ELECTRON LOSSES AND FIELDS INVESTIGATION

Mission Overview

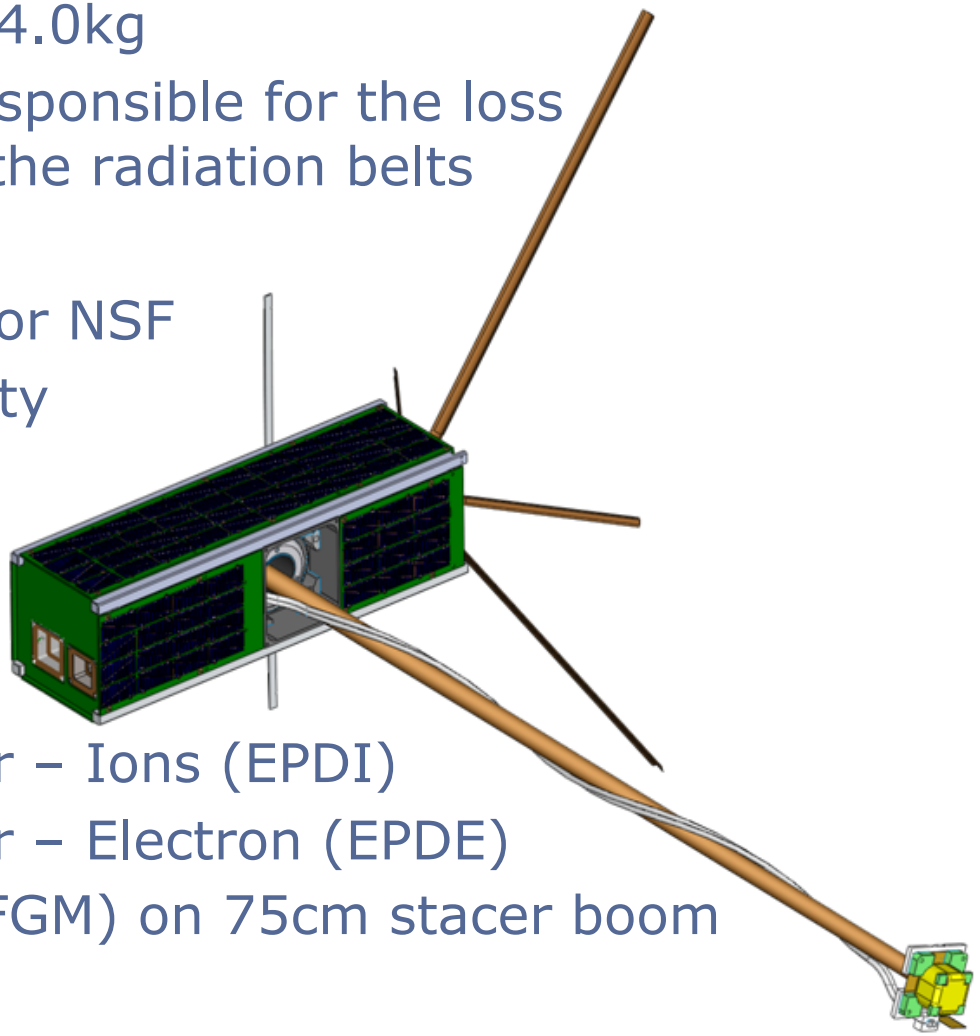
2013 CubeSat Developers Workshop

University of California, Los Angeles
April 25, 2013

Mission Overview

Electron Losses and Fields Investigation

- 3U Space Weather CubeSat, 4.0kg
- Exploring the mechanisms responsible for the loss of relativistic electrons from the radiation belts
- Spin Stabilized @ 20RPM
- Shortlisted but not selected for NSF
- Participant in AFRL's University Nanosat Program (NS-8)

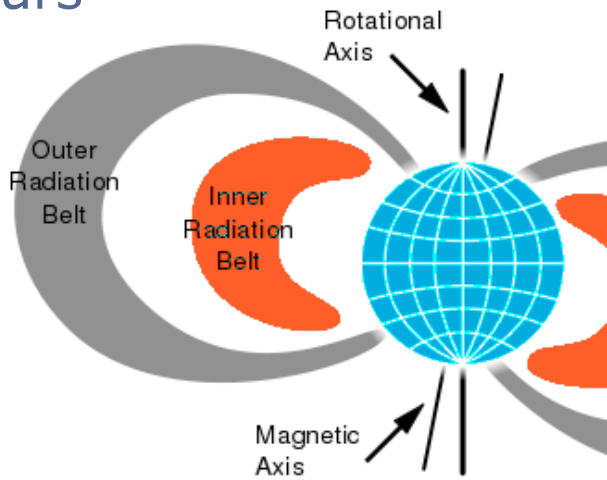


Instruments:

