IT-SPINS
Ionospheric Imaging Mission

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MONTANA STATE UNIVERSITY

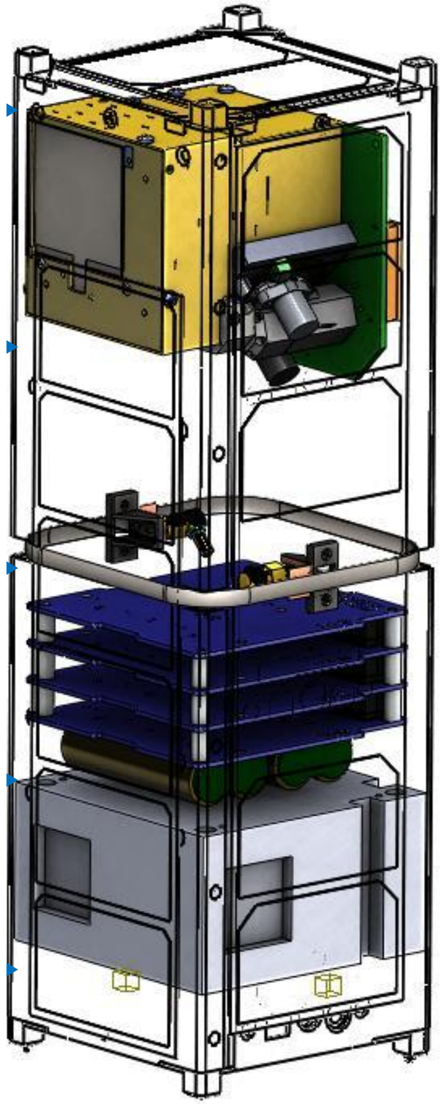
APL
JOHNS HOPKINS UNIVERSITY
Applied Physics Laboratory

SRI International

NSF

IT-SPINS Ionosphere-Thermosphere Scanning Photometer for Ion-Neutral Studies

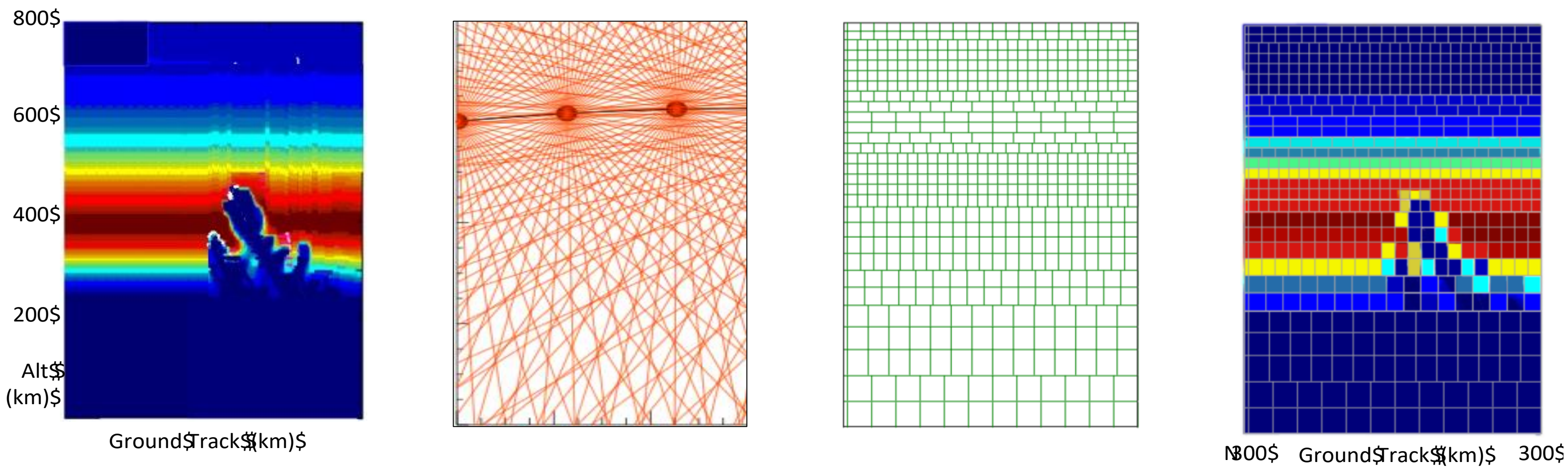
- **Mission Overview**
- **Science Sensor**
- **Attitude Control**
- **Flight Subsystem Status**



Science Goals

- **Study how dominant O^+ ions are lost to charge exchange with H and He atoms at the top of Earth's ionosphere**

- **Image disruptive ionospheric structures - polar cap patches, mid-latitude density plumes, and equatorial bubbles**



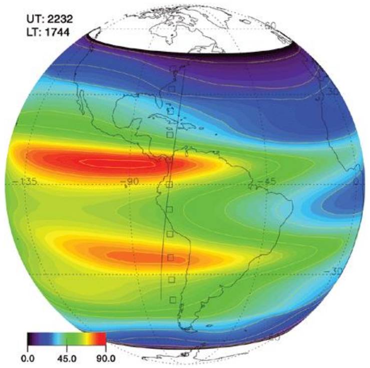
Ionospheric Nightglow

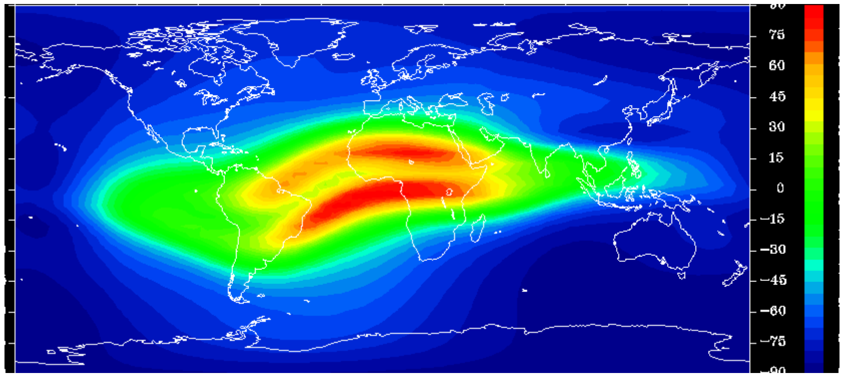
- O^+ ions constitute the primary ionospheric species in the F-region

- In the nighttime F-region ionosphere, UV photons are emitted spontaneously from the recombination of atomic oxygen ions,

$$O^+ + e^- \rightarrow O\,(5P) + h\nu_{135.6}$$

- O^+ and e- are in equal number and 135.6 nm emission is proportional to the path integral of $[O^+]$ squared





