

CubeSat Proximity Operations Demonstration (CPOD) Vehicle Avionics and Design

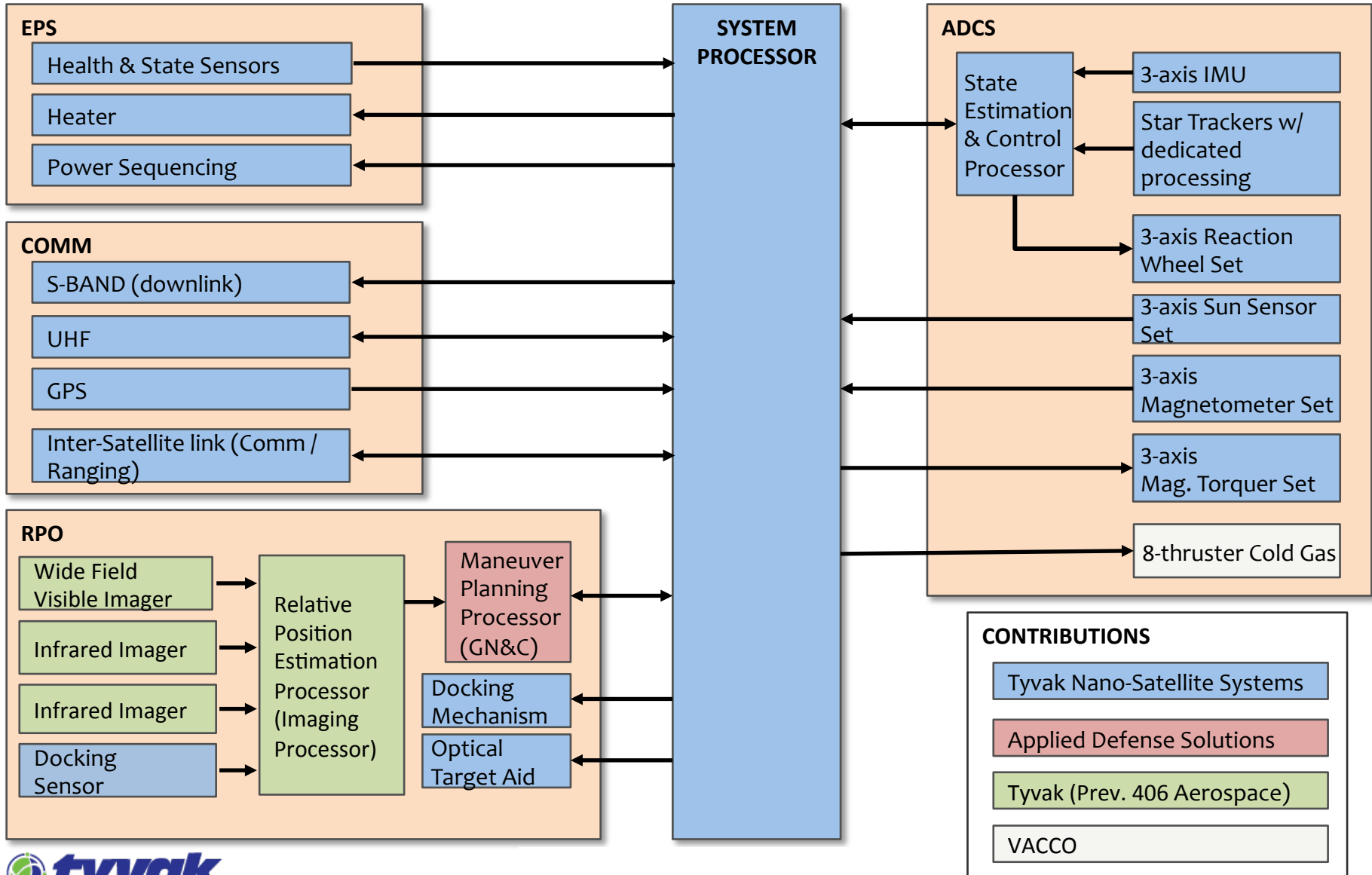
August CubeSat Workshop 2015

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VP, Space Vehicles**

CPOD: Big Capability in a Small Package

Communications	Directional Simplex S-band to Ground (2.2Ghz)
	Directional Half-Duplex Inter-Satellite Link (ISL) (2.4Ghz)
	Omni-Directional Half-Duplex UHF (400Mhz)
ADCS	3-Axis Multi-Objective Pointing with Momentum Dumping
	Contingency Coarse Pointing Mode
	Ground Tracking, Inertial Pointing, LVLH, Sun
Navigation	GPS L1 for Position and Velocity
	Relative Bearing and Distance Determination (Optical, RF)