- Energetic Particle Detector – Ions (EPDI)
- Energetic Particle Detector – Electron (EPDE)
- Fluxgate Magnetometer (FGM) on 75cm stacer boom

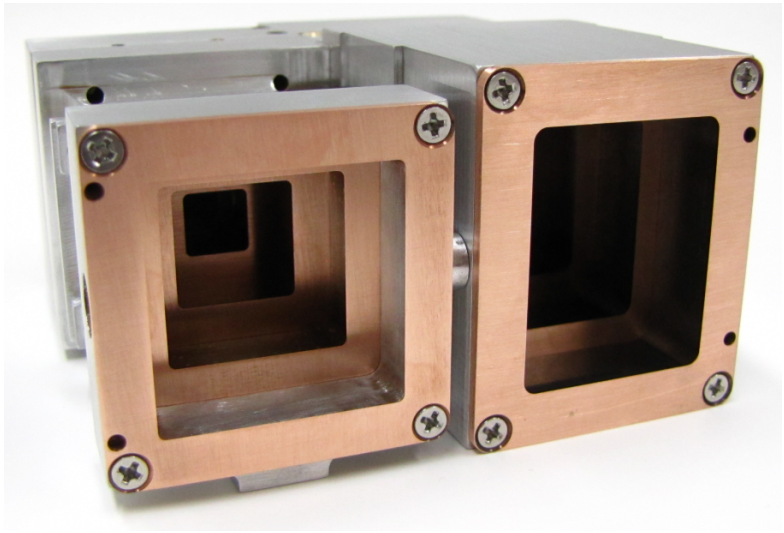
Science Requirements

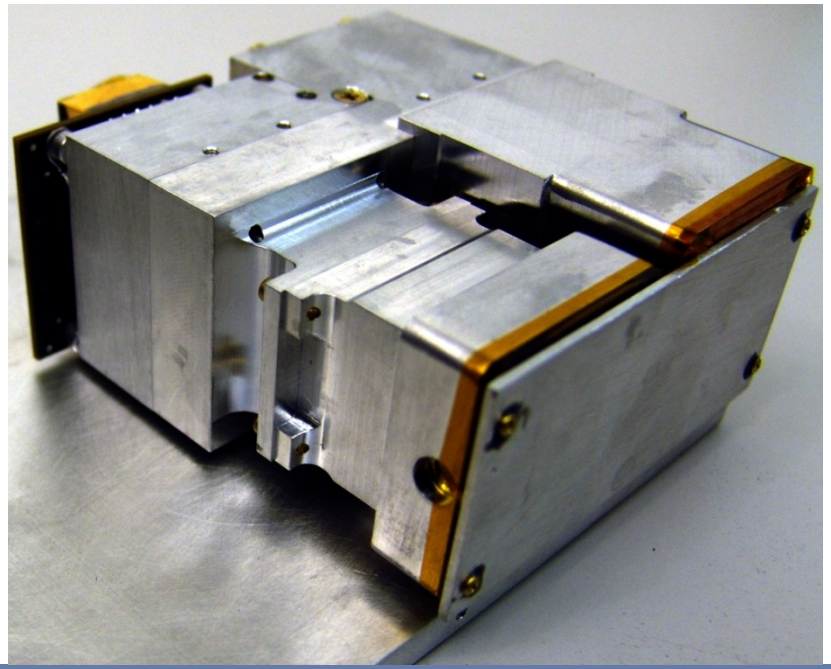
- Observe energetic particle populations
  - B-field within 15° of spin plane during observation
  - Observe L shells 3-8 at least every 6 hours
  - Latitude resolution of < 0.5° /spin
  - Pitch angle resolution of < 30°
- Orbital Requirements:
  - Inclination > 65°
    - Satisfies L shell & frequency criteria
  - Perigee > 400 km
    - Atmosphere absorbs particles; can't measure below this altitude
  - Apogee < 6000 km
    - Loss cone shrinks with altitude; above this it cannot be resolved
    - Apogee limited to < 2500 km due to thermal, comm, radiation, deorbit
- 6 month nominal mission (3 month minimum)
  - Observe at least one geomagnetic storm