Mission Design

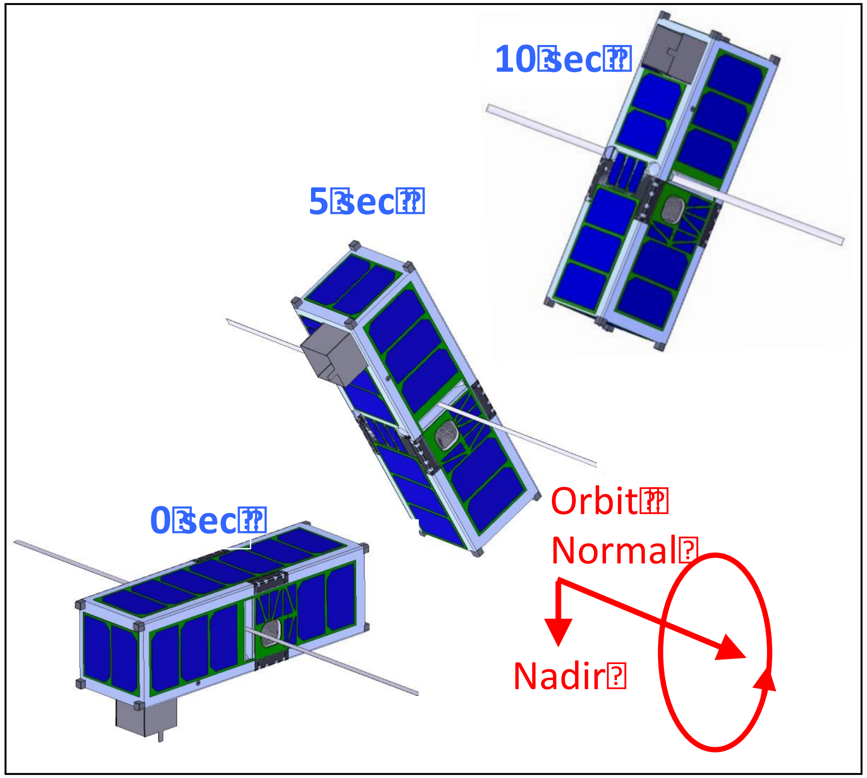
- **Sample atomic oxygen nightglow in orbit plane from a spinning 3U spacecraft to enable 2D tomographic inversions of 135.6-nm volume emission rate**

- **Clone 135.6-nm CTIP photometer from the AF/SMC supported SENSE CubeSat mission**

- **Build bus with significant heritage from MSU FIREBIRD mission**

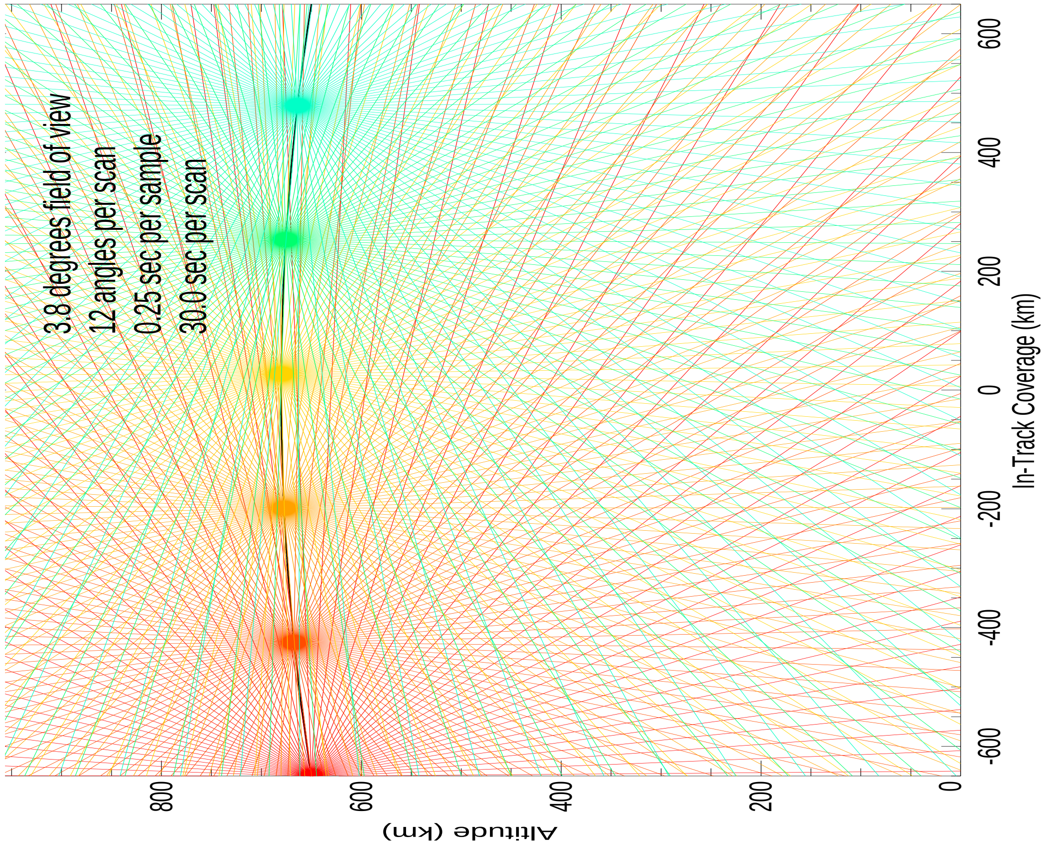
- **Develop ADCS approach with IR Earth limb sensing as the primary knowledge sensor for a 2 RPM pitch rate**