	Relative Attitude Determination (Optical)
	On-Board Navigation Solutions and Delta-V for Manuevers
EPS	Sufficient Peak Power, and Energy Storage
	Distributed Power Interfaces to Subsystems
	Docking Mechanism (Electro-Magnet)
Mechanical	Deployables (UHF Antenna, Solar Panels, Vehicle Separation)
C&DH	Vehicle Monitoring and Control
	Fault Management
	Inter-Processor Communication

Space Vehicle Architecture



CPOD Configuration

4x Radios

5x Linux Computers

4x Deployables

6x Antennas

3x Microcontrollers

6x Imagers

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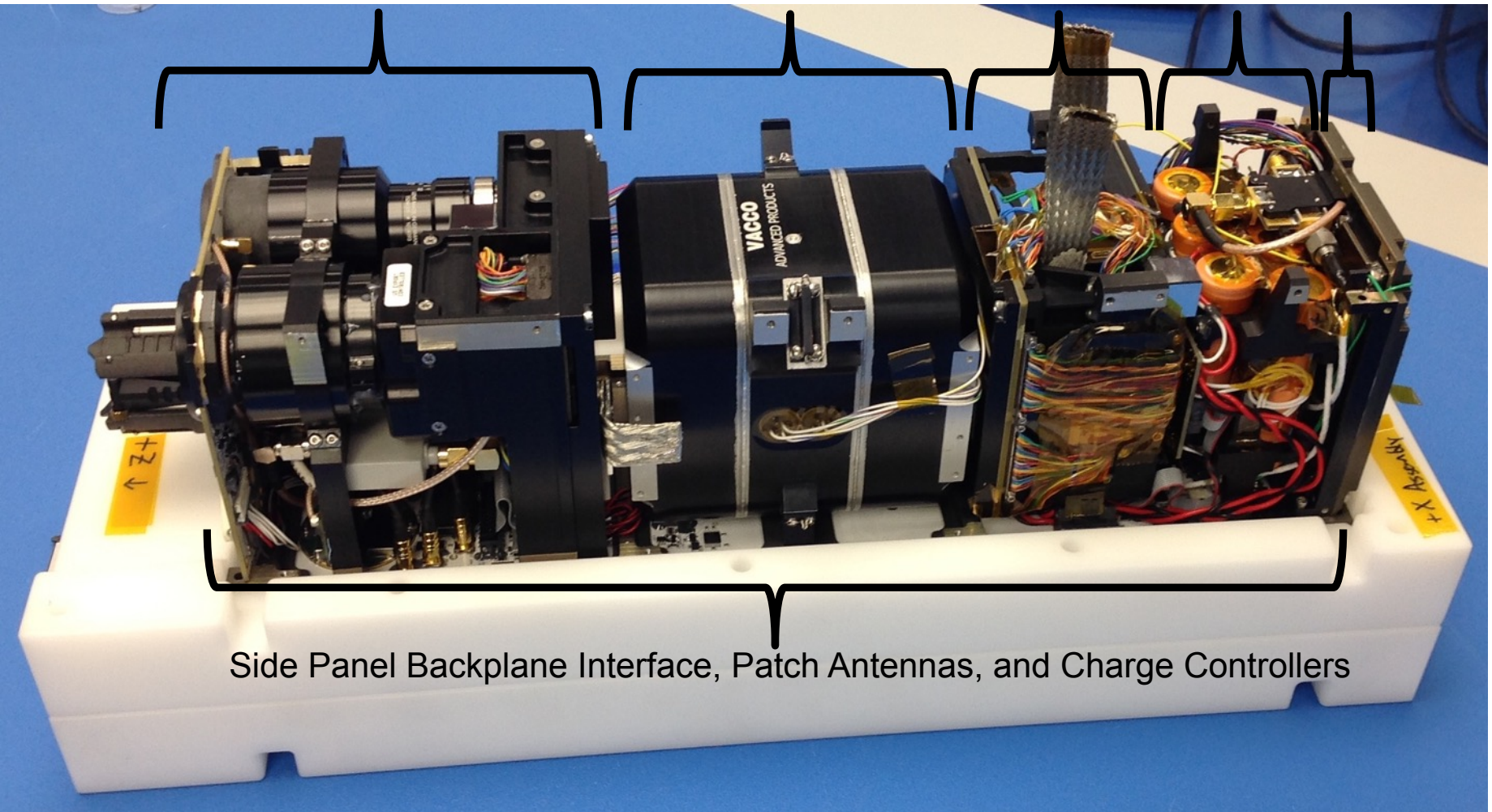
Navigation Solutions,
GPS, Docking Mechanism

