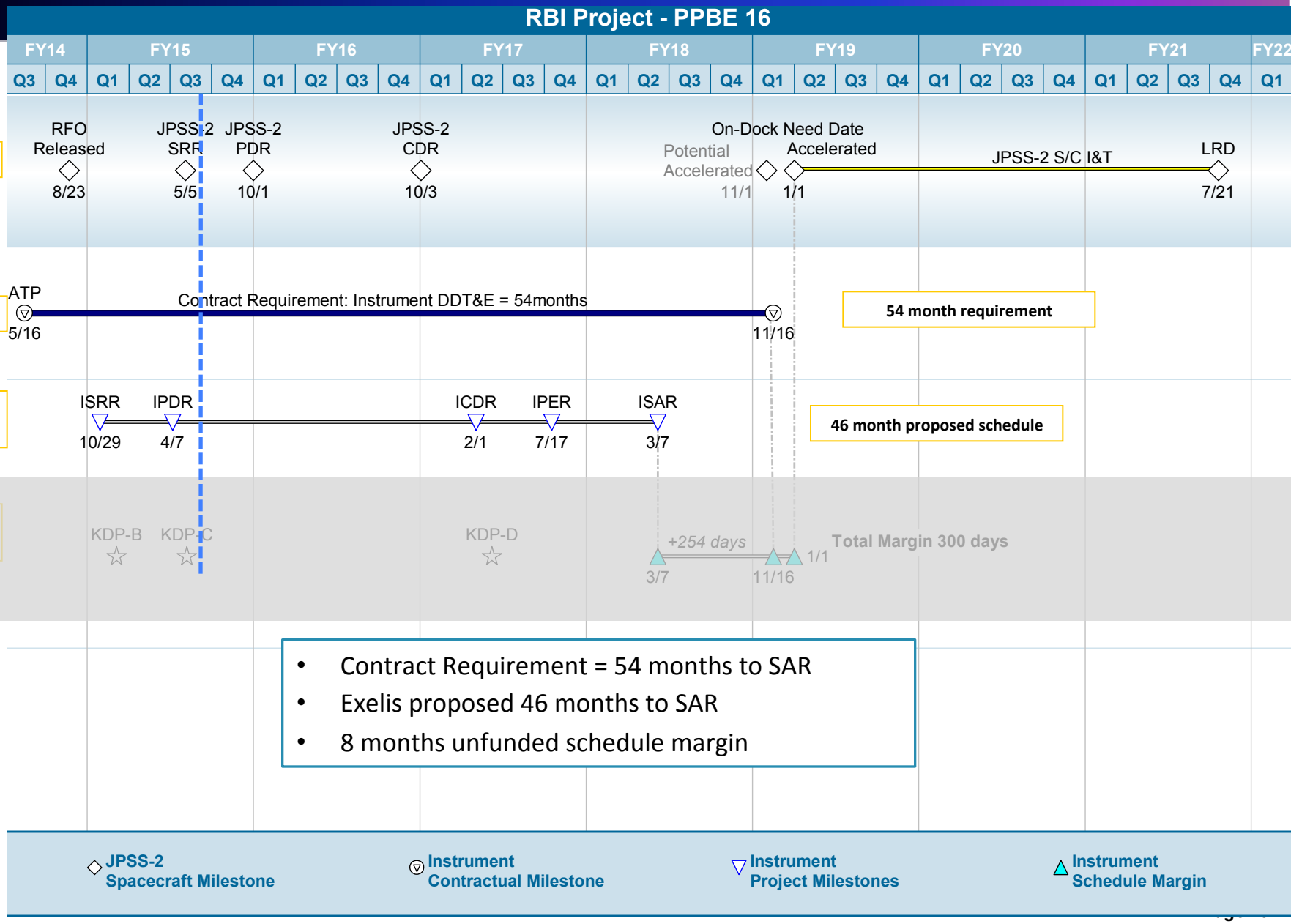
◇ JPSS-2 Spacecraft Milestone

▽ Instrument Contractual Milestone

▽ Instrument Project Milestones

△ Instrument Schedule Margin

RBI PPBE16 Schedule and Review Plan



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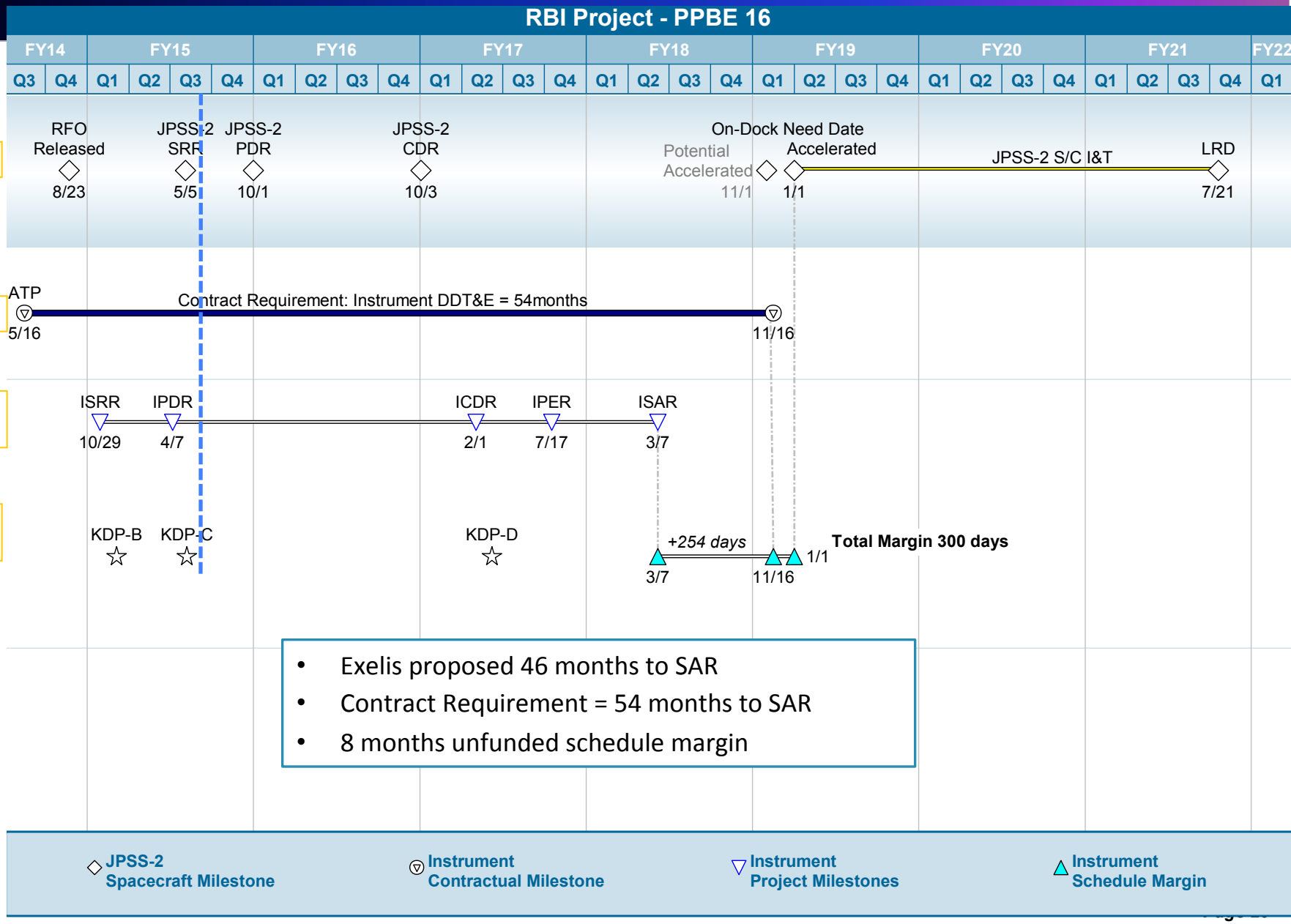


