



BioSentinel - Lessons Learned During I&T of the Spacecraft EDU

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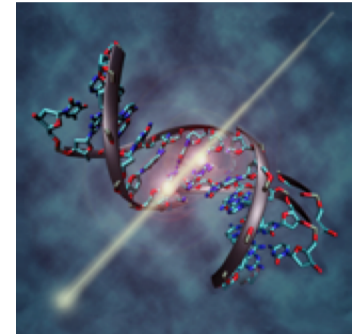
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BioSentinel Project Objectives

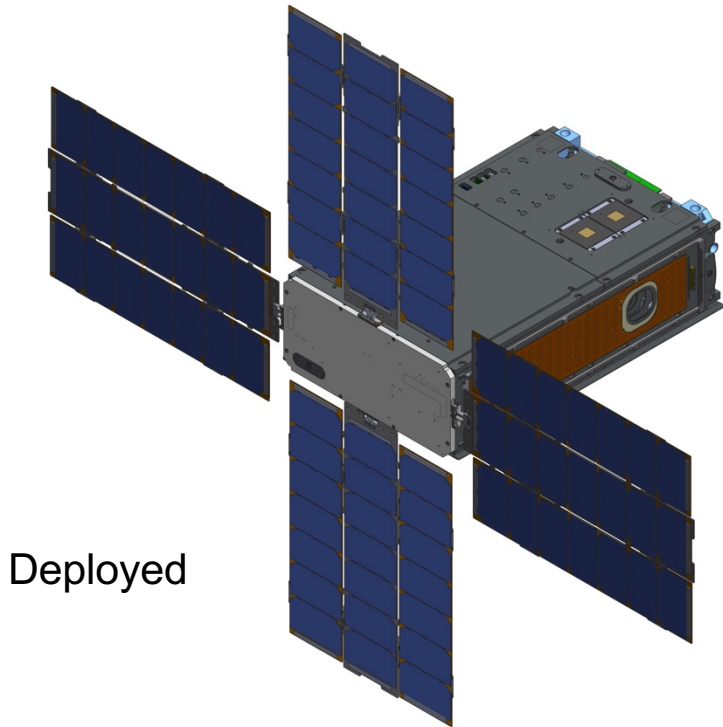
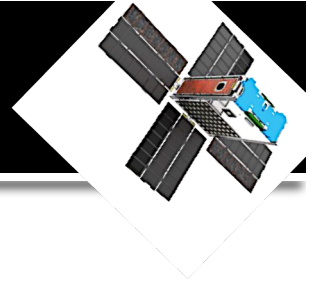


- Advanced Exploration Systems (AES) selected BioSentinel to fly on the Space Launch System (SLS) Exploration Mission (EM-1) as a secondary payload
 - Payload selected to help fill **HEOMD Strategic Knowledge Gaps in Radiation effects on Biology**
 - Current EM-1 Launch Readiness Date (LRD): 12/15/19 to 6/30/20
 - Delivery to Dispenser Integrator, Tyvak: **4/30/19** (to 10/31/19)
- Key BioSentinel Project Objectives
 - Develop a **deep space nanosat** capability
 - Develop a **radiation biosensor** useful for other missions
 - Define & validate **SLS secondary payload interfaces and accommodations** for a biological payload
- Collaborate with two other AES selected missions (non-biological) for EM-1
 - Near Earth Asteroid (NEA) Scout (MSFC)
 - Lunar Flashlight (JPL)

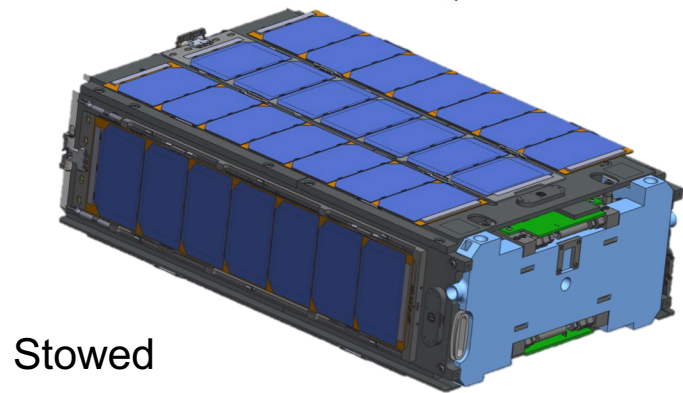
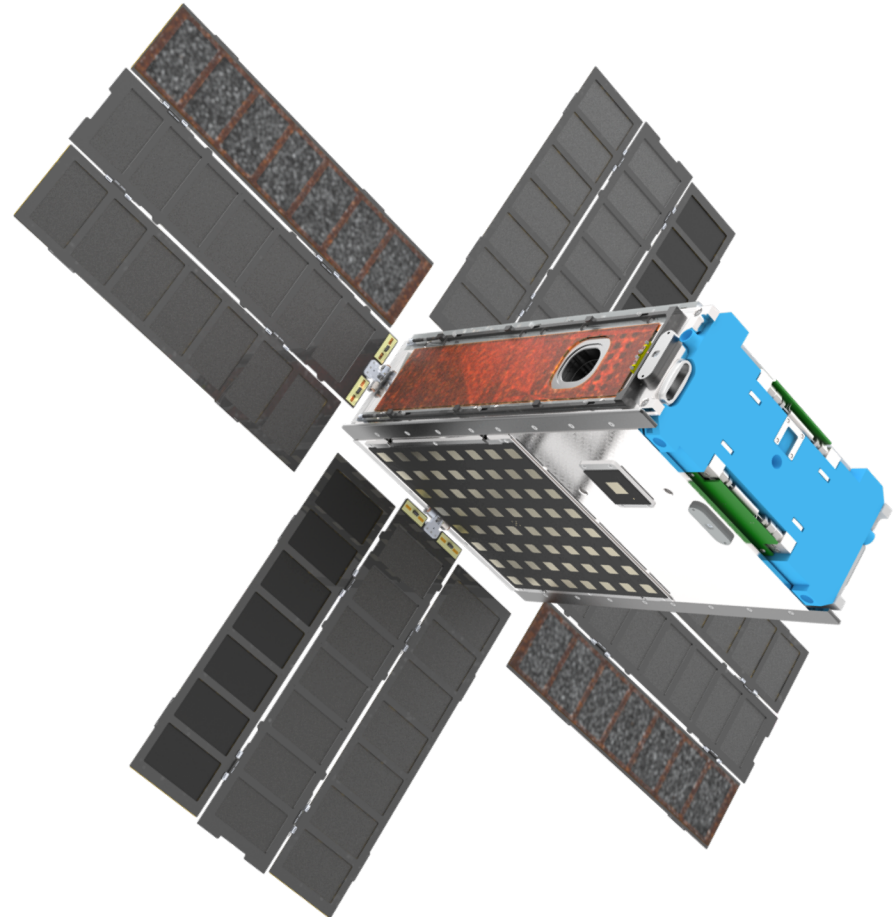