Mission Implementation



2 RPM Pitch Rate

Orbit Plane Geometry

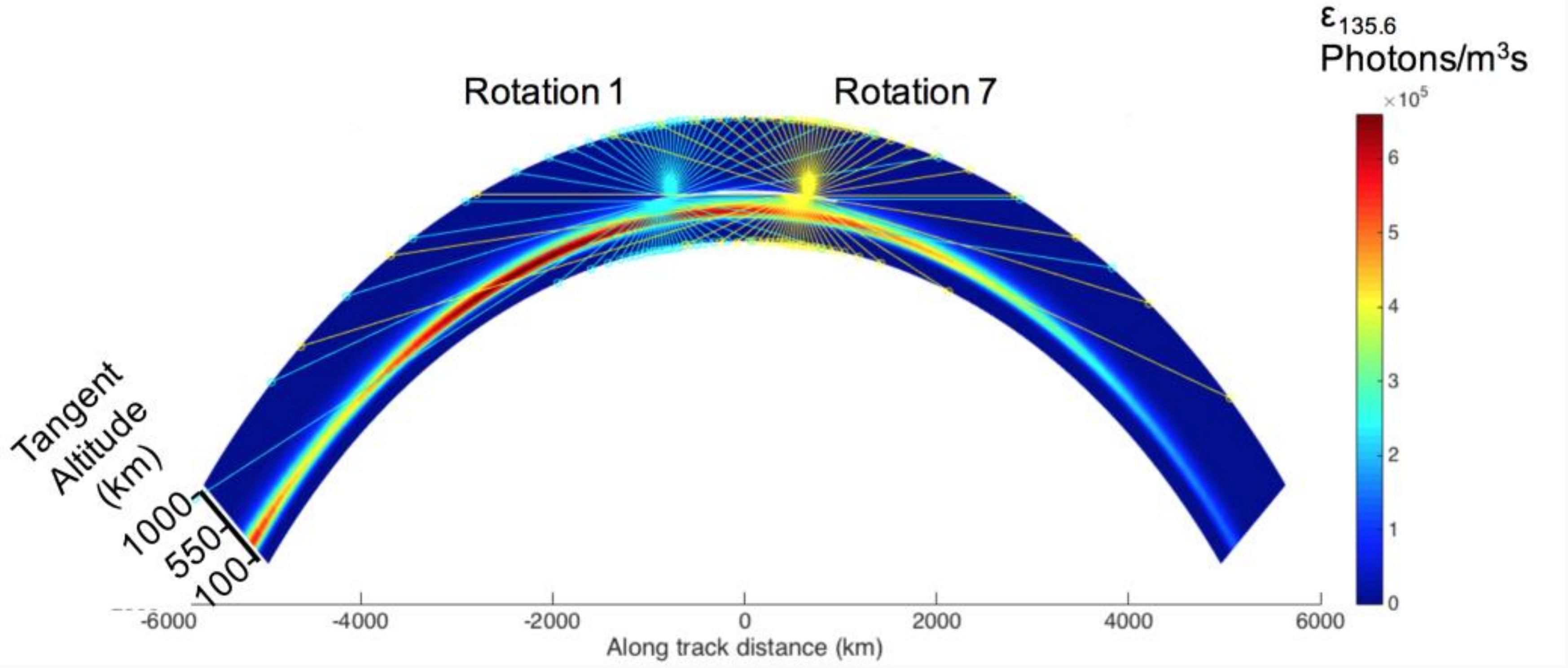


SNR Simulation

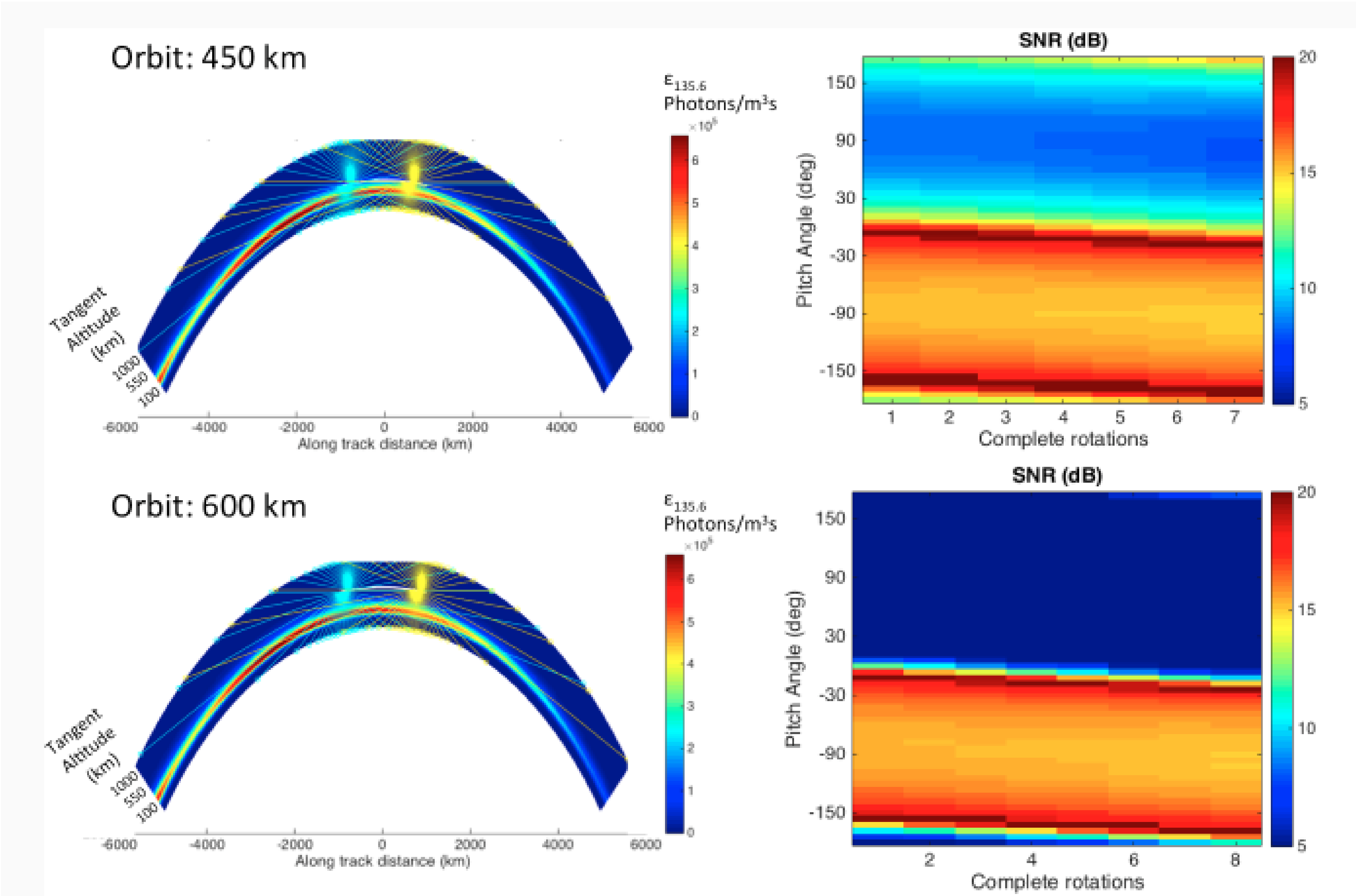
- Given the satellite orbit and a background ionosphere (from MSIS), we simulate the looking directions and compute the measured SNR.

$$\text{Signal} = \text{Sensitivity} \times \text{Brightness} \times \text{Integration Time}$$