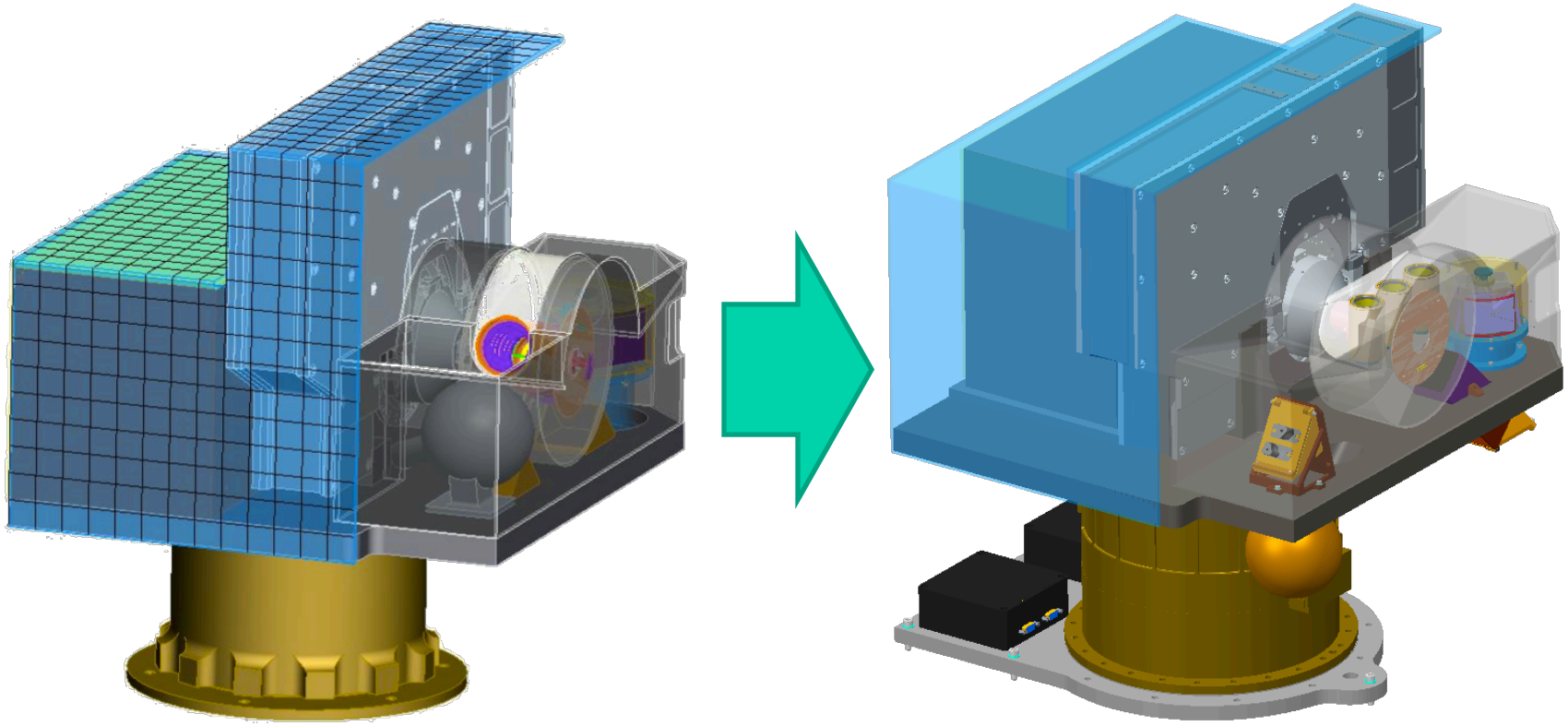
Key Driving Requirements

Parameter	Requirement
Mass	≤ 80 kg
Power	Orbital Average: ≤ 90 W Peak: ≤ 195 W Survival: ≤ 60 W
Static Payload Envelope	815mm x 567mm (Height x Diameter - Cylindrical)
Data Bus and Rate	SpaceWire Orbital Average: ≤ 3000 kbps Peak: ≤ 4000 kbps Safe: ≤ 2 kbps
Spectral Coverage	0.2-100 microns (Shortwave-SW, Total, and Longwave-LW)
Orbit	JPSS-2 Altitude: 824 km +/- 17 km Sun-Synchronous Ground Repeat Cycle: < 20 days Nominal Ascending Equator Crossing Time : 1330 Local
Field of Regard (FOR)	Entire Earth
Field of View (FOV)	2.6°x 1.3 °(Three Channels)

Three-Telescope Concept Currently Meets Accommodation Requirements

Proposal Single-Telescope Concept

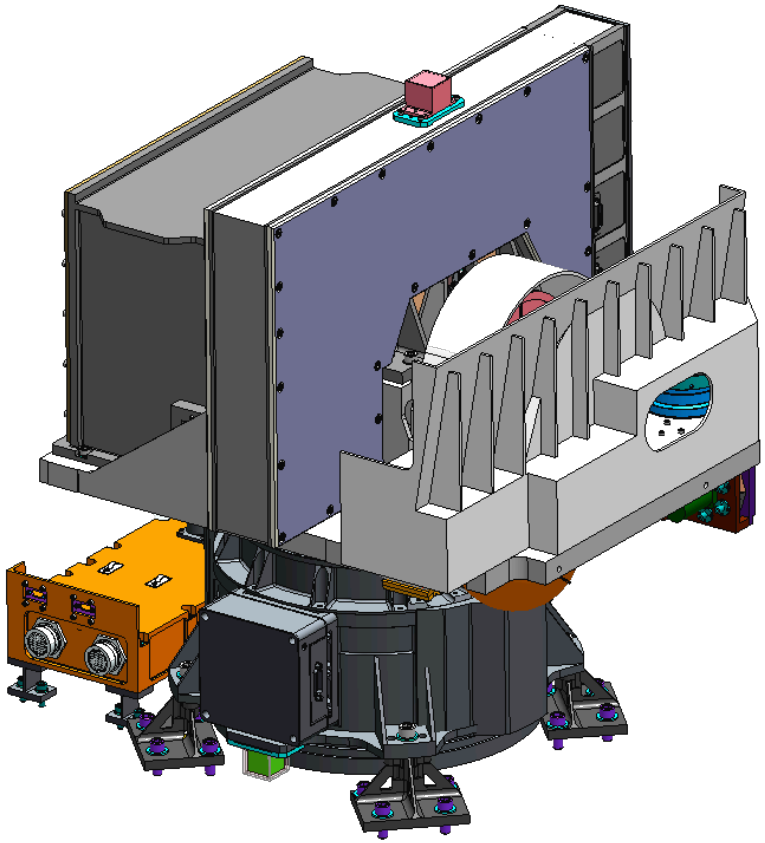
Current Three-Telescope Concept



Exelis refining concept for mass and power