BioSentinel Overview – Deployed & Stowed



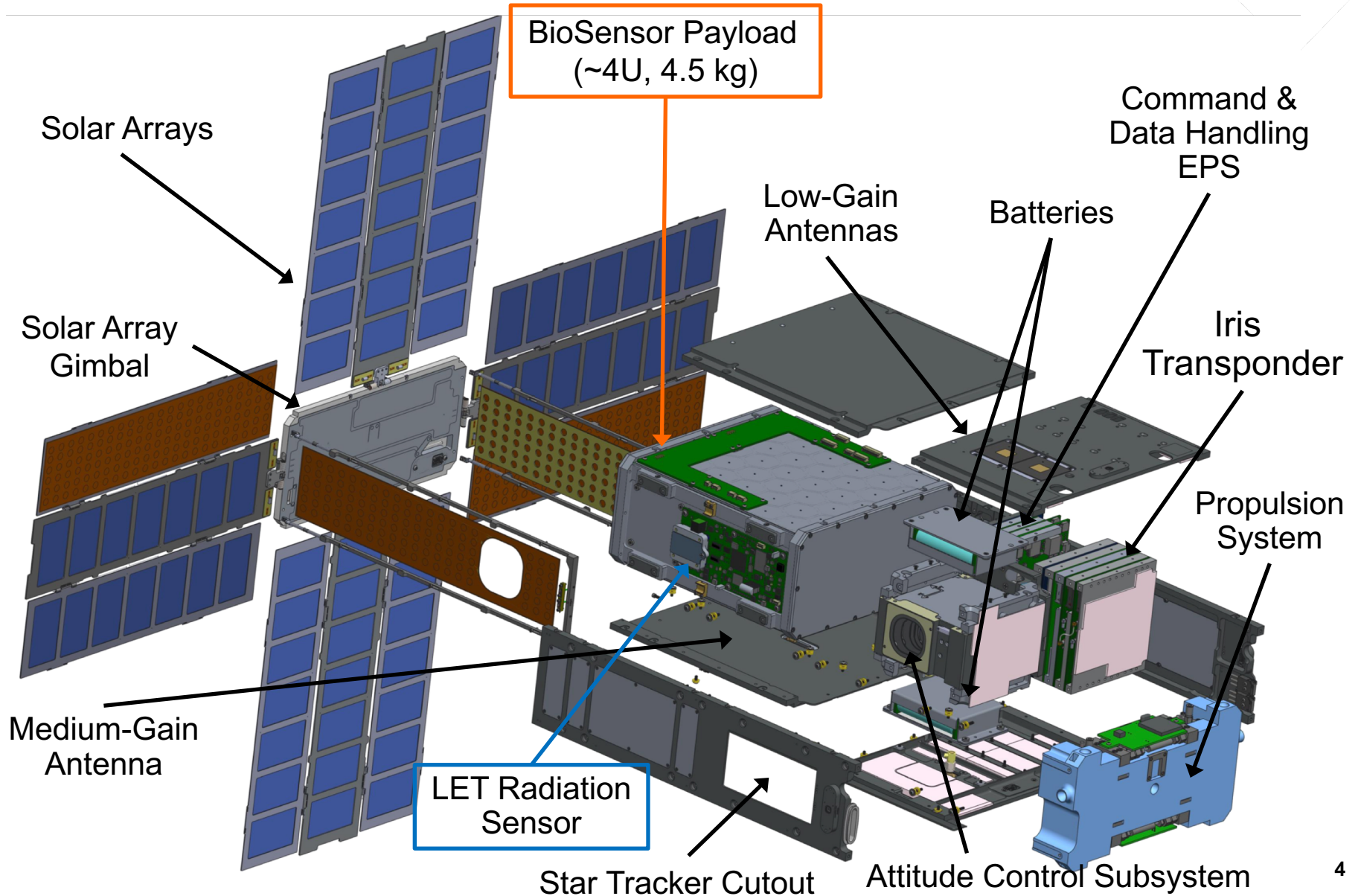
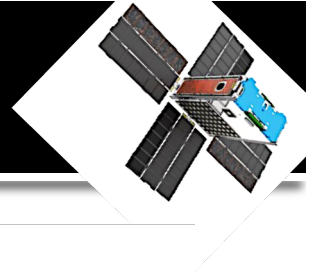
Deployed



Stowed

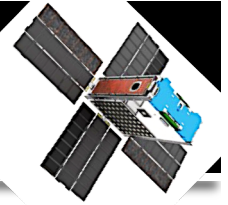


BioSentinel Subsystem Overview





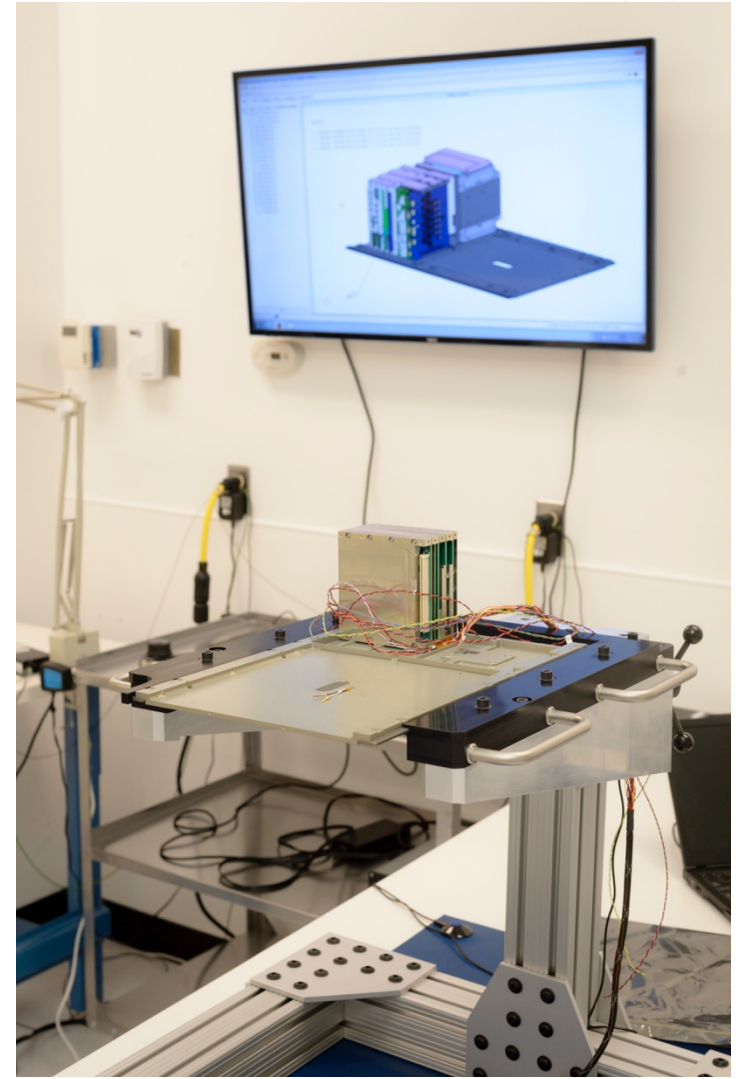
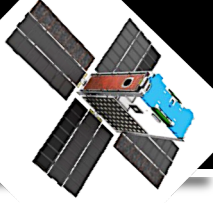
BioSentinel – I&T Accomplishments & Activities



- **Spacecraft Engineering Development Unit (EDU) build up, aliveness, and limited functional tests**
 - BioSentinel Payload EDU
 - BioSensor EDU
 - Linear Energy Transfer (LET) Spectrometer EDU
 - Spacecraft Bus
 - Structural panels
 - Propulsion System EDU
 - Thermal subsystem: Temperature sensors & payload heaters
 - Electrical Power System (EPS)
 - EPS, boards, Battery, & 2 panel Solar Array EDUs
 - C&DH EDU Boards
 - Thermal simulator of Iris Transponder (Radio, LNA, & SSPA)
 - XACT & Sun Sensors EDUs
 - Flight Software (Release 4)
- **Dispenser Fit Check using KSC Launch Service Provider (LSP) provided EDU**
- **Vibration Test using Tyvak provided test fixture**
 - Used Estimated dispenser isolated levels (tested levels now available)