Energetic Particle Detector

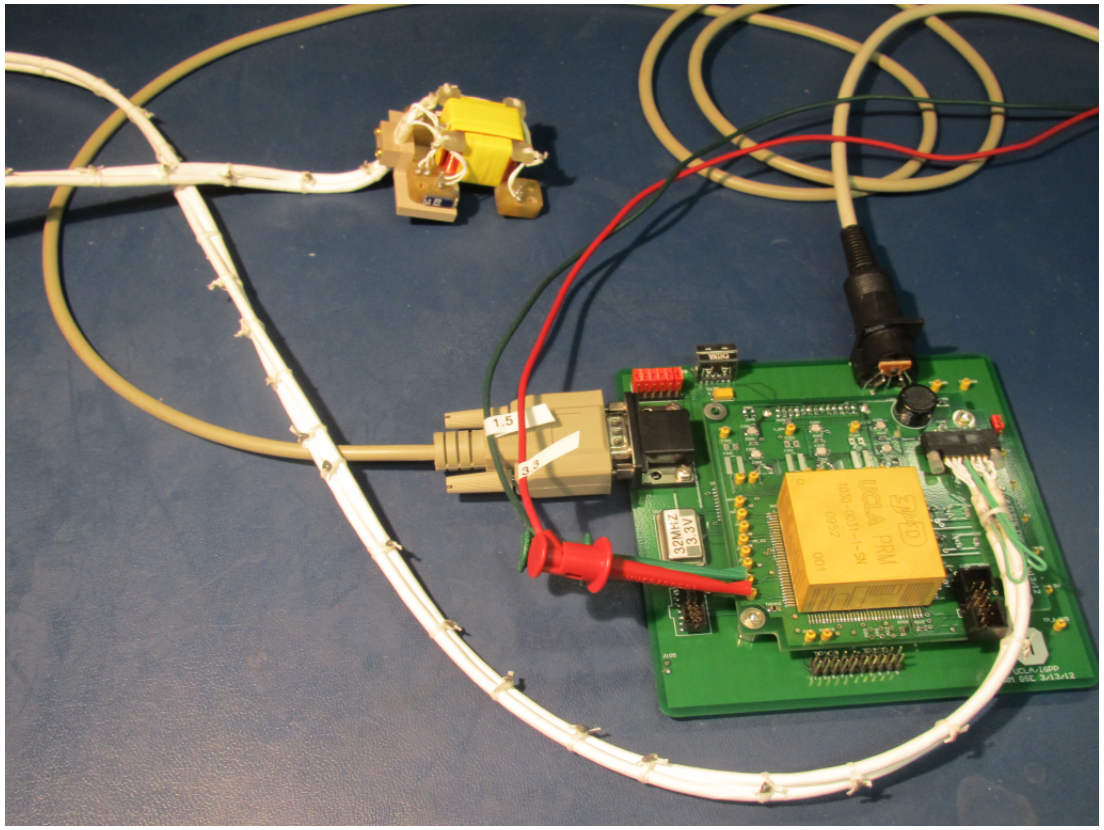
- Energetic Particle Detector – Electrons (EPDE)
  - 50keV – 4.2MeV (6 channels)
  - 7 Pulse Height Analysis sub channels < 1MeV
  - 1100mW (incl. IDPU)
- Energetic Particle Detector – Ions (EPDI)
  - 50keV – 500keV (8PHA sub channels)
  - 2x MSX03-1000 detectors
  - 300mW