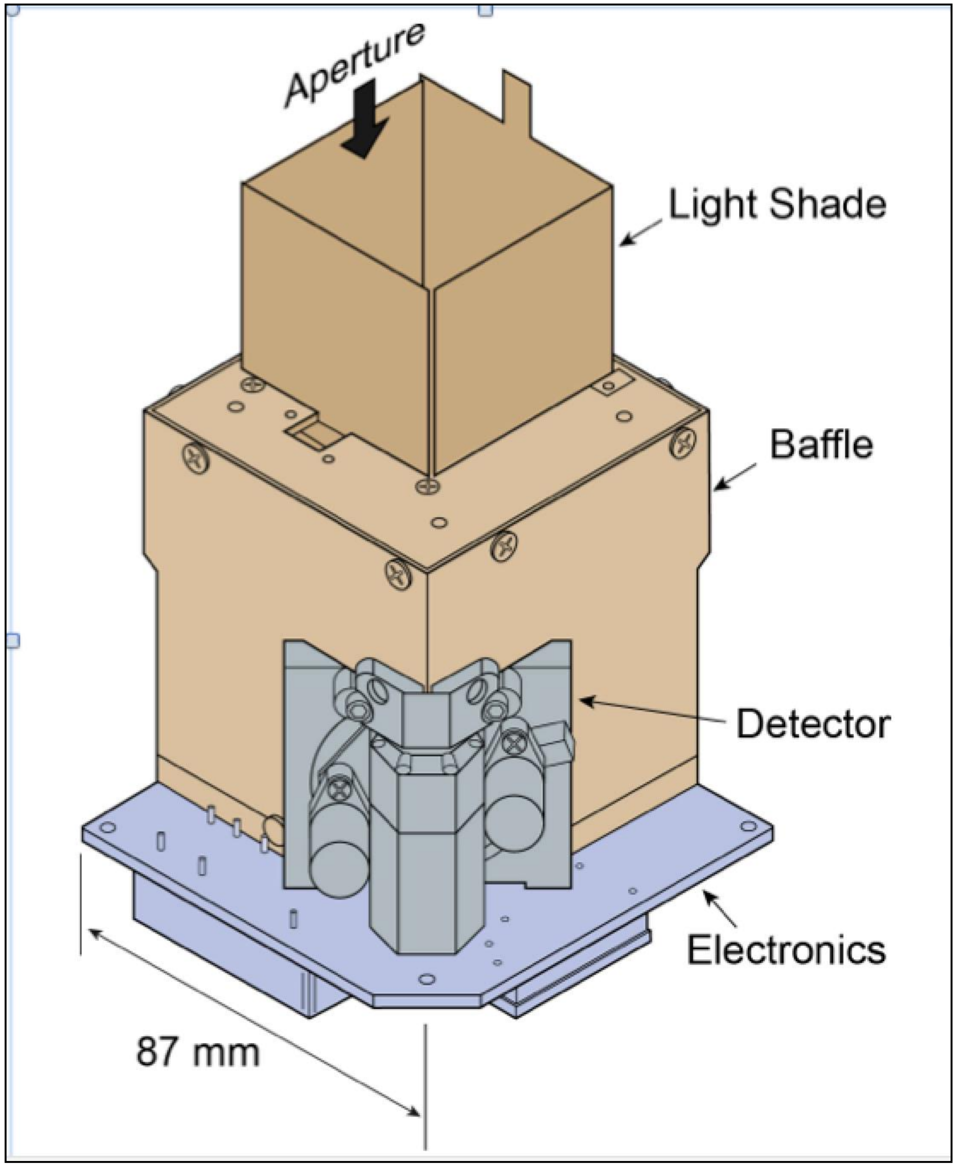
$$\text{SNR} = \frac{\text{Signal}}{\sqrt{\text{Signal} + \text{Dark Current} \times \text{Integration Time}}}$$



SNR Simulation

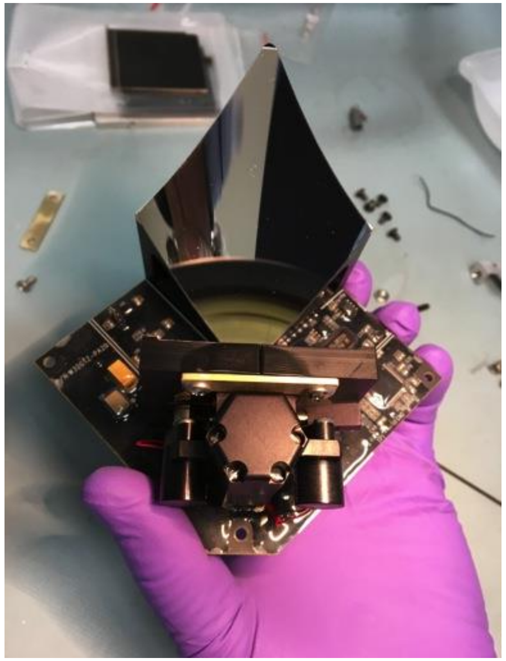


CubeSat Tiny Ionospheric Photometer - CTIP



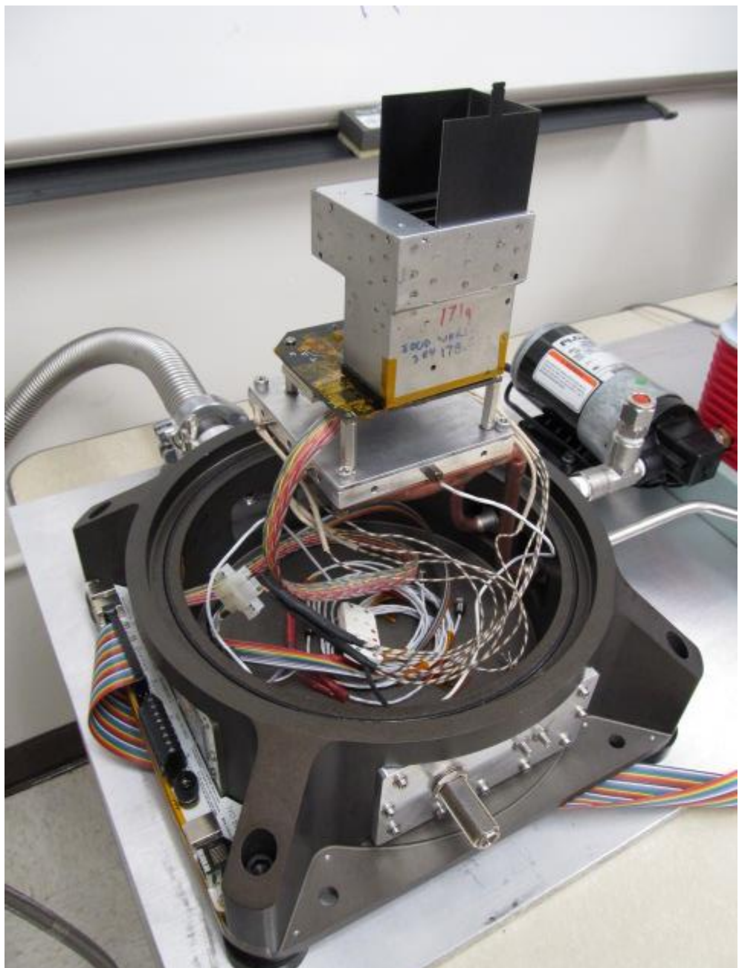
Parameter	Specification
Sensitivity	400 counts/R-s
Dark Current	~100 counts/s
Minimum Detectable Signal at Δt = ½ sec	0.7 R (SNR = 10)
Field of View	3.8°
Stray Light Rejection	$< 10^{-6}$
Orbit Averaged Power	1.6 W*
Stowed Form Factor	9.5 cm X 9.5 cm X 9 cm
Mass (Margin)	482 g (79 g)
Volume	875 cm^3
Electrical Power & Communication	5 ± 0.2 Vdc RS422 Serial