Uses same scan mechanism (CrIS) as the single-telescope concept

RBI is a New Instrument Developed as a Follow-on to CERES Flown on TRMM, EOS, NPP, and JPSS-1



Instrument Description:

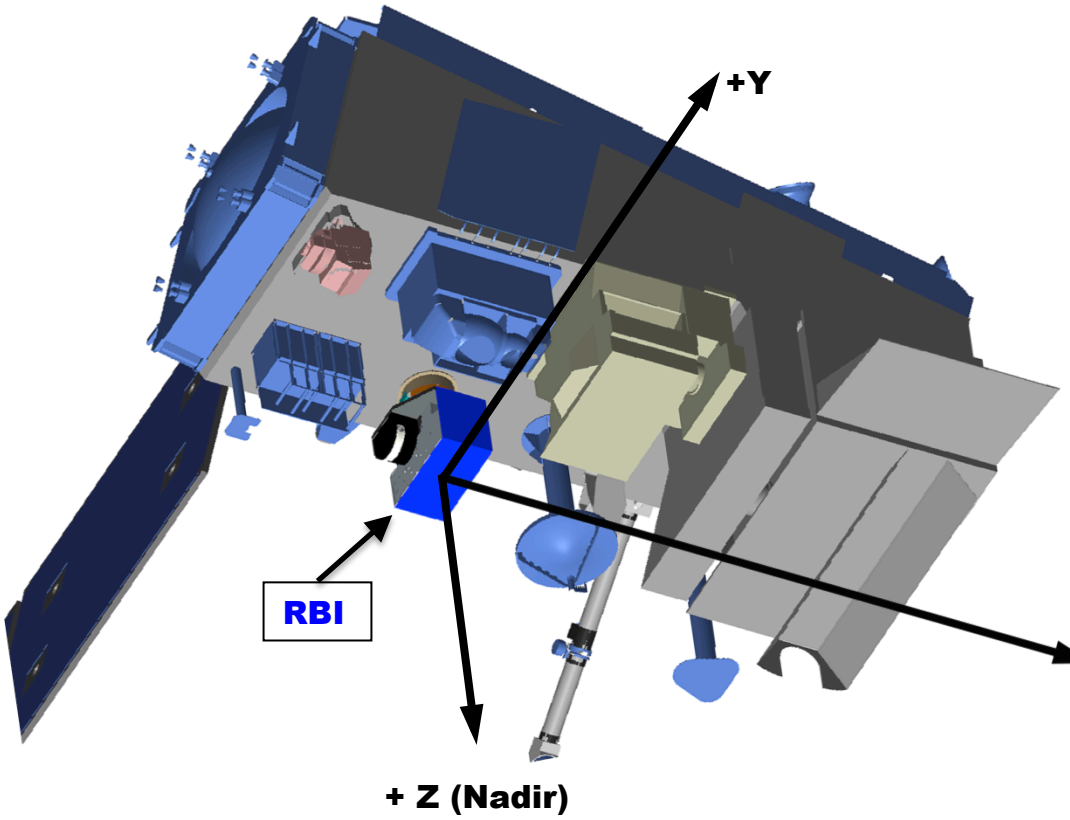
- A Three-Channel three-telescope broadband scanning radiometer designed to measure the solar reflected and Earth emitted thermal radiation at the top of the atmosphere
- Electrically redundant design to meet Level 1 life and reliability (7 years at 85%)
- Leverages the CrIS cross-track scan module (CSM) for Earth scanning and calibration target selection
- Utilizes one Infrared Calibration Target (ICT) with phase-change cells, one Visible Calibration Target (VCT), one Solar Calibration Target (SCT), space views, and Lunar views as flight calibration sources
- Each telescope utilizes redundant thermopile detectors