Cold Gas Propulsion

C&DH,
ADCS

EPS

UHF
S-Band

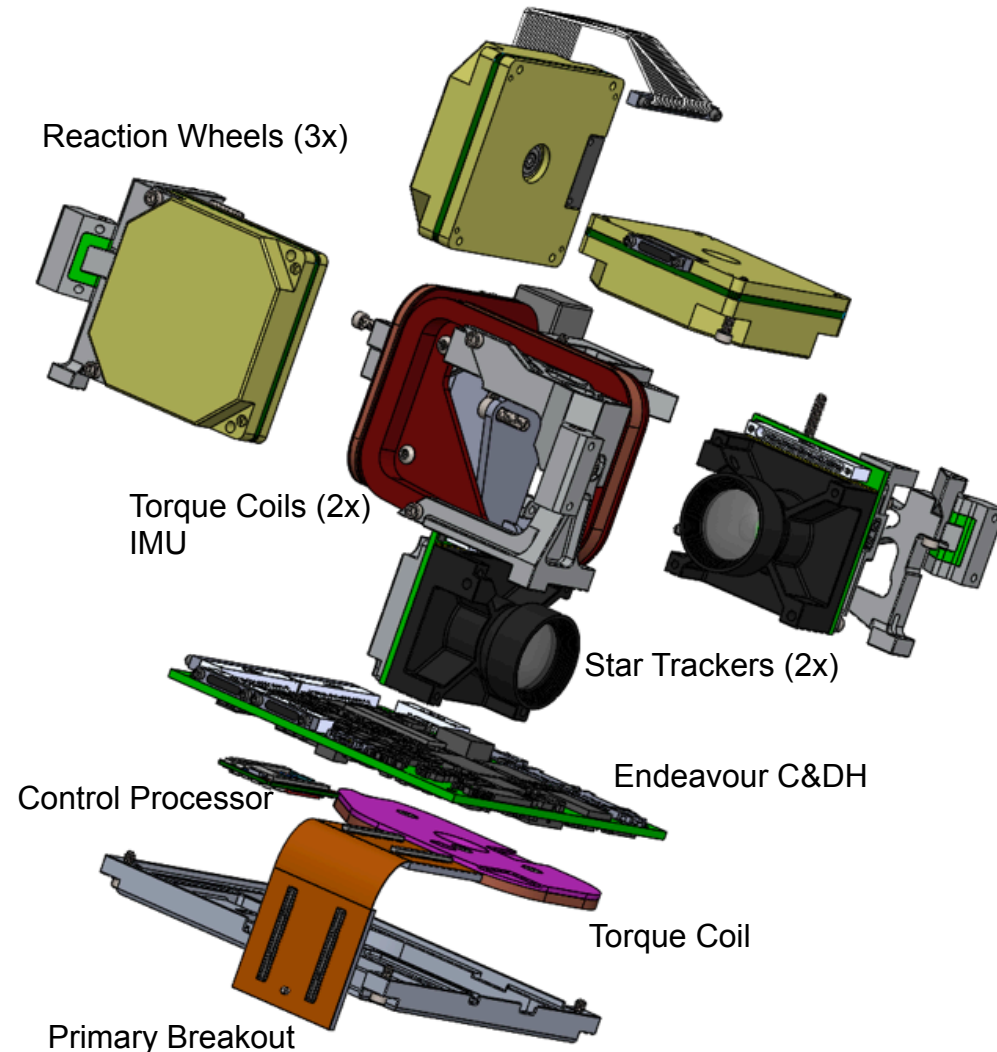
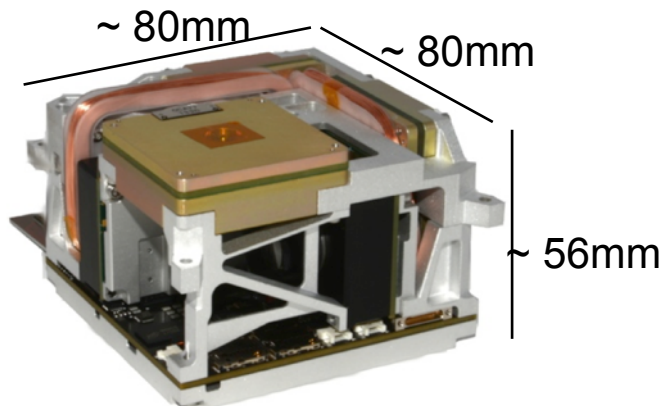