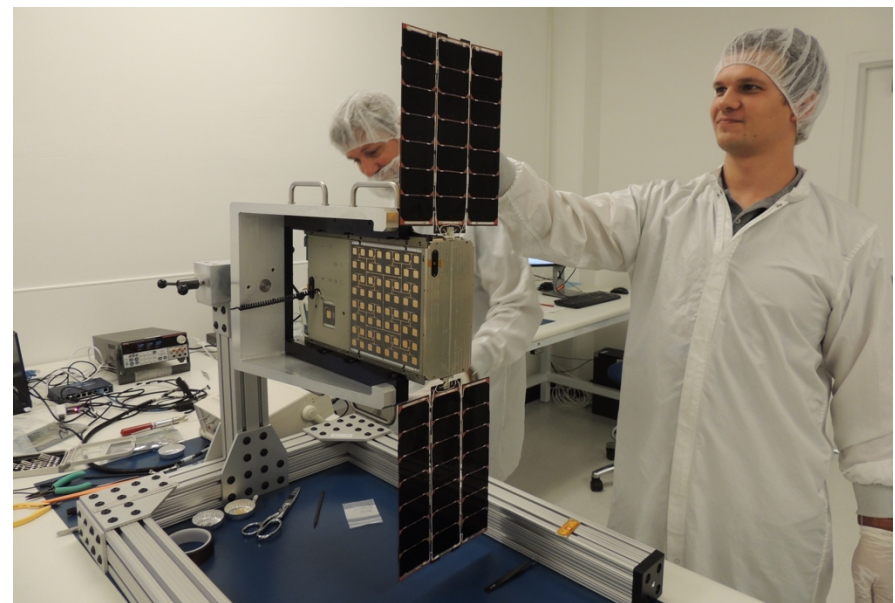
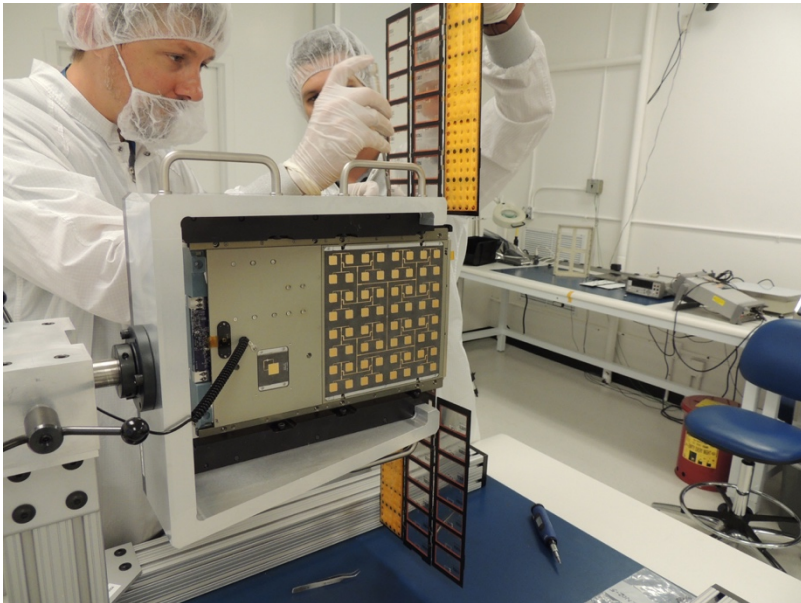
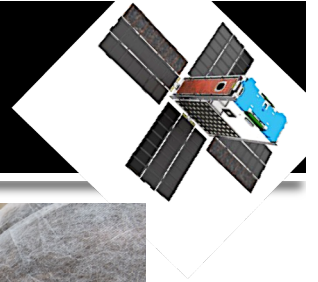


Use of CAD Model for Assembly in Clean Room



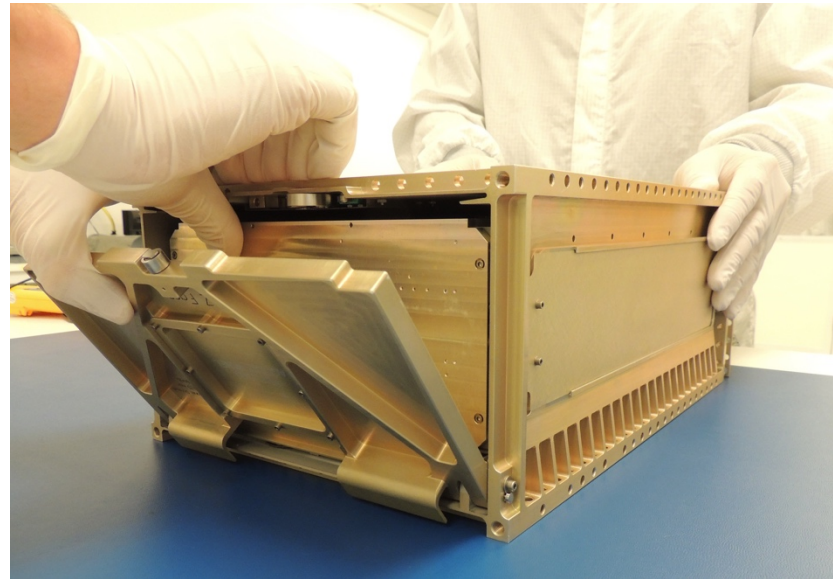
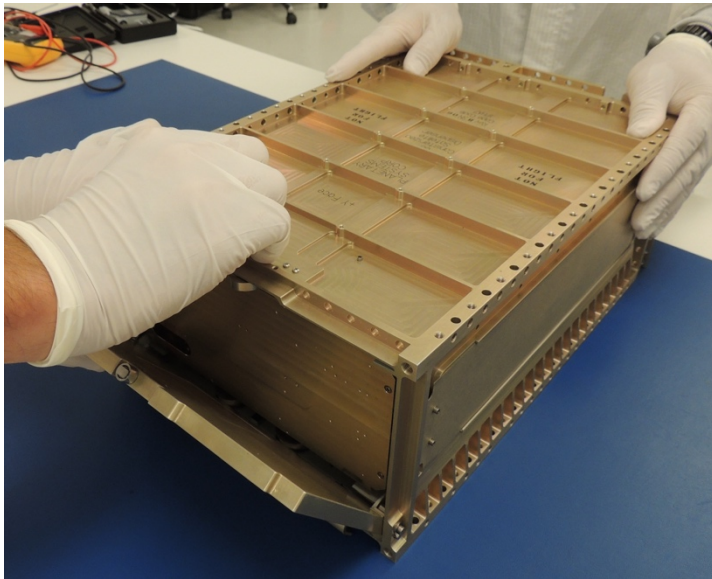
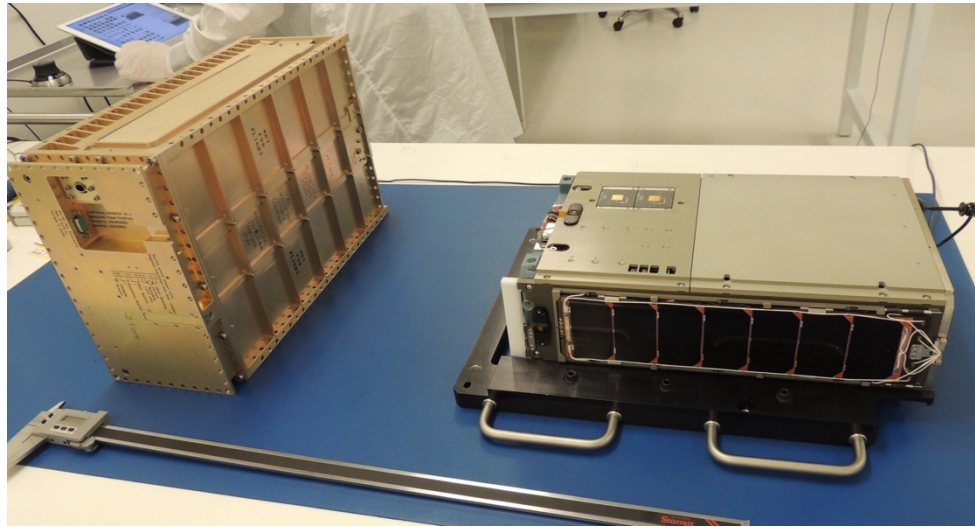
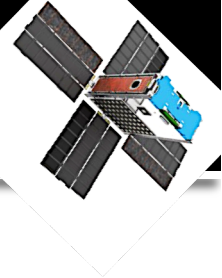


BioSentinel Spacecraft EDU with Solar Panels Deployed & MGA



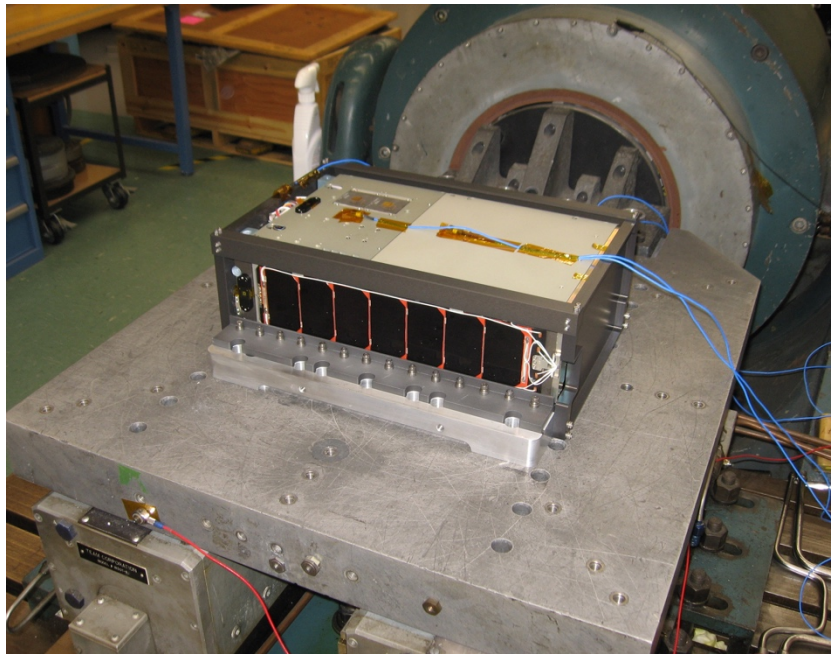
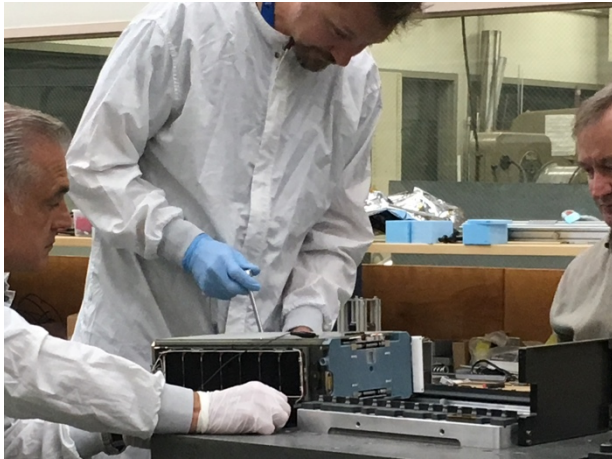
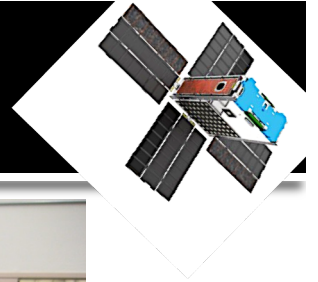