Characteristics:

- Spectral Range: ~ 320 nm – 100 microns
- Field of View (FOV): ~1.3 x 2.6 degrees
  - ~19 x 37 km at nadir
- Data Interface: MIL-STD-1553
  - <300 kb/sec (Average) / <400 kb/sec (Peak)
- Instrument including redundant electronics
  - Mass: ~68 kg (CBE) 80 kg (allocation)
  - Power: ~66 W (Cross-track mode)
- Envelope: ~815x640x375 (circular) cm^3

RBI Accommodated on JPSS-2 Spacecraft Nadir Deck

Clouds and the Earth's Radiant Energy System



JPSS-2 Instrument Complement

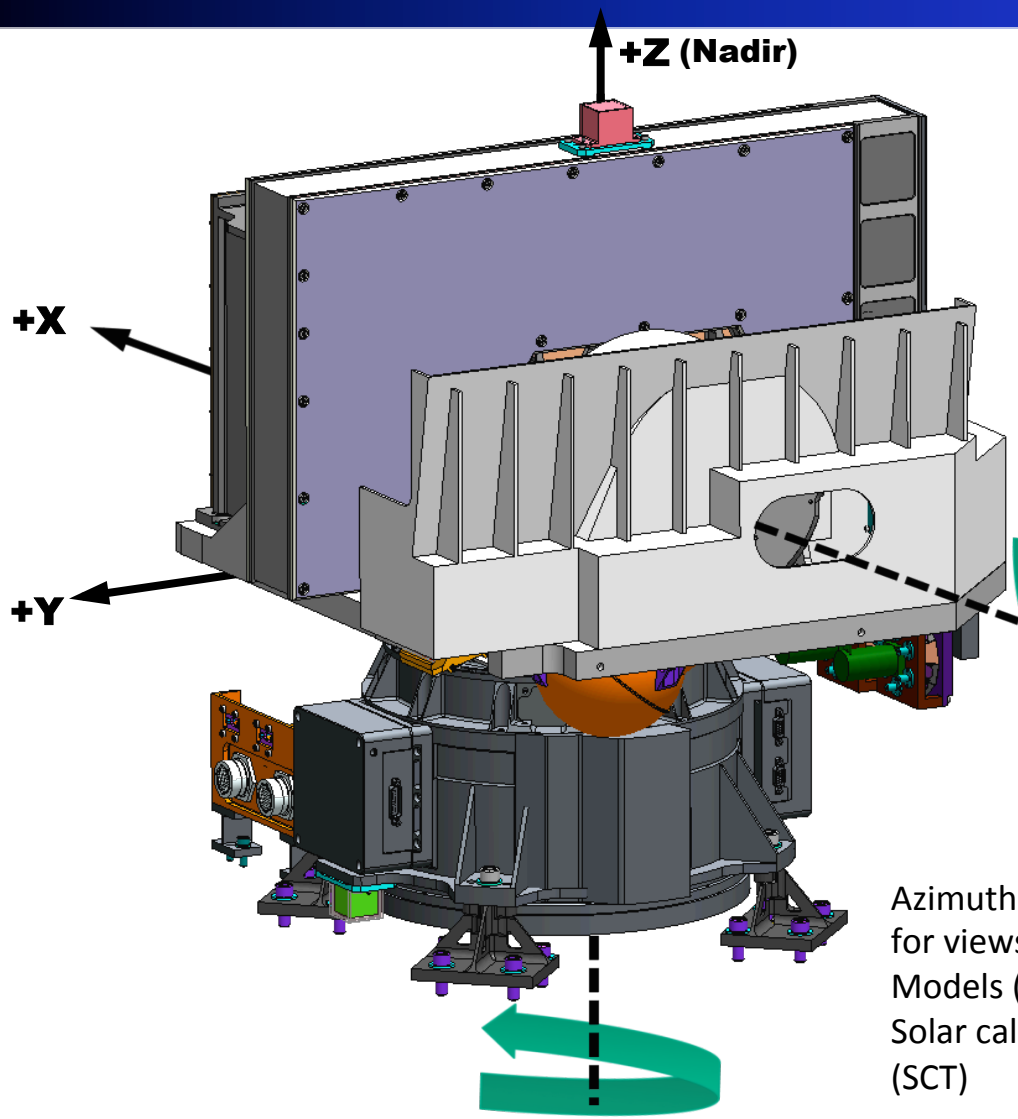
- Radiation Budget Instrument (RBI)
- Advanced Technology Microwave Sounder (ATMS)
- Cross-track Infrared Sounder (CrIS)
- Visible Infrared Imagining Radiometer Suite (VIIRS)
- Ozone Mapping and Profiler Suite (OMPS)