*Assumes 45 minutes standby mode and 5 minutes preheat per orbit



CTIP Status

- Both Engineering Model and Flight Model at MSU.
- Flight Code at 100% completion.



ADCS Design – Science Flow down Requirements

Spin long axis of the spacecraft about orbit normal at 12° /sec ± 1.2° /sec per second in the direction of the velocity vector

Maintain spin axis within a +/-1.5° cone about orbit normal

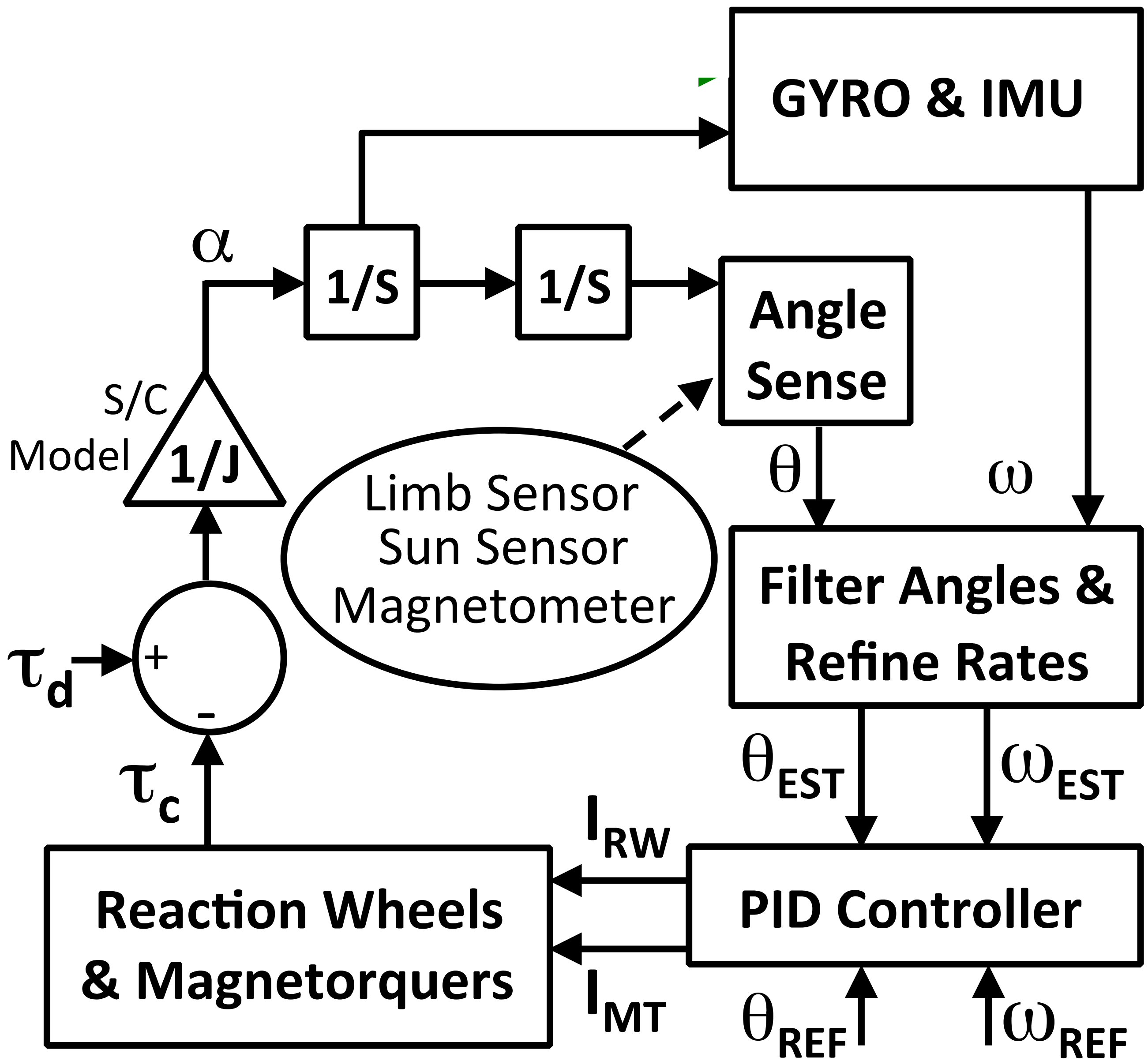
Control rotation rate of the spacecraft to 0 ± 3° /sec about the two axes normal to the spin axis