Side Panel Backplane Interface, Patch Antennas, and Charge Controllers

Endeavor Vehicle: C&DH and ADCS 1/2U Solution

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- **C&DH Linux Processor**
 - Arm9 @ 400Mhz
- **ADCS Linux Processor**
 - Arm Cortex-A8 @ 800Mhz
- **Reaction Wheels (x3)**
 - 10mn-m-s; 3mN-m; 10000 RPM Max
- **Star Trackers (x2) and IMU**
 - Pitch/Yaw/Roll 10/10/80" 1 σ
- **Magnetorquers (x3)**
 - 0.1 A-m² in all axis



EPS – Battery Module and Solar Panels

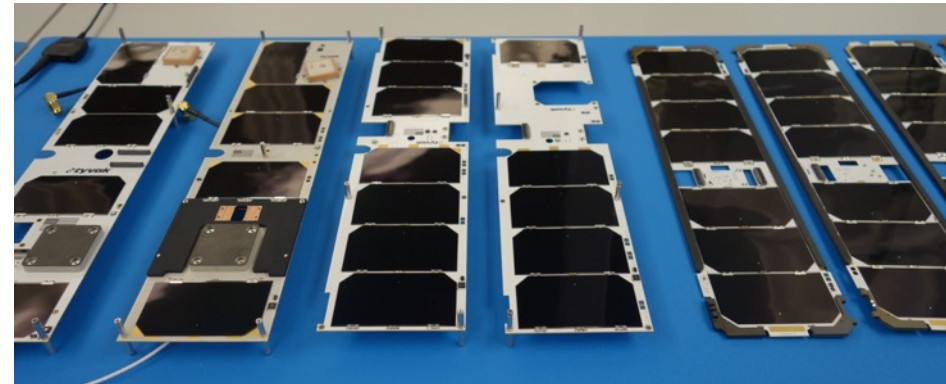
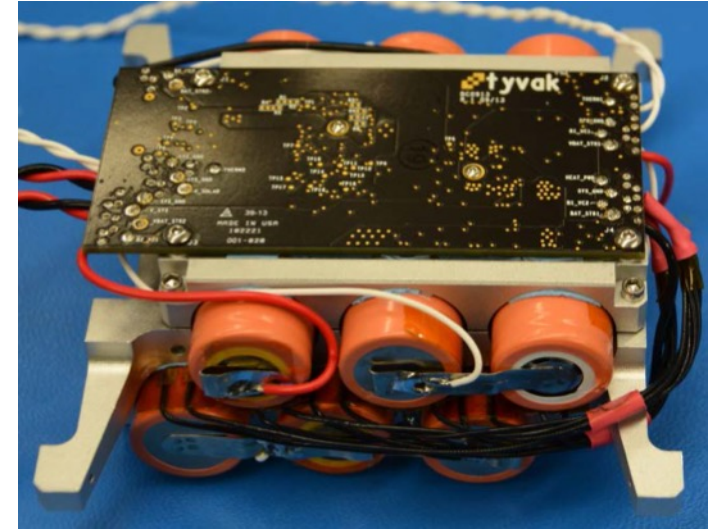
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- **Battery Module Features**

- 11.1V Unregulated System
- Greater than 80 watt power output capability
- Greater than 40 watt power input (charge) capability
- Temperature & power sensor telemetry
- Fail-safe battery heater controller
- Dual deployment switch power output inhibit

- **Solar Panels**

- Supports 3 to 5 cell strings
- Maximum Peak Power Tracking on Panels
- Deployable Configurations Available
- Thermal radiators
- Panels customized for the mission