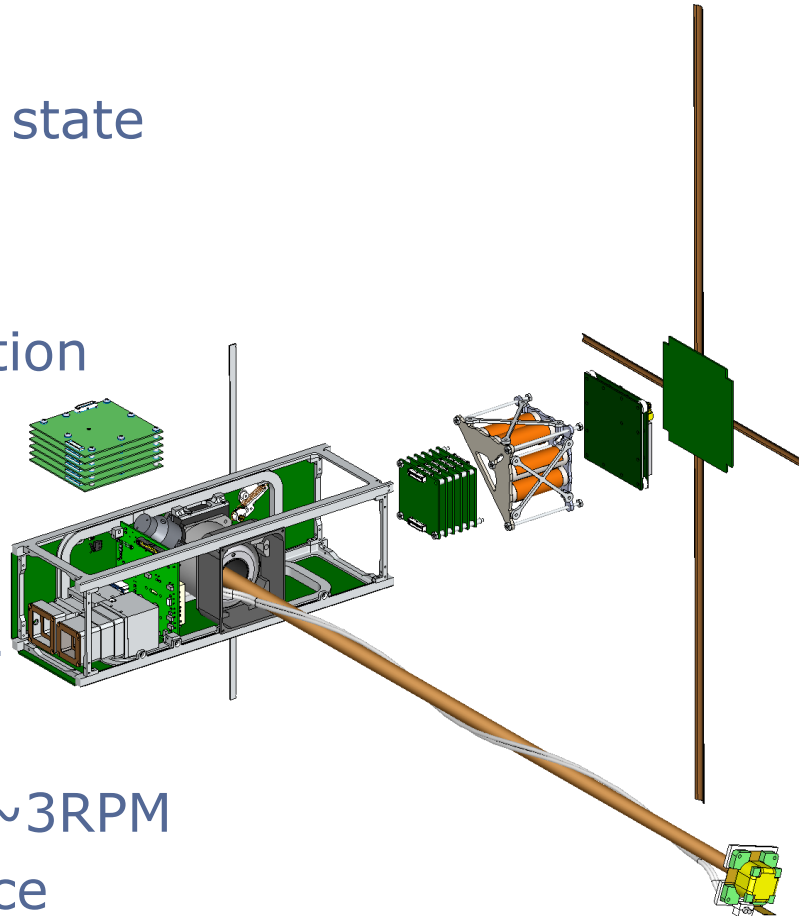
FLUXGATE MAGNETOMETER

- Fluxgate Magnetometer (FGM)
  - DC-64Hz (128Hz sample rate); 96dB linearity
  - 55,000nT range, 10pT resolution
  - 100pT noise, 610mW



CONCEPT OF OPERATIONS

- Early Orbit Operations
  - Verify & maintain power positive state
  - Deploy antennas
  - Collect ADCS data (CSS, MRM)
  - Beacon of critical health information
- Checkout (<2 weeks)
  - Stacer boom deploy
  - Initialize Fluxgate Magnetometer
  - FGM orientation determination
  - Detumble & partially spin-up to ~3RPM
  - Characterize antenna performance
  - Characterize ADCS sensors (FSS, HCIs)
  - Initialize Energetic Particle Detector
  - Precess to science attitude & spin-up 20RPM

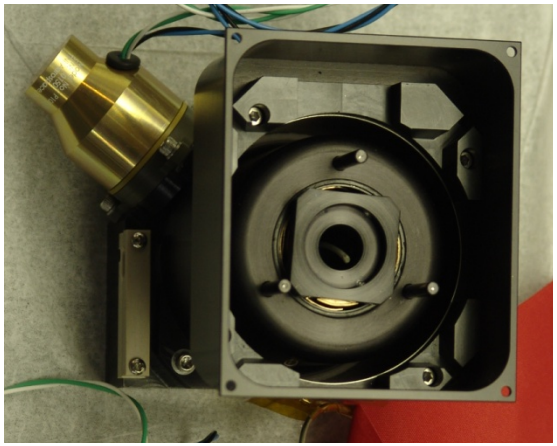


Concept of Operations

- Science Phase (3 – 6+ months)
  - Observations (4 – 60 per day)
    - # of observations f(inclination, altitude)
      - Observations prioritized based on expected quality
      - Some observation zones may be skipped due to attitude
    - Each observation lasts ~250 seconds
      - Duration tuned for power & data volume
  - Downlink (1 – 4 per day)
    - Two ground stations (UCLA & WPI)
    - Prime pass includes spacecraft housekeeping telemetry and science summary
    - Science summary is automatically processed
      - If summary scores highly selective science download is scheduled
  - ADCS (daily or weekly)
    - Spin vector ~orbit normal if sun-synchronous orbit
    - Spin vector needs to precess 3.6°/day
    - ¼ RPM/day despin (@ 20RPM) expected

Atypical CubeSat Characteristics

- 20RPM spinner
  - Only a handful of spinners exist, most slower, some faster
  - A lot of them are inadvertent spinners (or tumblers)
- Deployable fluxgate magnetometer
  - Magnetic cleanliness
  - 75cm stacer (Kaleva Design)