BioSentinel Spacecraft EDU Dispenser Fit Check



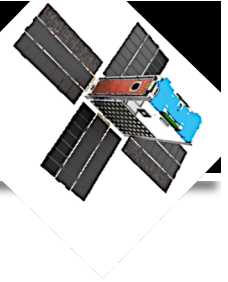


BioSentinel Spacecraft EDU Preparation for Random Vibration Test

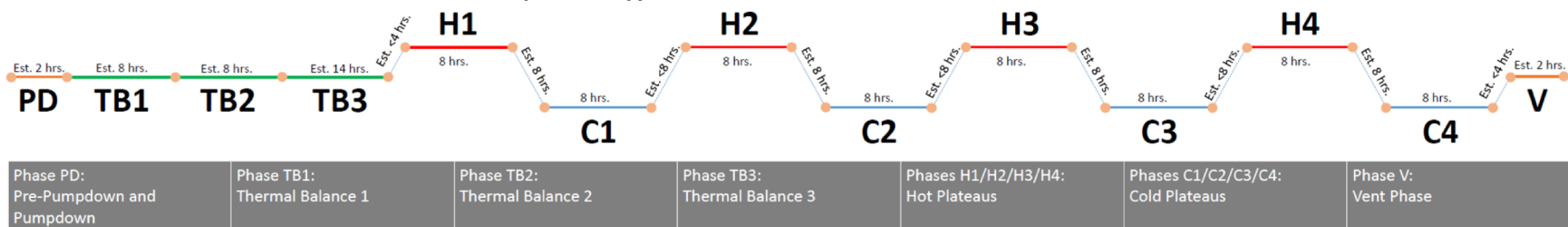




BioSentinel – I&T Accomplishments & Activities

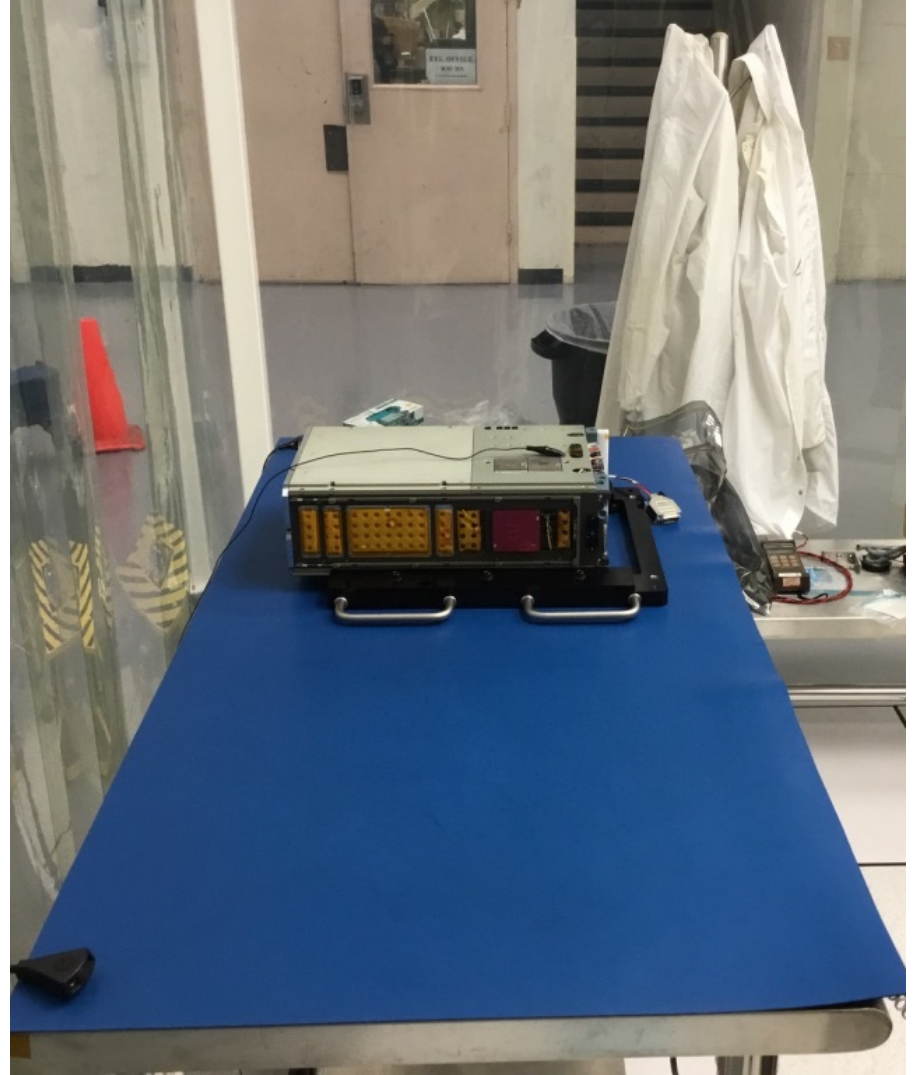
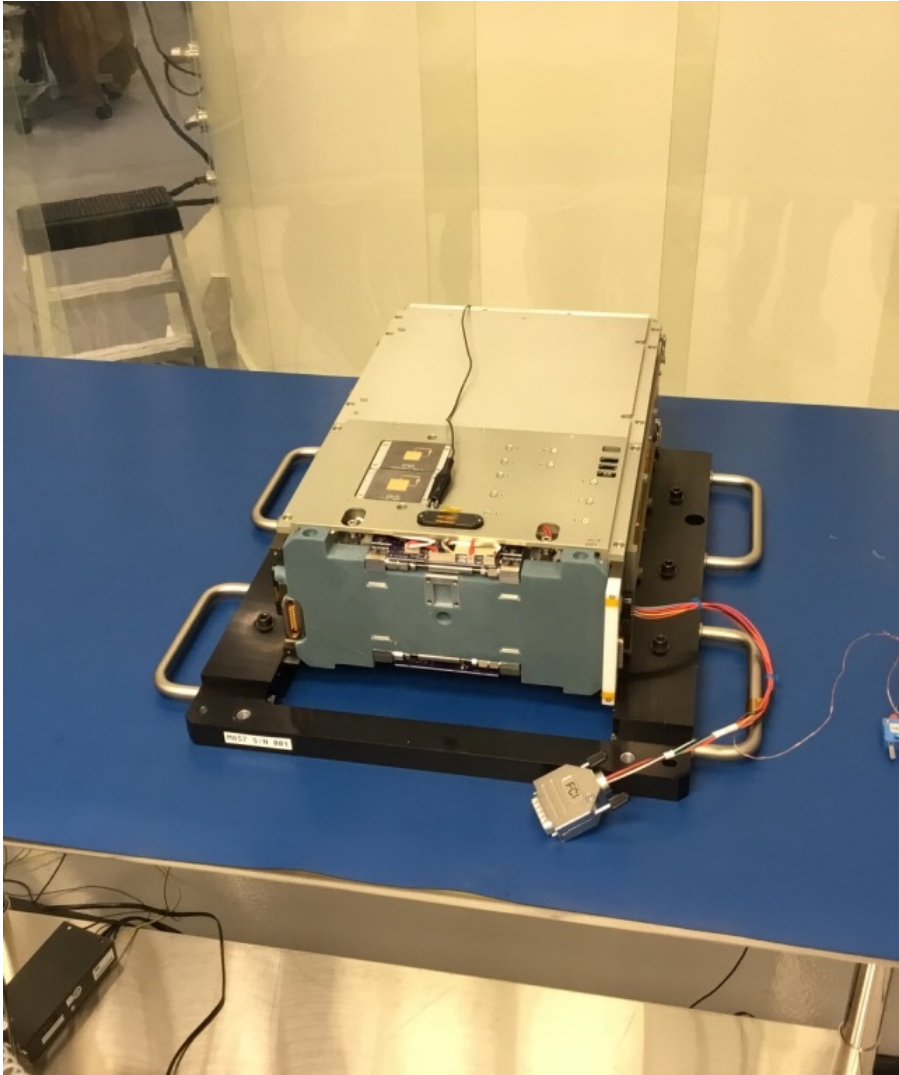
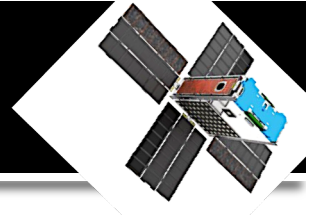