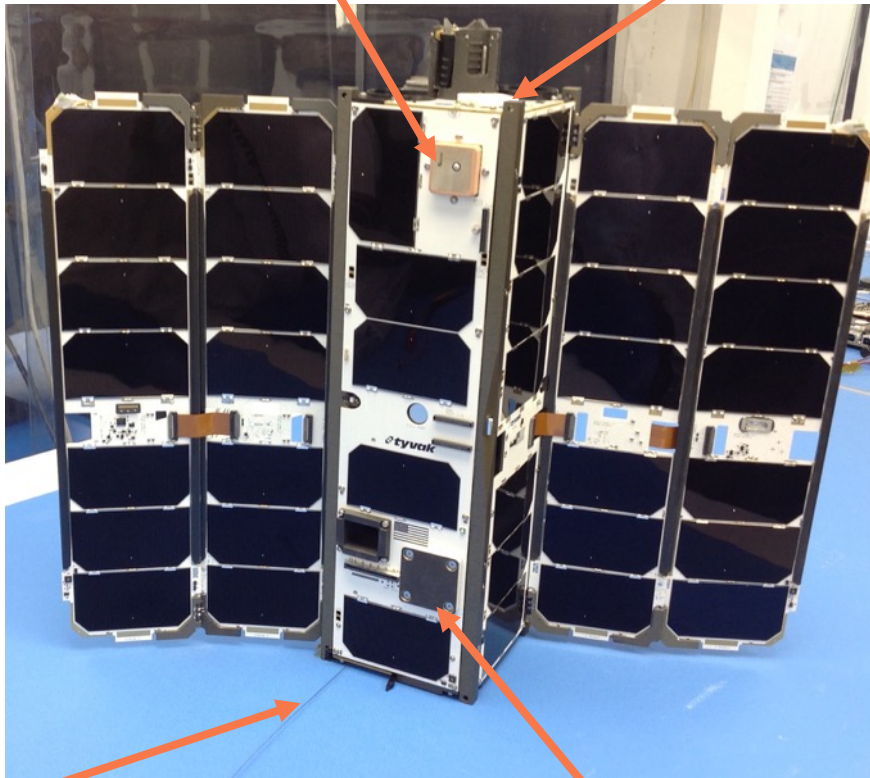
RF Communications

GPS Patch Antenna

L1 Band, Two Phased Elements

Inter-Satellite Link

250kbps, RF Ranging @ 2.4Ghz

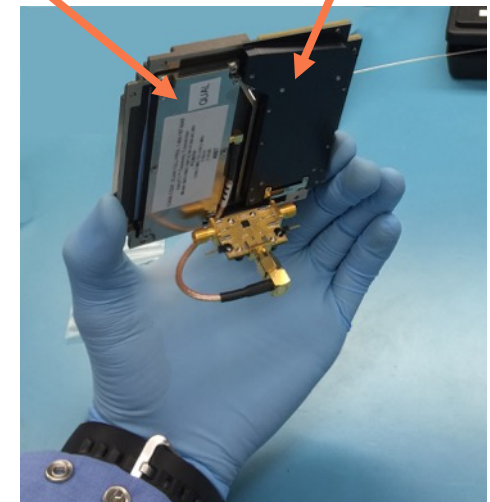


UHF Half-Duplex Radio

9.6kbps GMSK @ 400Mhz

S-Band Transmitter

1Mbps BPSK @ 2.2Ghz



Deployable UHF Antenna

Omni-directional

S-Band Patch Antenna

Two Switched Elements

CPOD Performance Summary

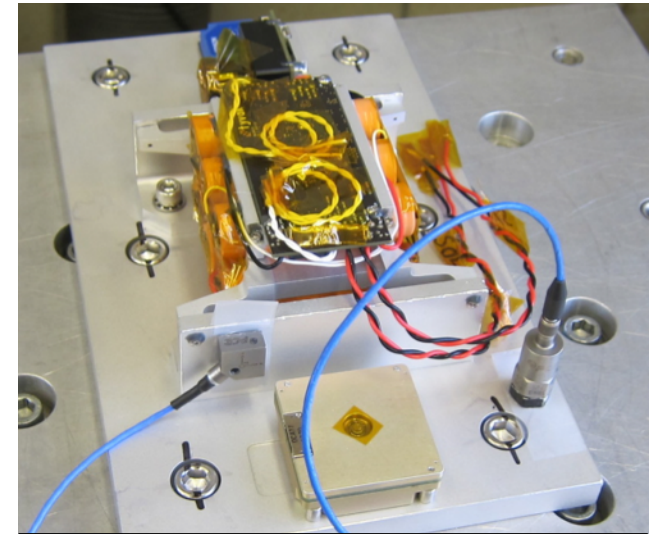
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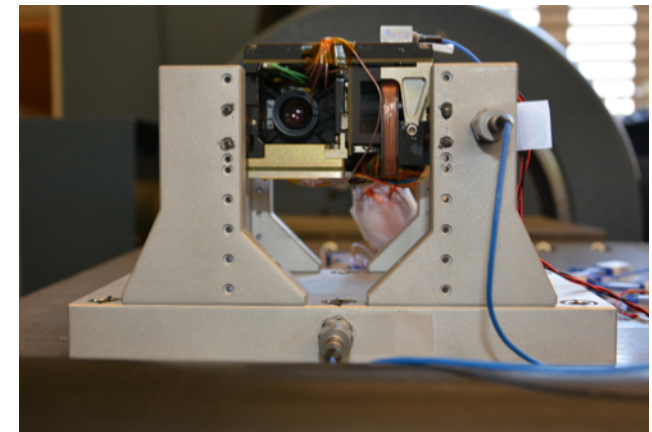
Capability	Specification	Comments
Average Power Generated	~17W to 30W OAP	Polar Sun-Sync
Average Load	~15W	Fully Active
Pointing Accuracy	<0.15 degrees	Star Trackers available under all mission scenarios
Mission Data Downlink	~60MB / day	UHF and S-Band
Delta-V	~30 m/s	Cold Gas
Total Mass	5.990kg	Wet Mass (13% Margin)

Component and Subsystem Environmental Testing

- **Early component and subsystem environmental testing used to reduce risk of issues at system level**
 - Risk reduction environmental testing completed on low TRL components (RWA, battery module, star camera, and IMU show on right)
 - Modules used to enable testing complex subsystems before full vehicle integration (IRM, RPOD, etc.)