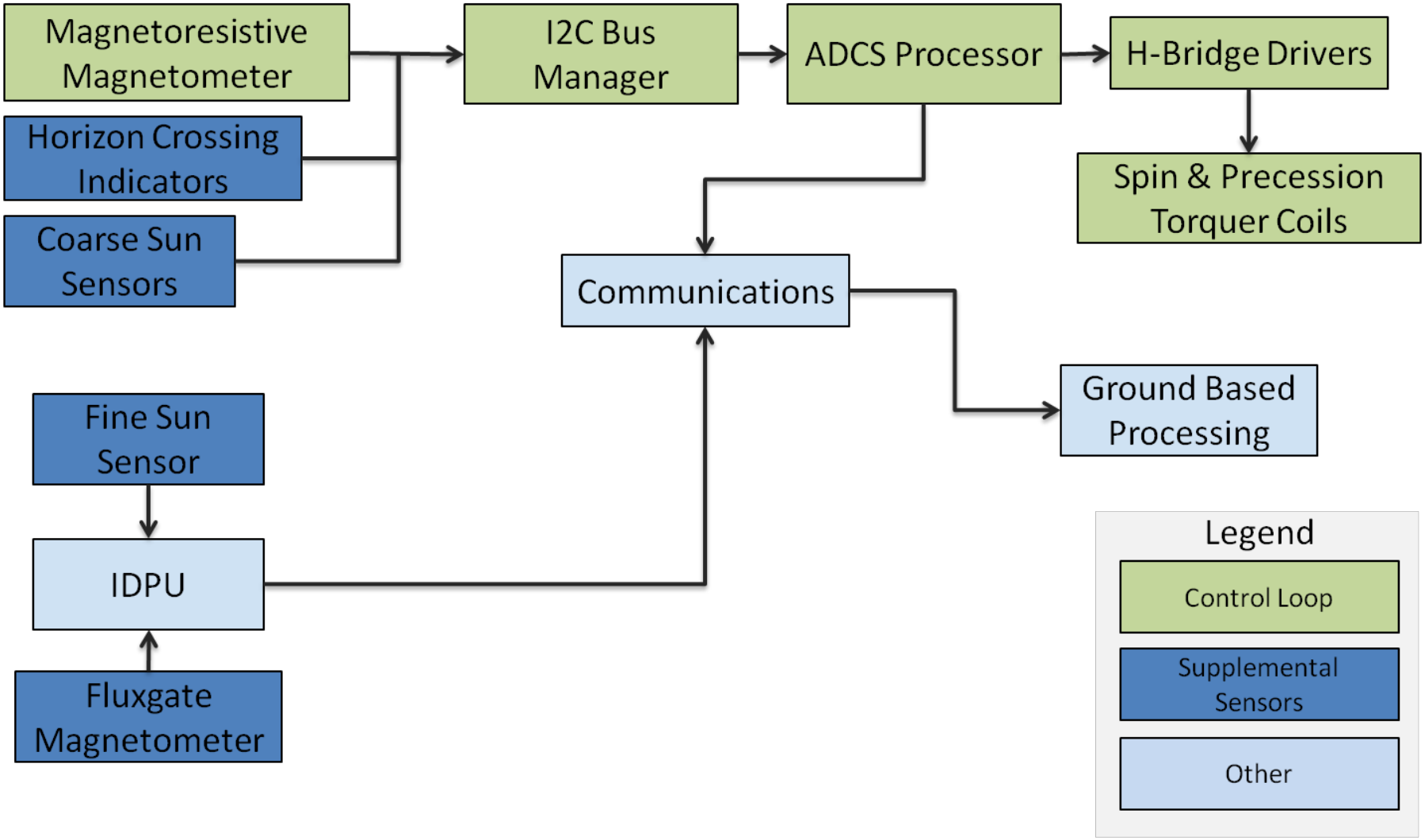


- Substantial payload & longevity
  - EPD shielding is heavy
  - We have to wait for a storm
    - mission life is important
- Moderate instrument data volume (~2.63 MiB/day)
  - 4 downlinks/day (2 ground stations)
  - Not a high speed downlink
    - but not run-of-the-mill 1200 baud FM AX.25 packet either