- **Remove BioSentinel Payload EDU**
 - Operate 1 bank of Payload, take apart and inspect
- **Reassemble with new BioSentinel Payload EDU and functional tests**
 - Some anomalies required rework, others judged to be acceptable for EDU TVPM
- **Spacecraft Engineering Development Unit (EDU) Thermal Vacuum Power Management (TVPM) Test**
 - TVPM plan is to run the timeline (below), 24/7 test planned for 14 days.
 - As delays pushed us closer to the Holidays we ran the Pump Down (PD) through 1st Thermal Cycle (C1) and then Vented (V) leaving the chamber powered off and at ambient conditions
 - This occurred 12/15 thru 12/20/18
 - After a Team quorum returned from the Holidays the chamber was pumped down again, the final 3 thermal cycles were run and chamber vented.
 - This occurred 1/3 thru 1/8/18
 - Spacecraft EDU returned to clean room and major subsystems disassembled and for inspection and some additional anomaly testing



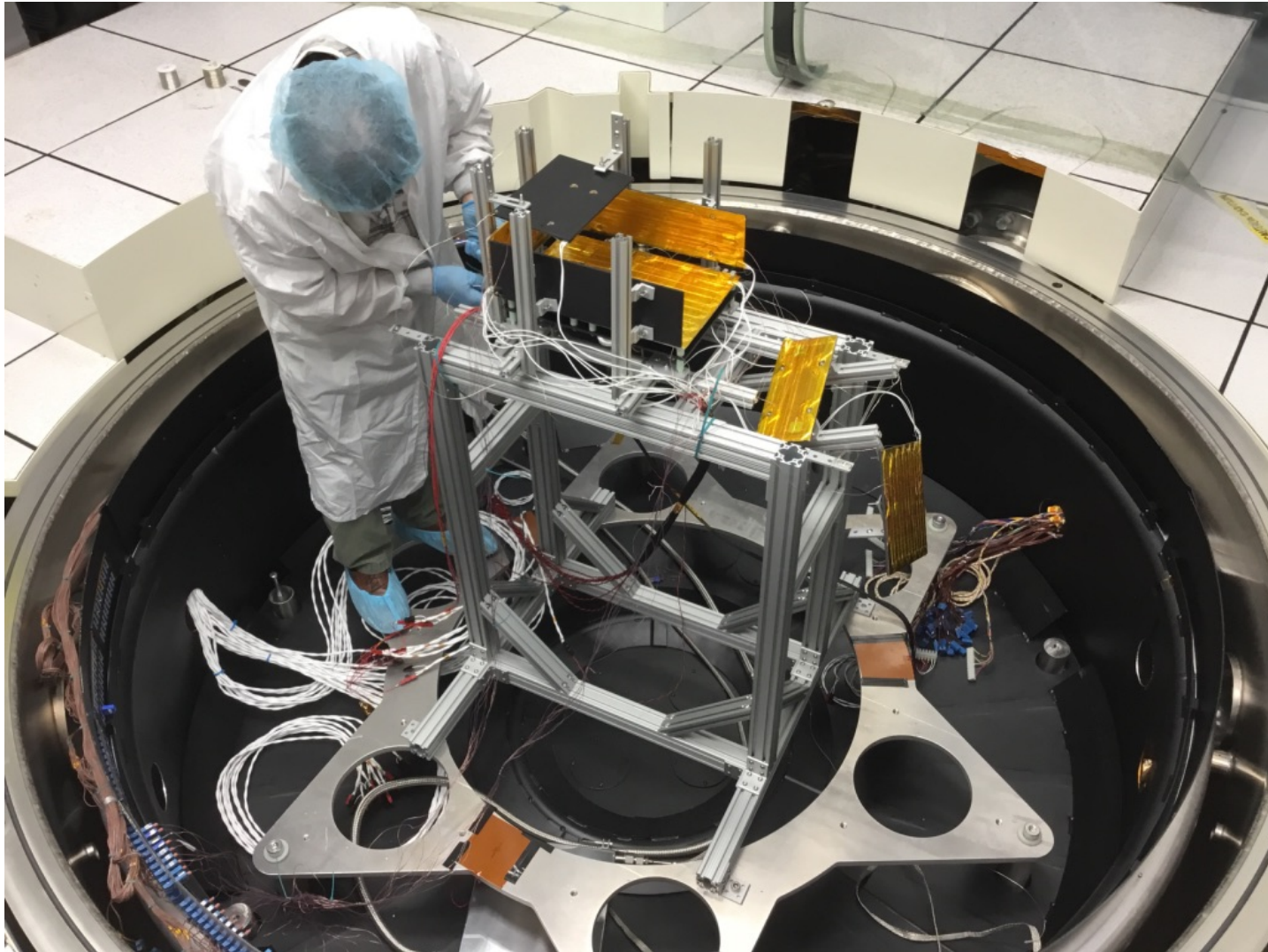
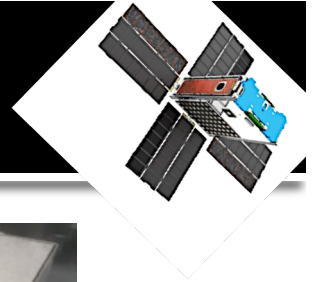