JPSS-2 Observatory Requirements

- Nominal Altitude: 824 km ± 17 km
- Ground Track Repeatability Accuracy: ±20 km at the equator
- Ground Track Repeat Cycle: <20 days
- Nominal Ascending Equator Crossing Time: 1330 (local time) ± 10 min

Spacecraft design and Instrument locations are notional and representative of JPSS-1
JPSS-2 configuration has not been determined

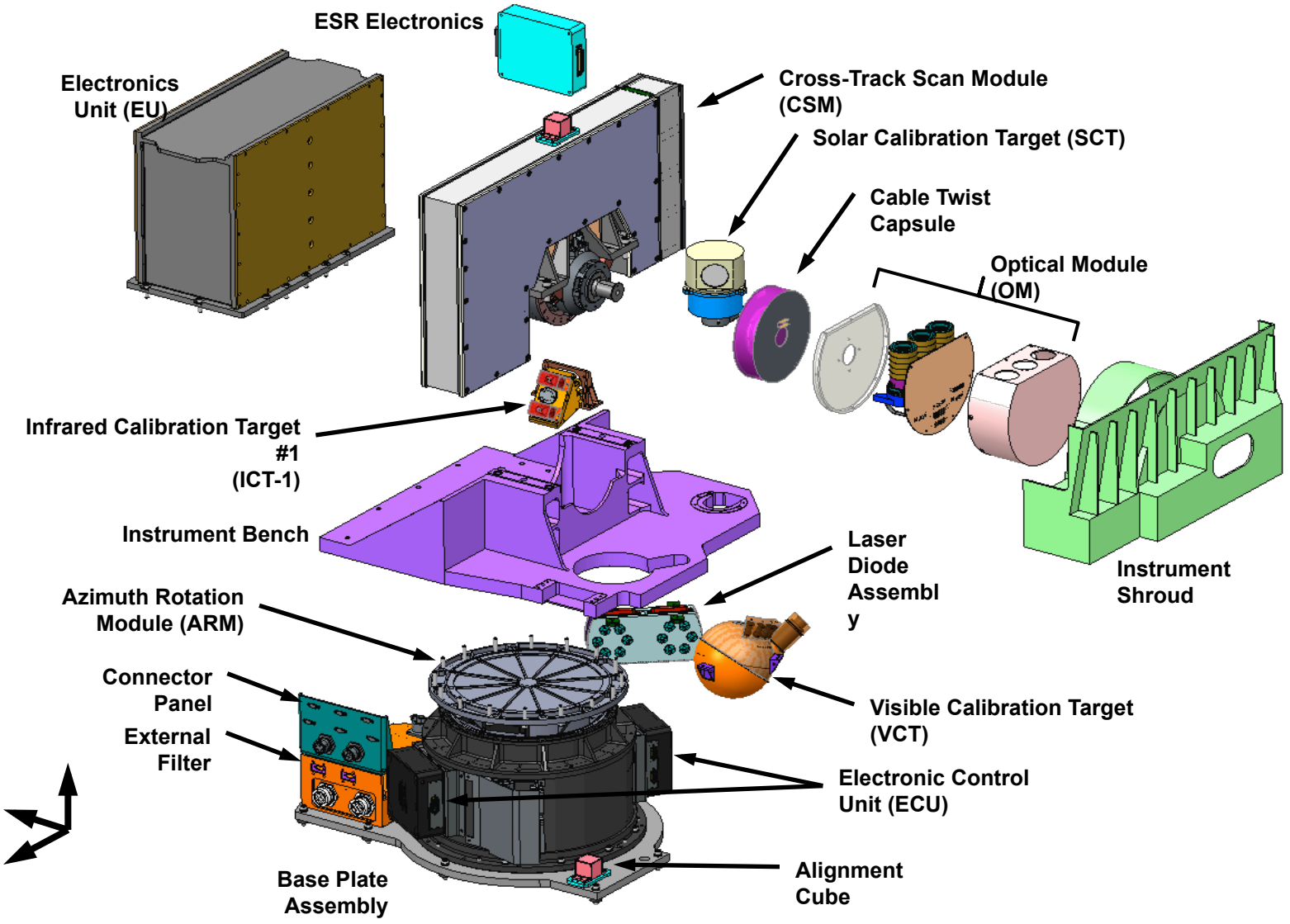
Field of Regard Obtained by Mounting Orientation & Two-Axis Pointing



Cross-track Scan Module (CSM) enables swath mode views of the Earth, internal calibration targets, and space views

Azimuth Rotation Module (ARM) enables biaxial-mode for views of the Earth to support Angular Distribution Models (ADM), direct Lunar calibration, and indirect Solar calibration using the Solar Calibration Target (SCT)