SPINNER IMPACTS

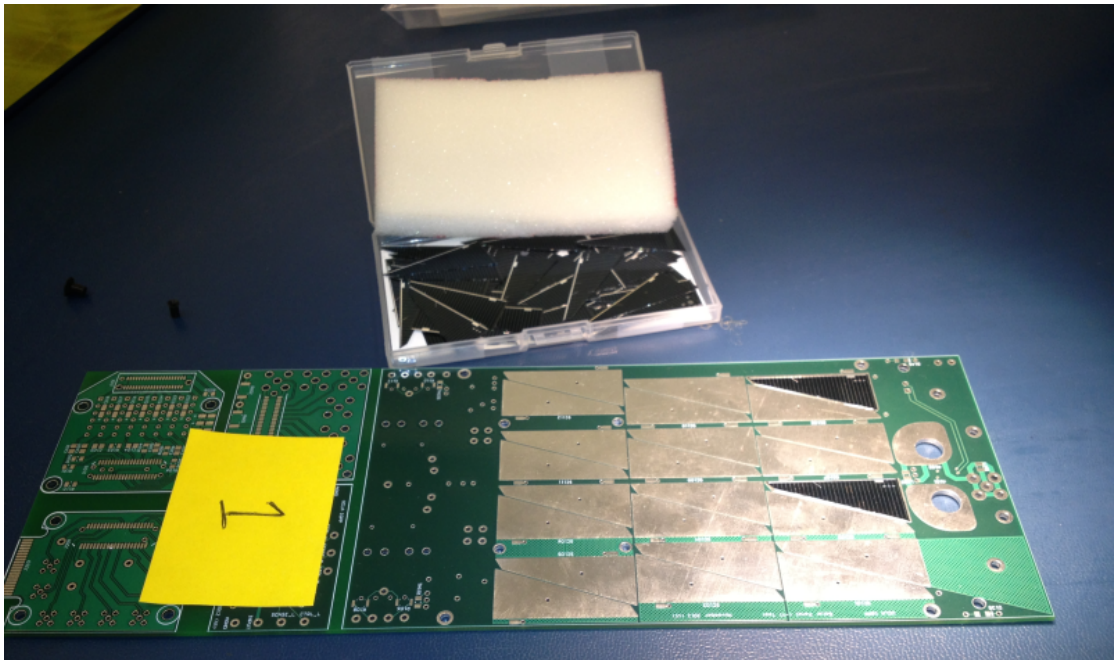
- Electrical Power Subsystem
  - Reduced power generation (2.4W AAOAP)
  - Dynamic power over a revolution
- Attitude Determination & Control Subsystem
  - Spinning is rare & usually avoided; little/no COTS
  - High-efficiency magnetotorquers
  - Nutation & damping modeling
- Mechanical
  - Need to balance moments of inertia
  - Four deployable antennas (including stacer)
- Communications
  - No nadir tracking – omni-directionality is key
  - Spin fading