BioSentinel Spacecraft EDU Ready for TVPM



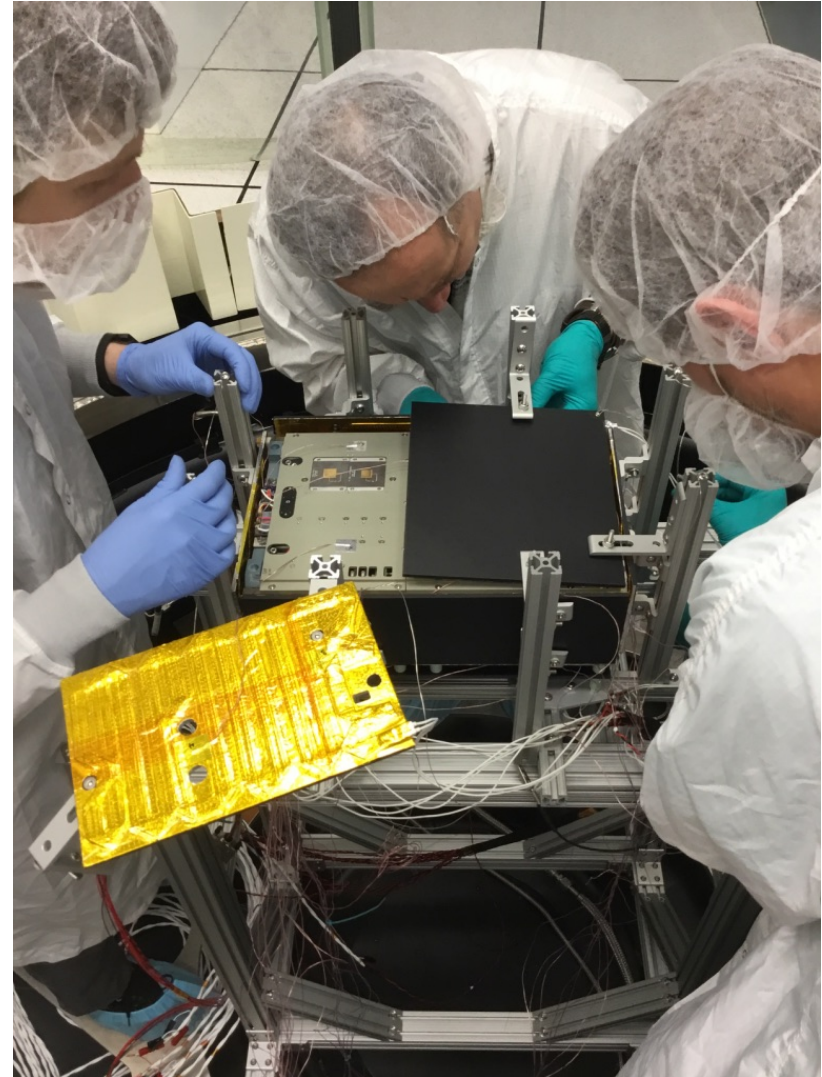
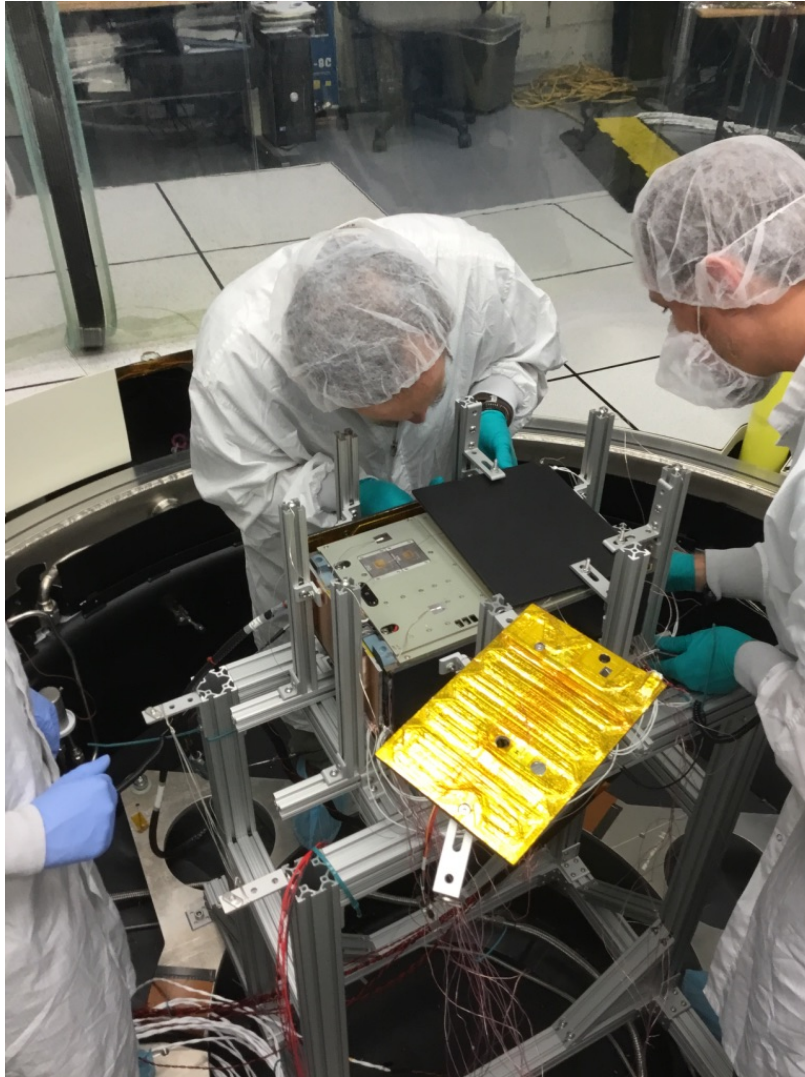
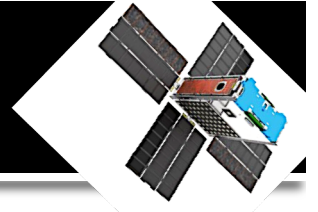


BioSentinel Spacecraft EDU TVPM Chamber Preparation



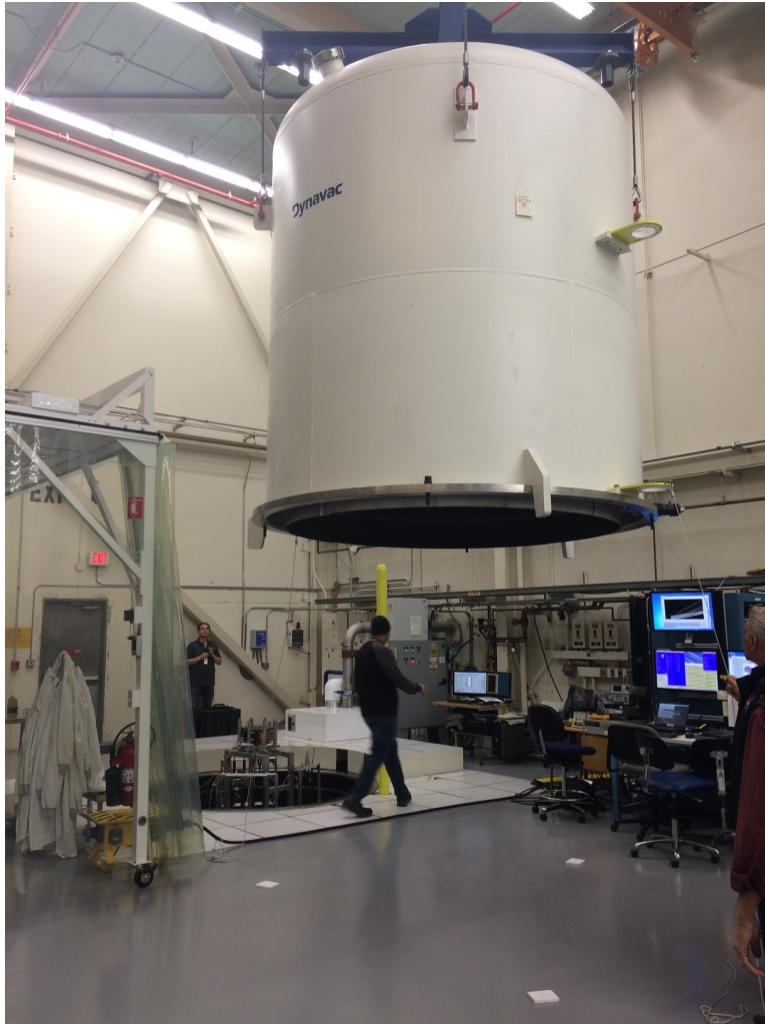
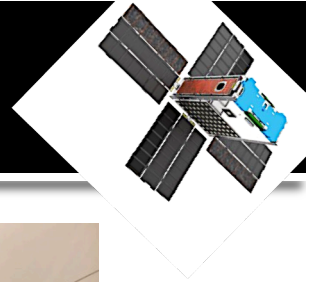