Determine angular orientation of spacecraft to within 0.3° **(TBR)**

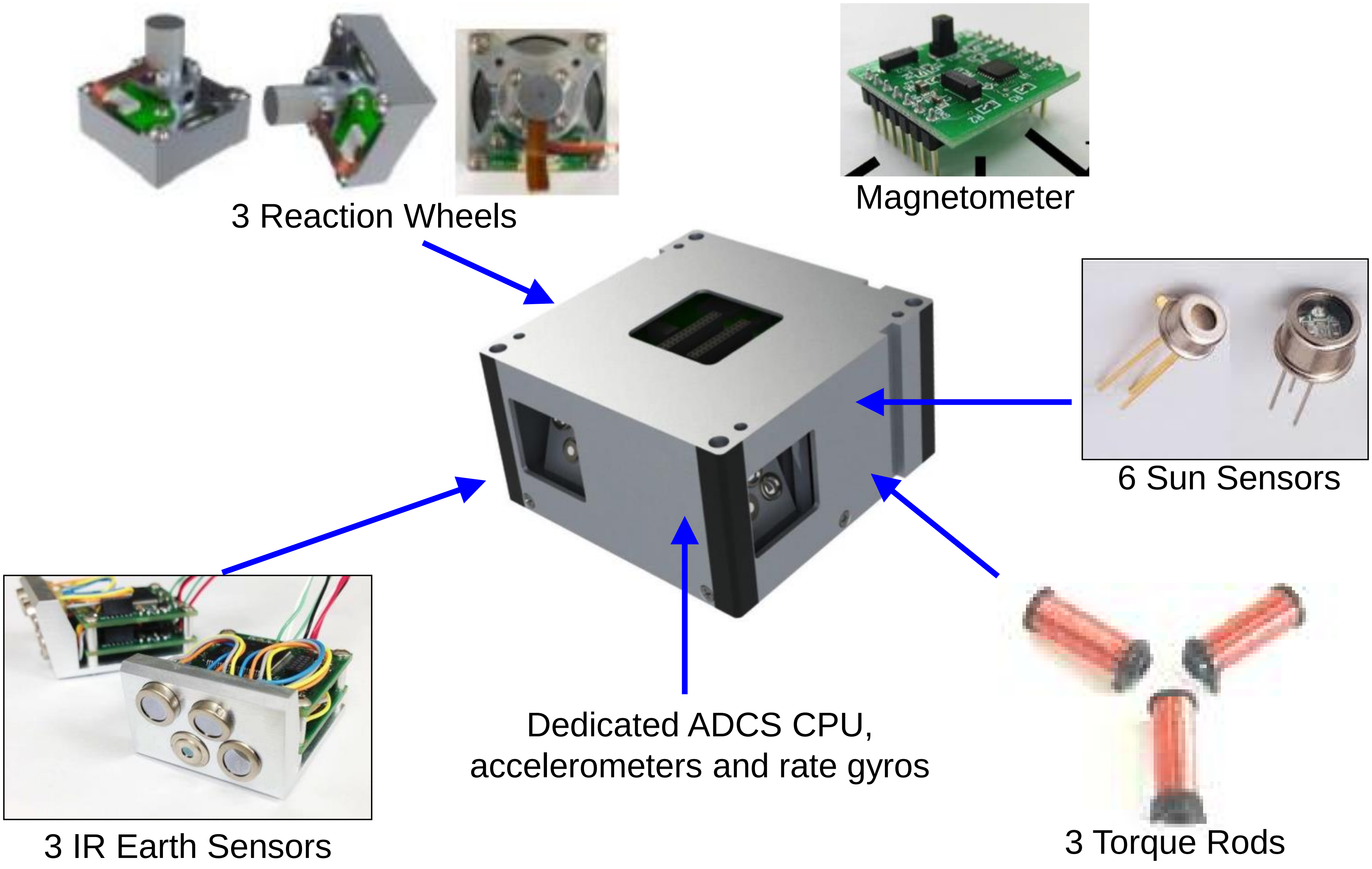
Determine the angular rates of spacecraft to within 0.12° /sec

Orient payload FOV within a +/- 1.5° cone about the nadir vector (and other targets TBR) during payload commissioning and spectral calibration operations.

ADCS Design – Basic Elements



ADCS Design – “Enhanced” MAI-400 from Maryland Aerospace



ADCS Current State

Status:

- Final Simulation Program delivery soon.
- Hardware delivery soon.
- Space Flight Computer FSW at 80% Completion
- Current Hardware in the loop simulations

Features:

- IT-SPINS Specific “Spin Mode” added to MAI 400 ADCS.
  - Additional Limb Crossing sensors
  - Faster processing

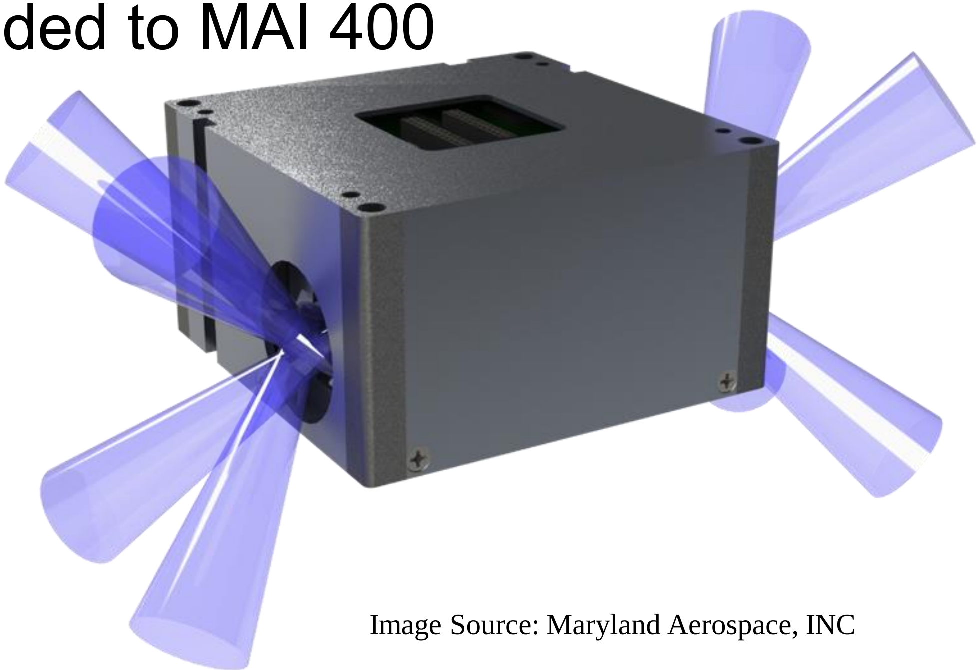
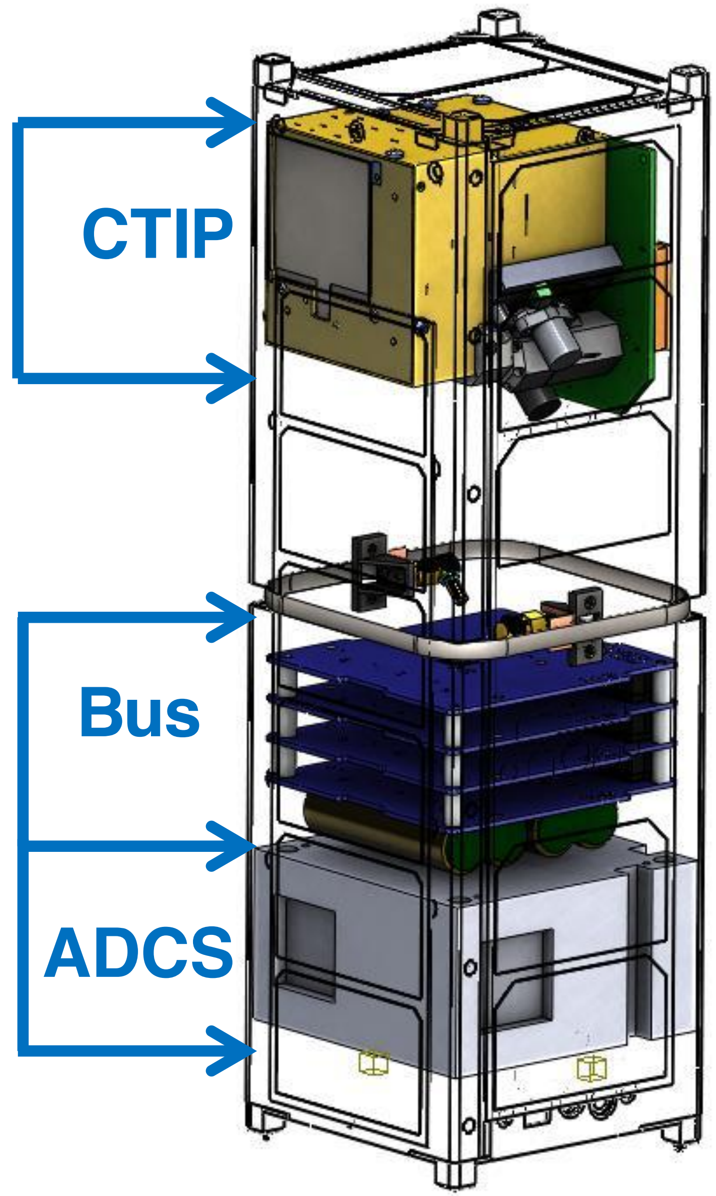