ADCS Block Diagram

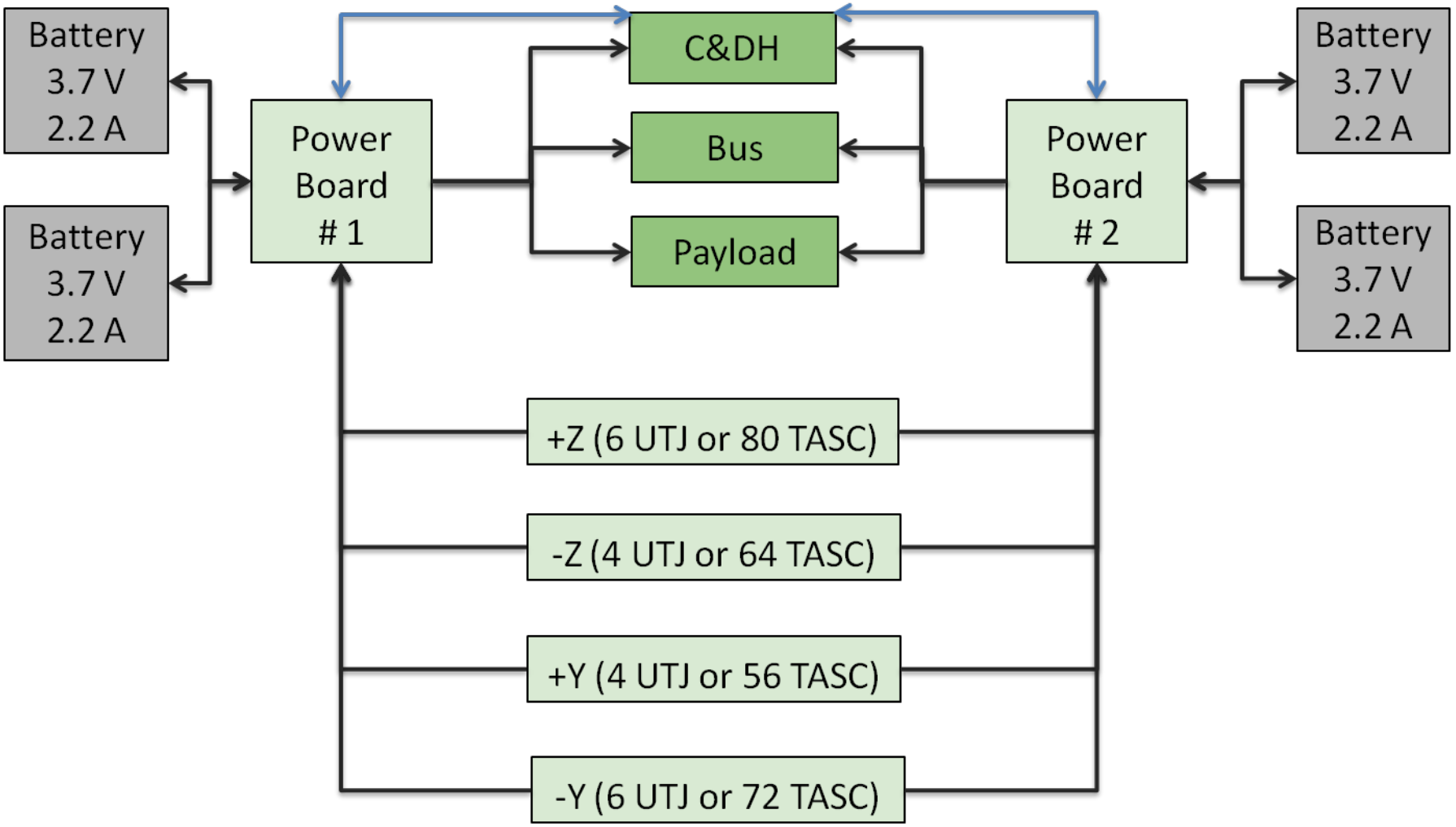


EPS: Electrical Power Subsystem

- Panels developed in-house
  - Magnetic cleanliness not a design driver in COTS panels
- UTJ vs TASC remains an ongoing trade
  - Subsystem accommodations result in higher BOL power from TASC than UTJ due to higher packing factor
  - TASC is not a CIC, so lower EOL
  - Building TASC panels now
  - On-orbit longevity & assembly challenges key considerations

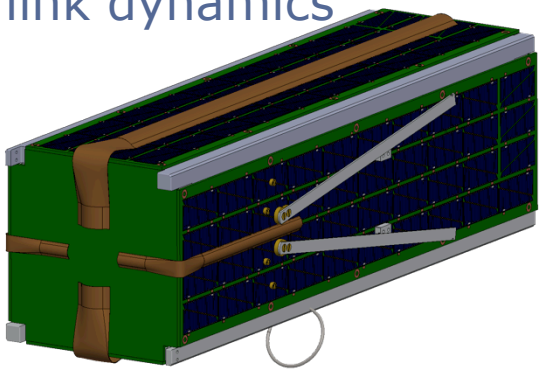


Electrical Power Subsystem Block Diagram



COMMUNICATIONS

- Ground segment
  - 3 stations; 2 @ UCLA, 1 @ WPI (Mass)
  - 4.45MiB/day (4 passes; 50% margin)
  - 22 dBi UHF, 15 dBi VHF for UCLA primary
- Space segment
  - Redundant Astrodev Li-1 radios baselined
    - 440MHz GMSK; 250mW - 4W RF
      - Additional inhibit to comply with LSP-REQ-317.01A
    - Stepped throttling of RF power to leverage link dynamics
  - Dedicated uplink and downlink dipoles
    - One pair each in axial and radial planes
    - Stacer boom is radial VHF monopole



- 19.2 kbaud V/U (VHF up, UHF down)
  - Likely "Amateur-like" w/ experimental license
  - Protocol TBD; FX.25 (AX.25+FEC) is ~17% overhead

QUESTIONS?