BioSentinel Spacecraft EDU Installation into Chamber



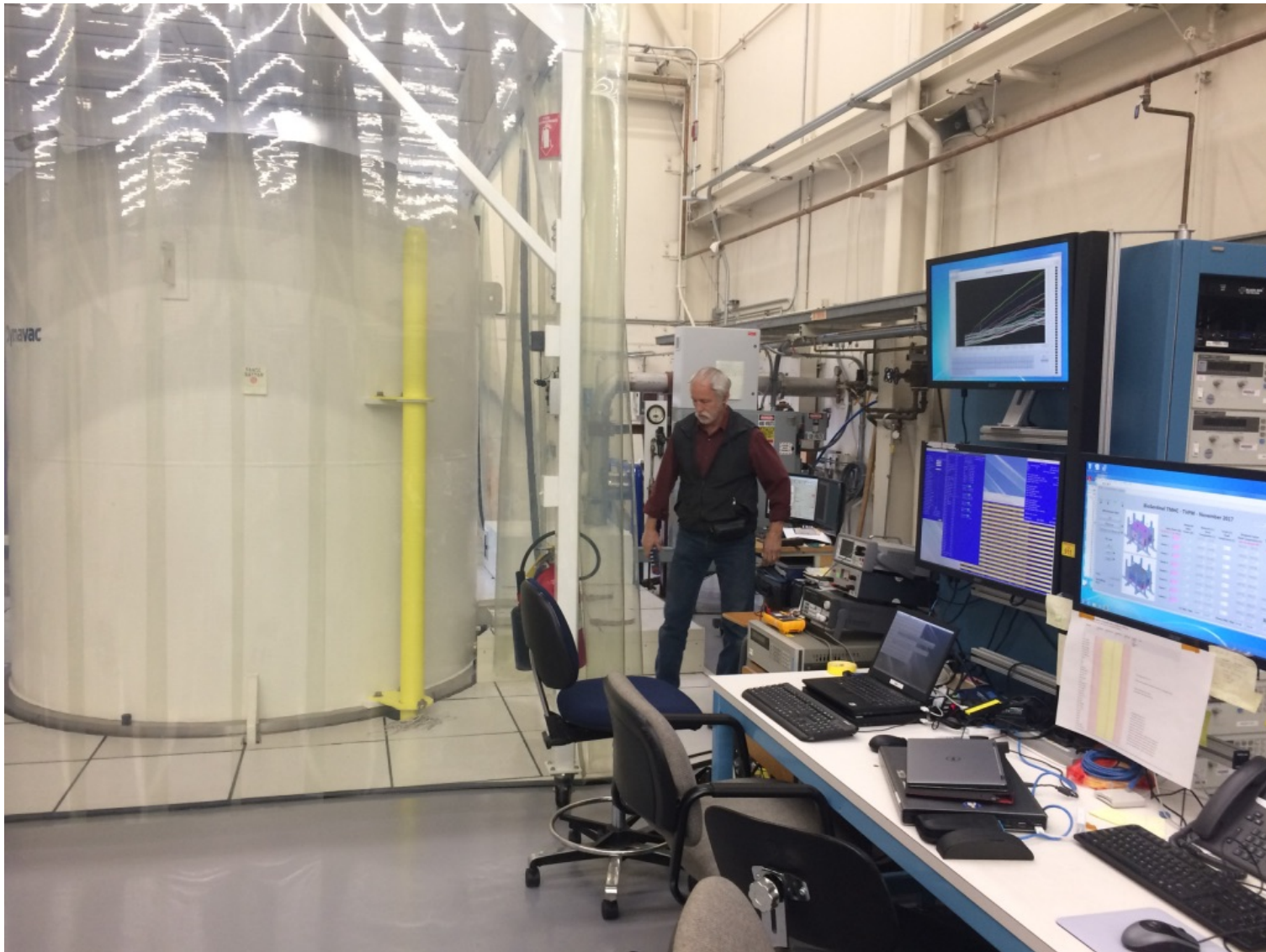
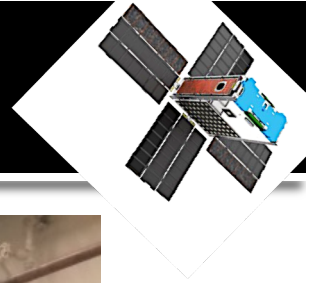


Dynavac Dome Lifted and Lowered on top of Chamber



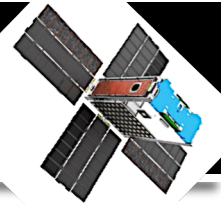


Ready to Pump Down for TVPM

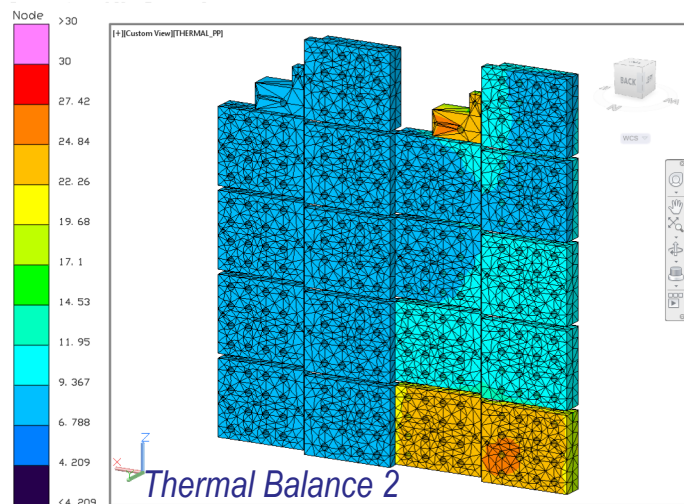
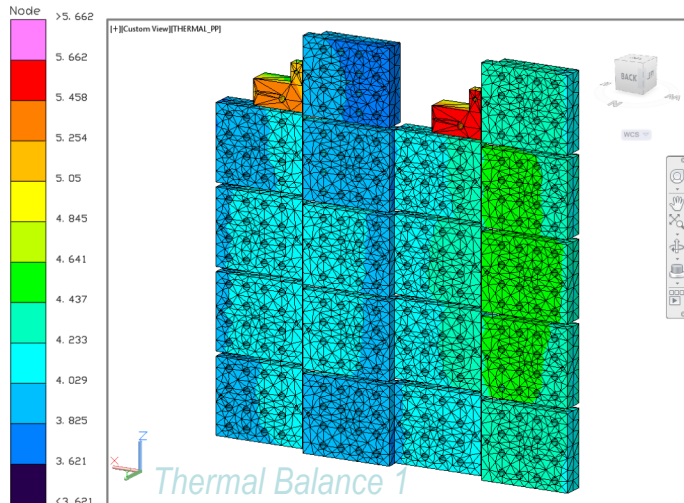




Payload Thermal TVPM Predictions and Actuals



Thermal Model Predicted Payload Temperature Distribution



Temperature [C], Time = 0 sec

Fluidics Card Temperature Distributions, Model Predictions vs. Actual

Thermal Balance 1

| Card Number | Test Temperature [C], End of Thermal Balance 1 | Delta-T, Sim Steady-State Predict Minus Actual |
|-------------|--|--|
| 1 | 3.99 | 0.34 |
| 2 | 4.42 | -0.21 |
| 3 | 3.99 | 0.45 |
| 4 | 3.99 | 0.26 |
| 5 | 3.99 | 0.51 |
| 6 | 4.01 | 0.21 |
| 7 | 4.01 | 0.44 |
| 8 | 3.99 | 0.14 |
| 9 | 4.00 | 0.33 |
| 10 | 4.01 | -0.16 |
| 11 | 5.34 | -1.33 |
| 12 | 4.67 | -0.67 |
| 13 | 5.60 | -1.52 |
| 14 | 5.40 | -1.33 |
| 15 | 3.97 | 0.11 |
| 16 | 4.81 | -0.74 |
| 17 | 4.01 | 0.01 |
| 18 | 3.98 | 0.02 |

Thermal Balance 2

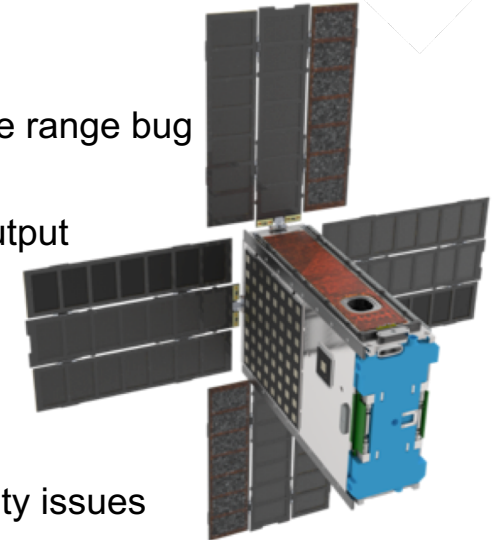
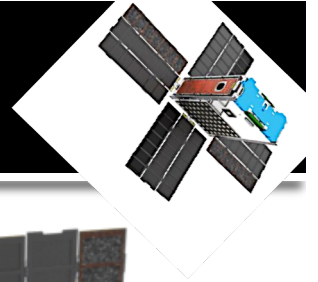
| Card Number | Test Temperature [C], End of Thermal Balance 2 | Delta-T, Sim Steady-State Predict Minus Actual |
|-------------|--|--|
| 1 | 6.54 | 2.82 |
| 2 | 8.13 | 1.10 |
| 3 | 6.98 | 2.39 |
| 4 | 8.04 | 1.34 |
| 5 | 8.23 | 1.49 |
| 6 | 11.38 | -0.23 |
| 7 | 11.40 | 0.04 |
| 8 | 22.87 | 0.15 |
| 9 | 22.82 | 0.56 |
| 10 | 6.69 | 1.45 |
| 11 | 8.76 | -0.50 |
| 12 | 8.19 | 0.16 |
| 13 | 9.05 | -0.60 |
| 14 | 9.17 | -0.59 |
| 15 | 6.51 | 2.10 |
| 16 | 8.54 | 0.28 |
| 17 | 7.34 | 1.35 |
| 18 | 7.13 | 1.78 |