Image Source: Maryland Aerospace, INC

Subsystem Integration

- 3U Solid-Wall CubeSat Chassis from Pumpkin
- Extensive reuse of secondary structural elements from FIREBIRD
- Mass distribution is a key driver
  - MOI and CG
- Major structural modifications:
  - CTIP and ADCS FOVs
  - Cutouts for antenna system and solar array harnesses



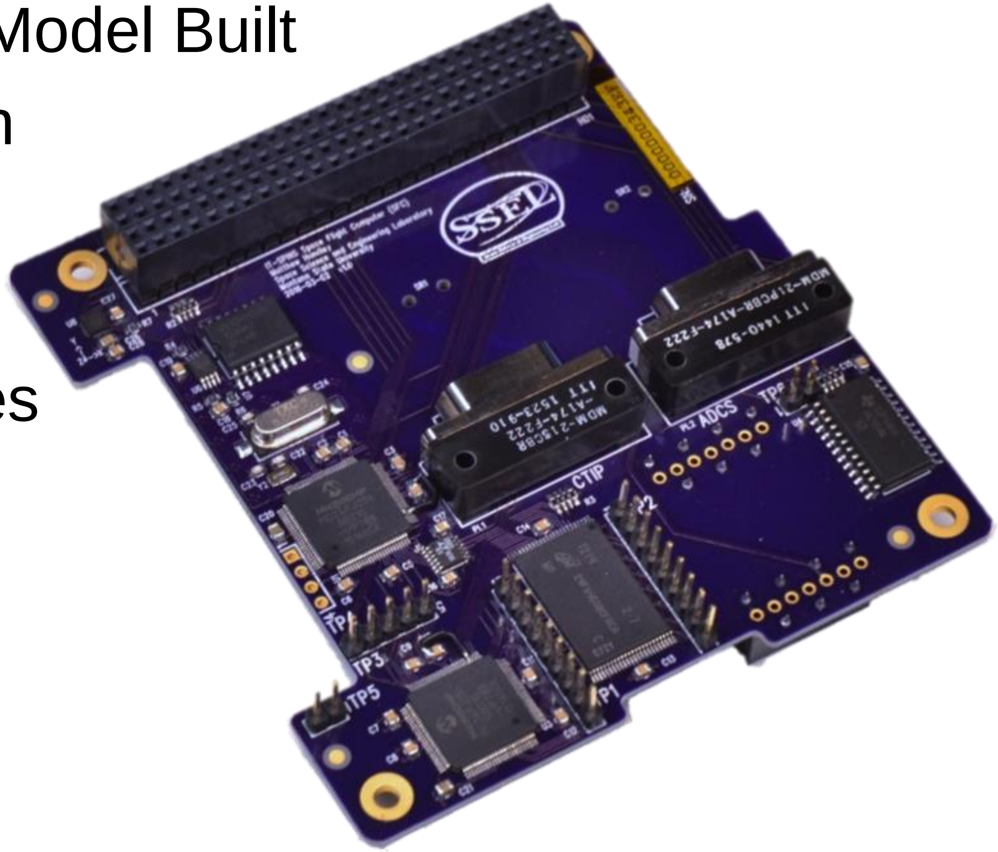
Flight Subsystems - Space Flight Computer (SFC)

Status:

- SFC Functional
- Flight Model and Engineering Model Built
- Flight Code at 90% Completion

Features:

- NOR Flash for CMD Sequences
- NAND For Telemetry Storage
- ADCS interface
- Payload (CTIP) interface



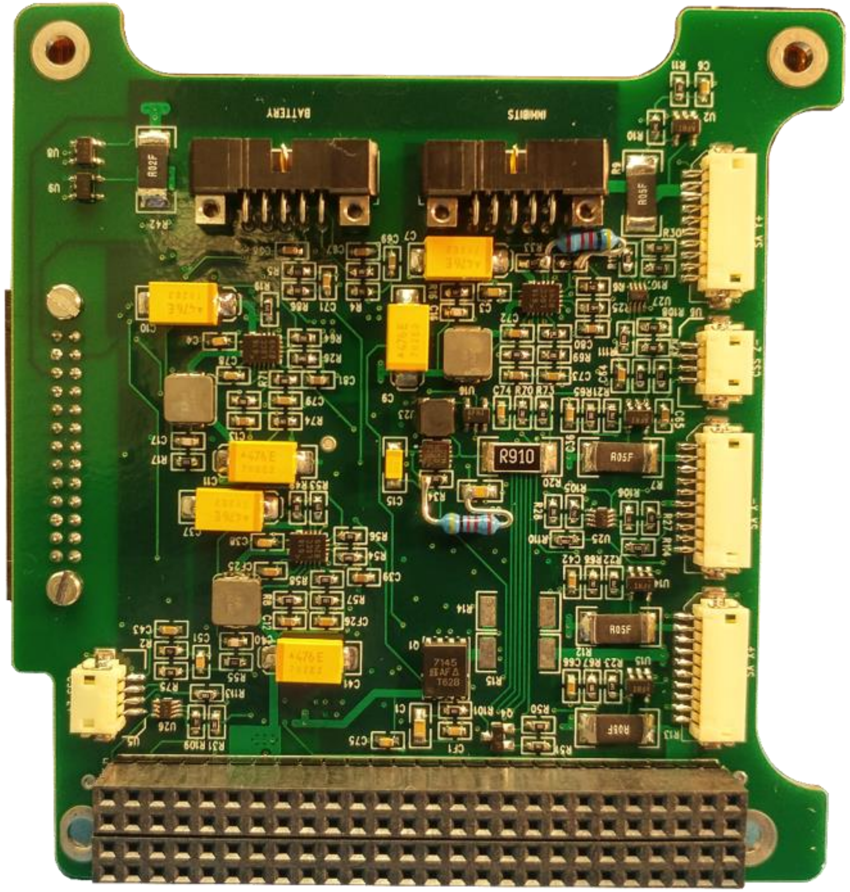
Integration Status – Electrical Power System (EPS)