Major RBI Sensor Modules and Subsystems



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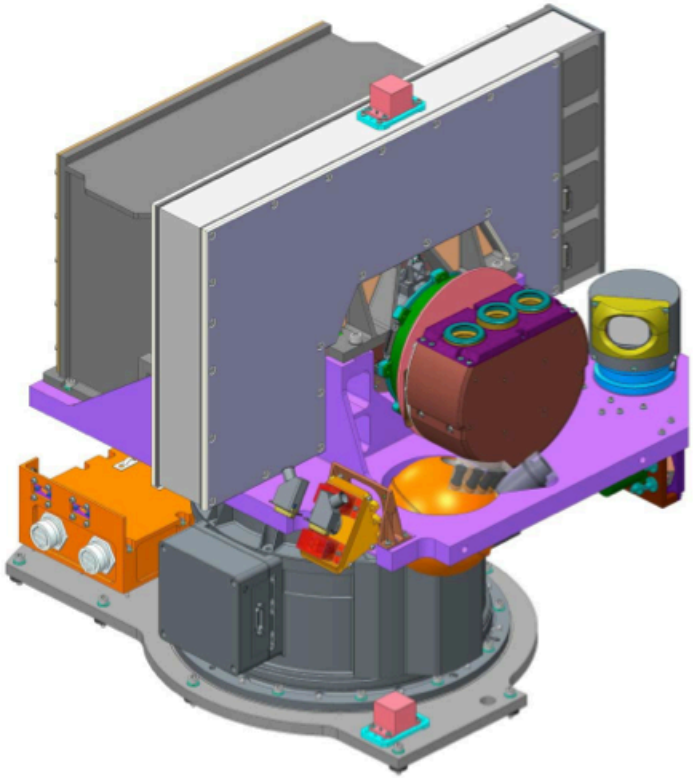
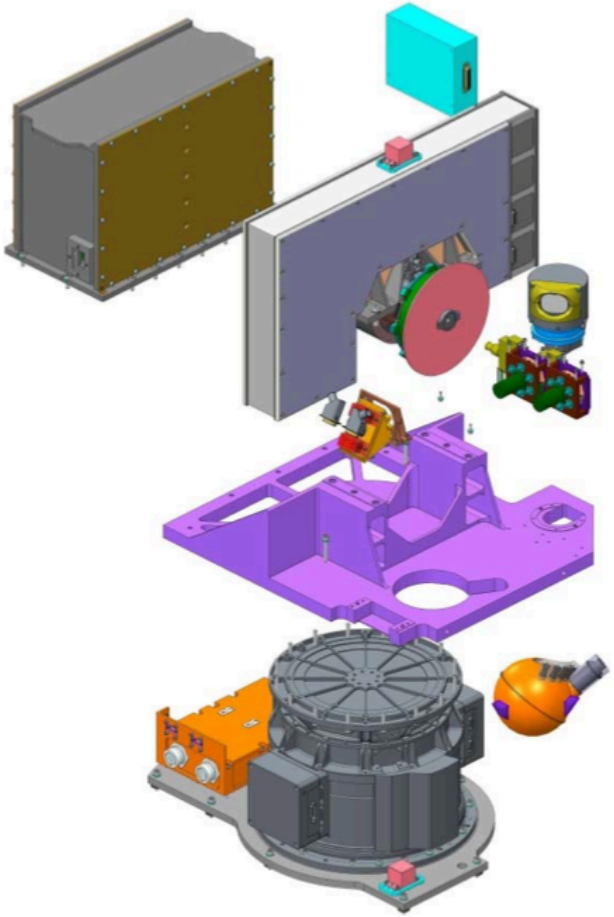
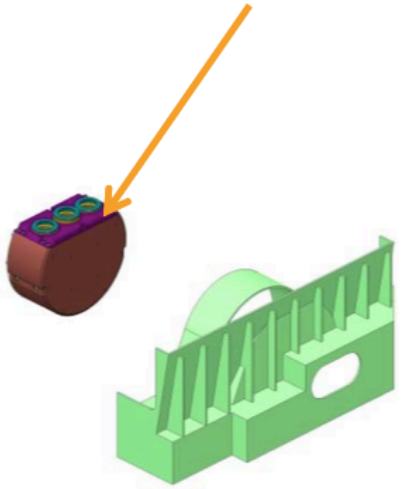