- **Lessons Learned**
 - Thermal test before thermal vacuum testing
 - Design for repeated assembly and disassembly of complex modules
 - Feature rich test interfaces are invaluable when attempting to understand issues without deintegration
 - Testing with non flight like surface finishes may hide surface roughness issues



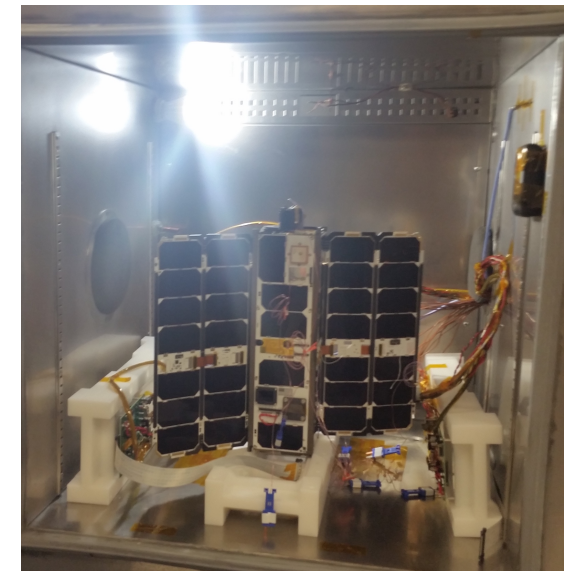
Component Vibration Testing



Subsystem Vibration Testing

Vehicle Level Avionics Testing

Test	Description	Status
Self RF Compatibility	Verify all radios operate to specification under all vehicle operational scenarios	Passed
Anechoic Chamber Testing	Perform anechoic chamber test of S-Band, ISL, and UHF Antennas	Passed
GPS Lock	Check that vehicle achieves GPS lock under all operating modes	Passed
Hardware In The Loop	Guidance, Navigation and Control simulations driving flight-like actuators	Passed
Night Sky Testing	Outdoor Night sky testing of IRM	Passed
Payload Calibration and Sensor Alignments	2 Visible, and 2 IR Imagers aligned with star-trackers and IMU.	Passed
Vibration	22 grms vibration test	Passed
Thermal Vacuum	Complete vehicle operations over thermal vacuum cycles	Passed



Vehicle Environmental

Questions?