Thermal Balance 1: All cards in stasis (cold)

Thermal Balance 2: Two cards in growth 23°C



BioSentinel Flight Unit Modifications (1/2)



Propulsion

- Work wire re-routing to prevent stress/compression of wire harness
- Flight unit will need to be upgraded to v3.1 of software to correct temperature range bug

C&DH

- Capture connector location modification on board to accommodate power output
- Update functional and test procedures
- Flatsat functional tests with all subsystem components, including Iris

Mechanical & Structures

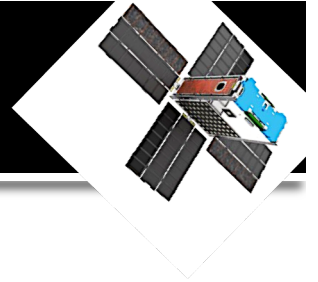
- Resolve grounding path issue to isolate IRIS transponder from structure
- Modify flight unit side panel to correct for diagnostic port alignment and quality issues
- Fabricate new bottom, top and one side panel for flight to accommodate updated Solar Array design

EPS

- EPS board modifications and re-fabrication to accommodate C&DH and ADCS needs
- Switch board modifications and re-fabrication to accommodate ADCS and TCS needs
- Peak Power Tracker board modifications and re-fabrication to accommodate ADCS and TCS needs
- System-level low voltage testing
- SW change to serially fire burn wires
- Battery charge limit 14.1V need to test the Solar array simulator to ensure we can charge the battery



BioSentinel Flight Unit Modifications (2/2)



ADCS

- Identify root cause of unexpected IMU reboots and resolve

FSW

- SW release with Iris incorporated
- SW release with ConOps and Fault Management implemented

Thermal

- Identify path forward for calibration cell heating during pumping phase
- Improve uniformity of thermal contact for MGA thermal gasket; minimize bowing of antenna structure
- Assess change to thermal conduction/isolation of LET board to payload canister interface
- Optimize exterior thermo-optical tape sizing/placement based on TVPM analysis results

Comm

- Hardware testing at NASA ARC pending IRIS EDU arrival

Cabling

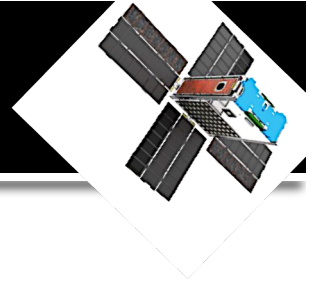
- Provide SDL with feedback on how to best strain relieve **SBC-IXC** power and data cables
- Build new XACT cable
- Update AD590 cable

BioSensor

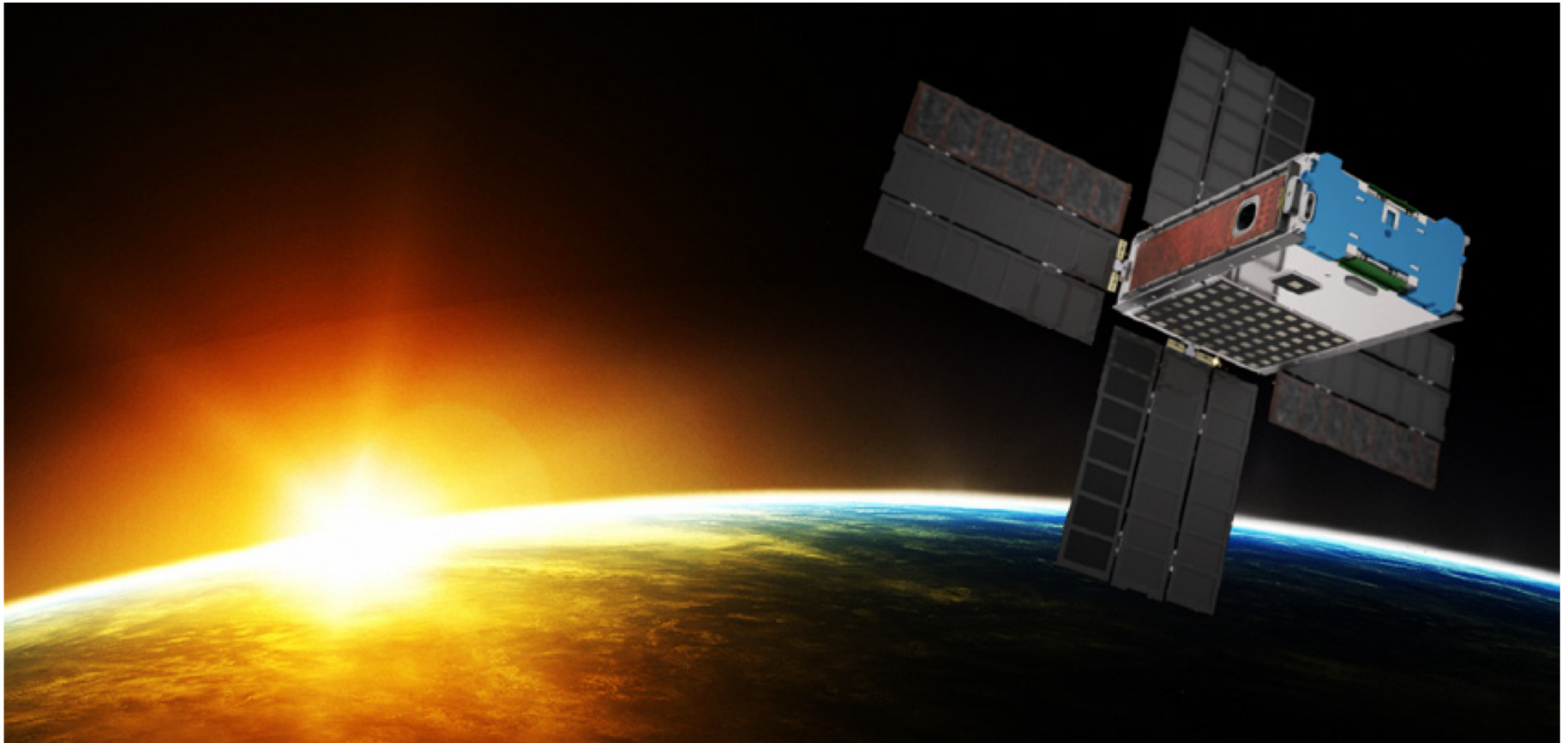
- Investigate CalCell optics reading anomaly
- Perform Optical calibration testing



BioSentinel Back-Up Charts

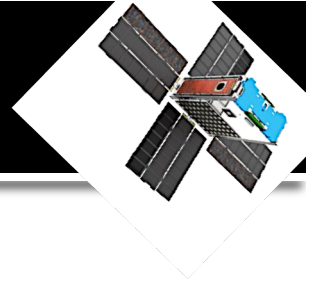


Questions & Back-Up Charts





BioSentinel Teaming



- **Mission Management** - Bob Hanel, Dawn McIntosh, James Chartres, Mario Perez, Elwood Agasid, Vas Manolescu, Matt D'Ortenzio
- **Science** - Sharmila Bhattacharya, Sergio Santa Maria, Lauren Liddell, Sofie Tieze, Diana Gentry, Macarena Parra, Tore Straume, C. Mark Ott, Sarah Castro, Greg Nelson, Troy Harkness, Roger Brent
- **Payload** - Eric Tapio, Rich Bielawski,, Tony Ricco, Travis Boone, Ming Tan, Aaron Schooley, Mike Padgen, Lance Ellingson, Dayne Kemp, Charlie Friedericks , Scott Wheeler, Susan Gavalas, Edward Semones
- **Spacecraft and Bus** – Rudy DeRosse, Hugo Sanchez, Matthew Sorgenfrei, Jesse Fusco, Vanessa Kuroda, Craig Pires, Shang Wu, Abe Rademacher, Josh Benton, Matt Knudson, Doug Forman

Affiliations

NASA Ames, NASA JSC - RadWorks, LLUMC, Univ. Saskatchewan

Support

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