Instrument Shroud Hidden



Optical Module



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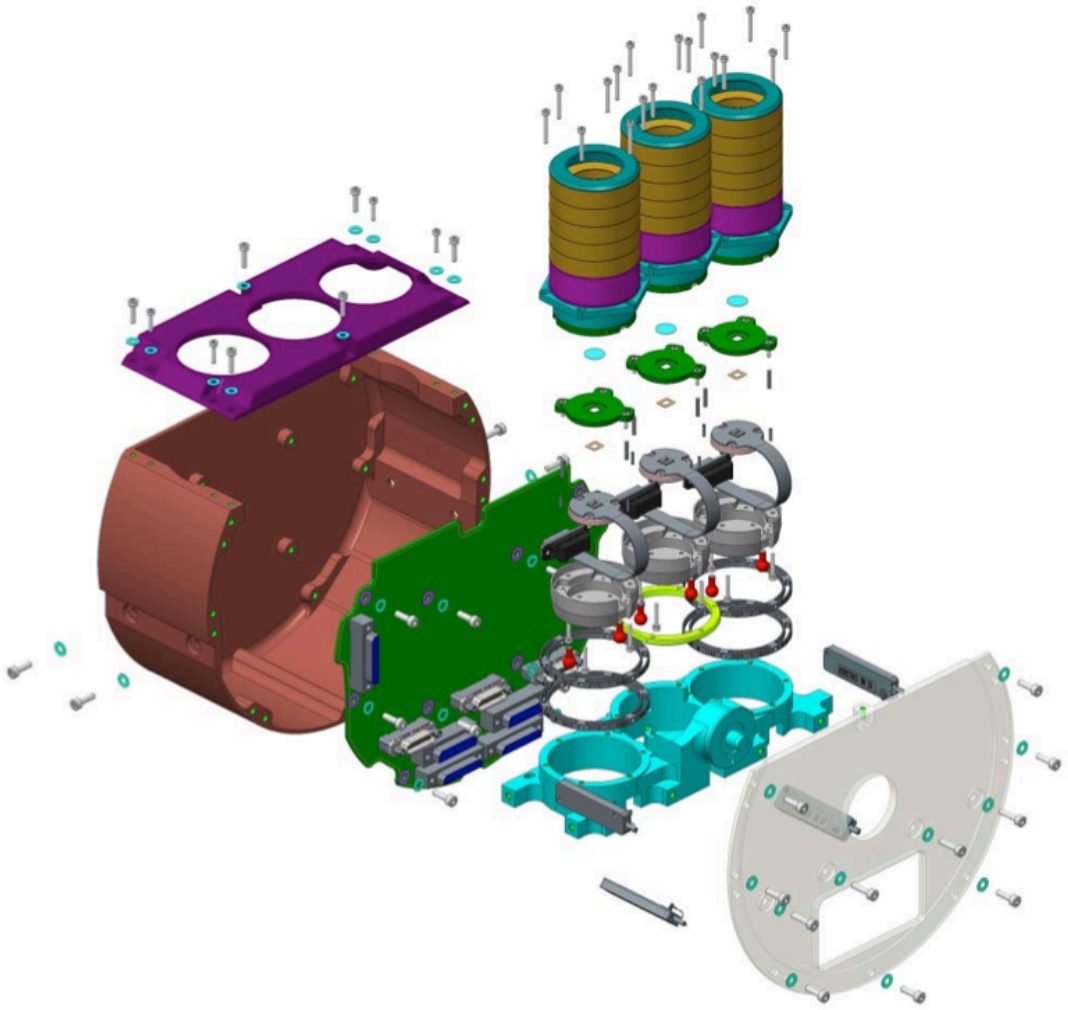
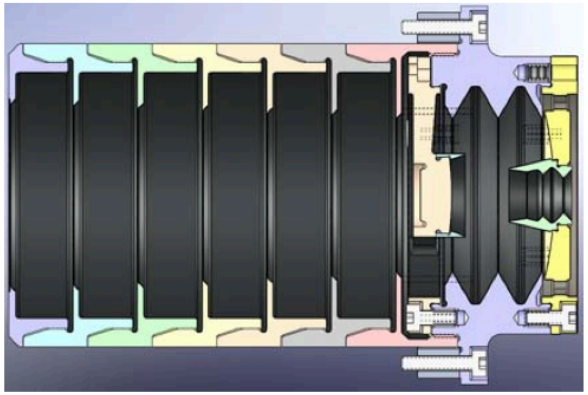
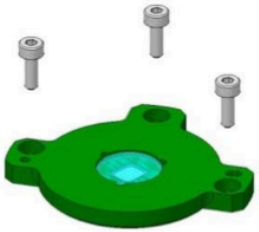
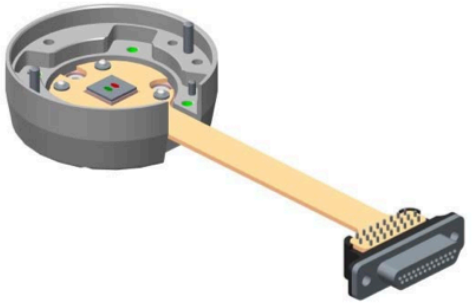


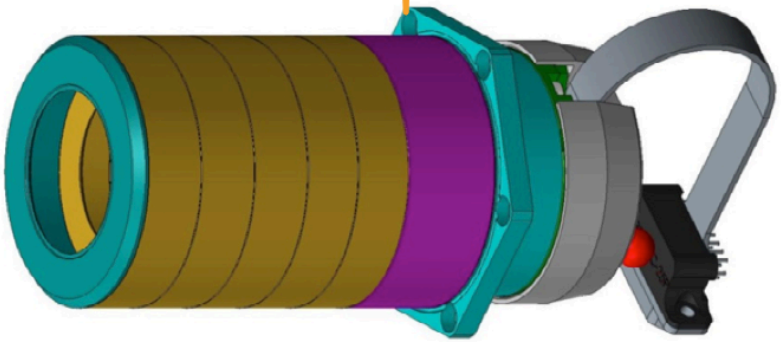
Three-Telescope Concept Currently Meets Accommodation Requirements

Radiance in → **Fore Baffle** → **Telescope** *Includes Primary & Secondary Baffles* → **Spectral Filter** *SW and LW* → **Detector** → Electrical signal out

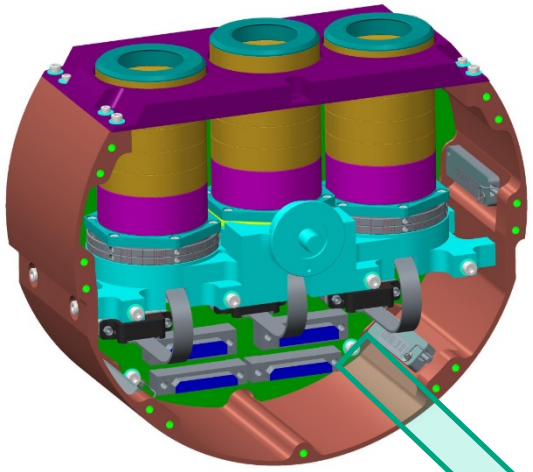


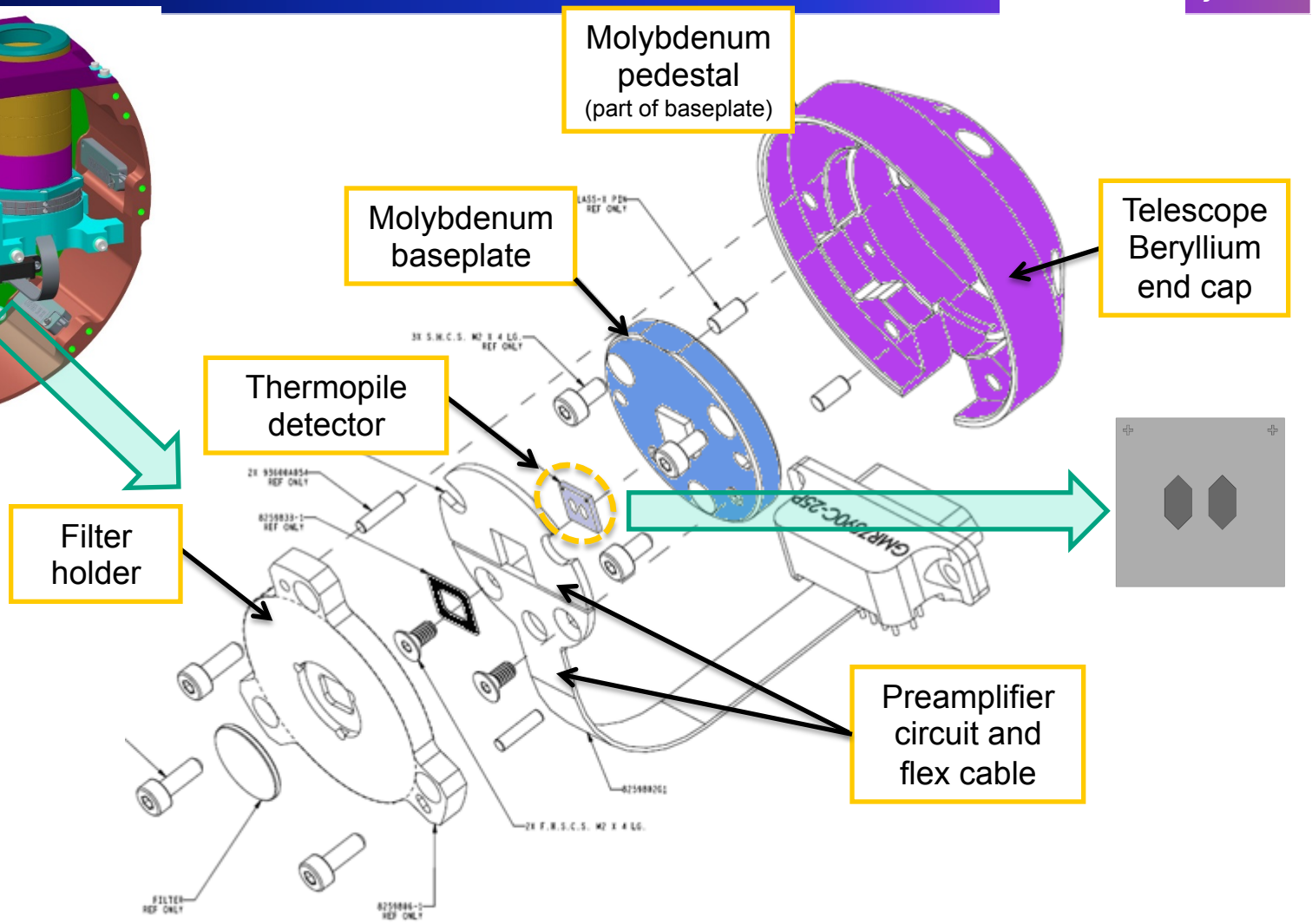






RBI Focal Plane Module Assemblies Utilize Redundant Detectors





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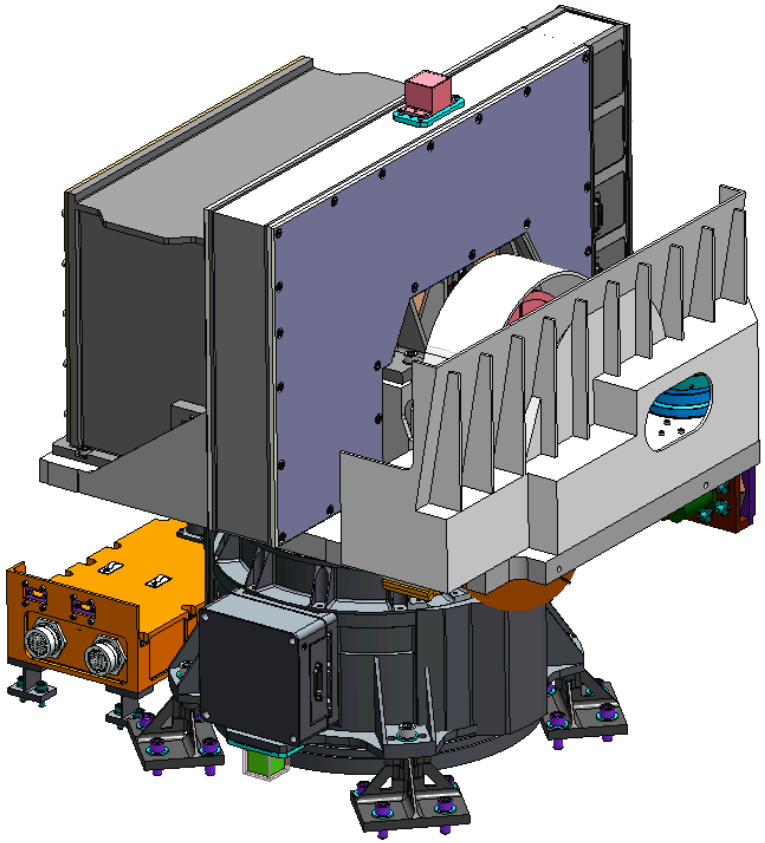
Summary and Wrap-up



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