Status:

- EPS is Functional
- Engineering Model Built
- Flight Code at 100% completion

Features:

- Watch Dog Timer (WDT) for system power
- ADCS power not under WDT control, but is resettable.
- EGSE connection which allows any processor to be reprogrammed.



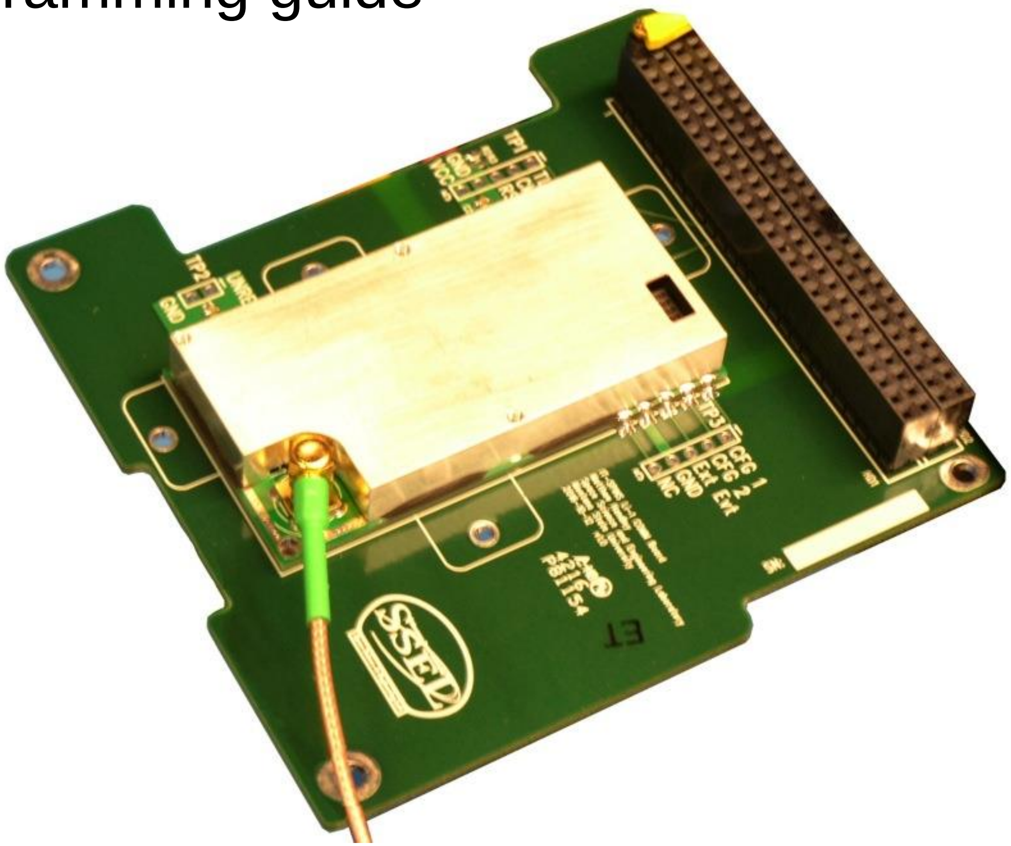
Integration Status – Communication Subsystem

Status:

- Basic functionality with workarounds developed at MSU.
- MSU team awaiting final programming guide from Astrodev LLC.

Off-Nominal Features:

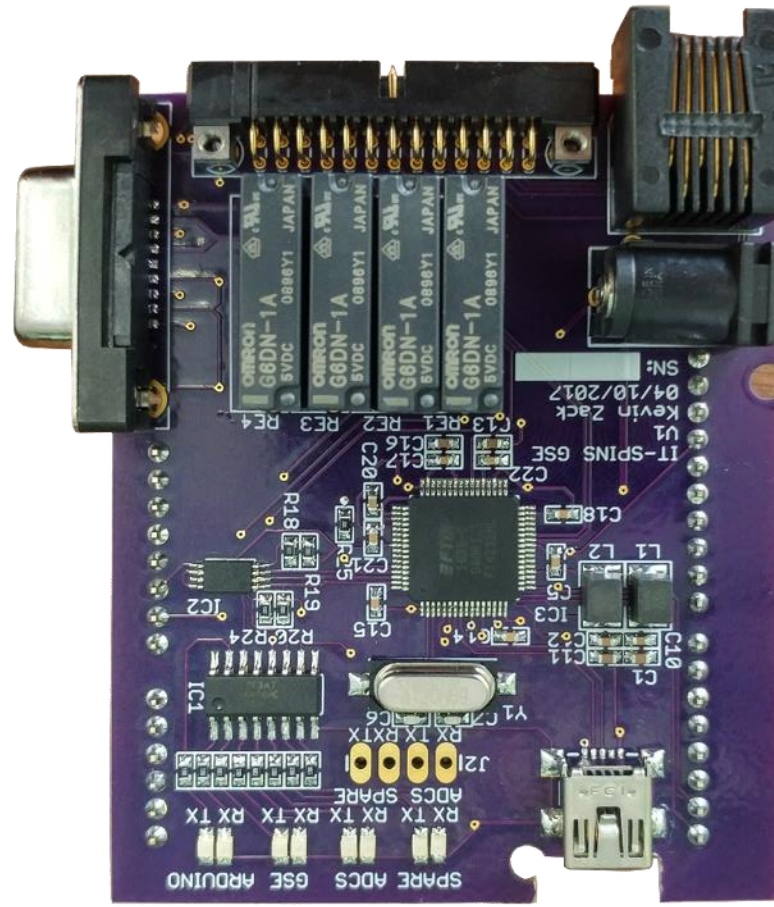
- None.



Integration Status – Electrical Ground Support Equipment

Status:

- EGSE is Fully Functional
- Engineering GSE Built
- EGSE Code at 100% Completion



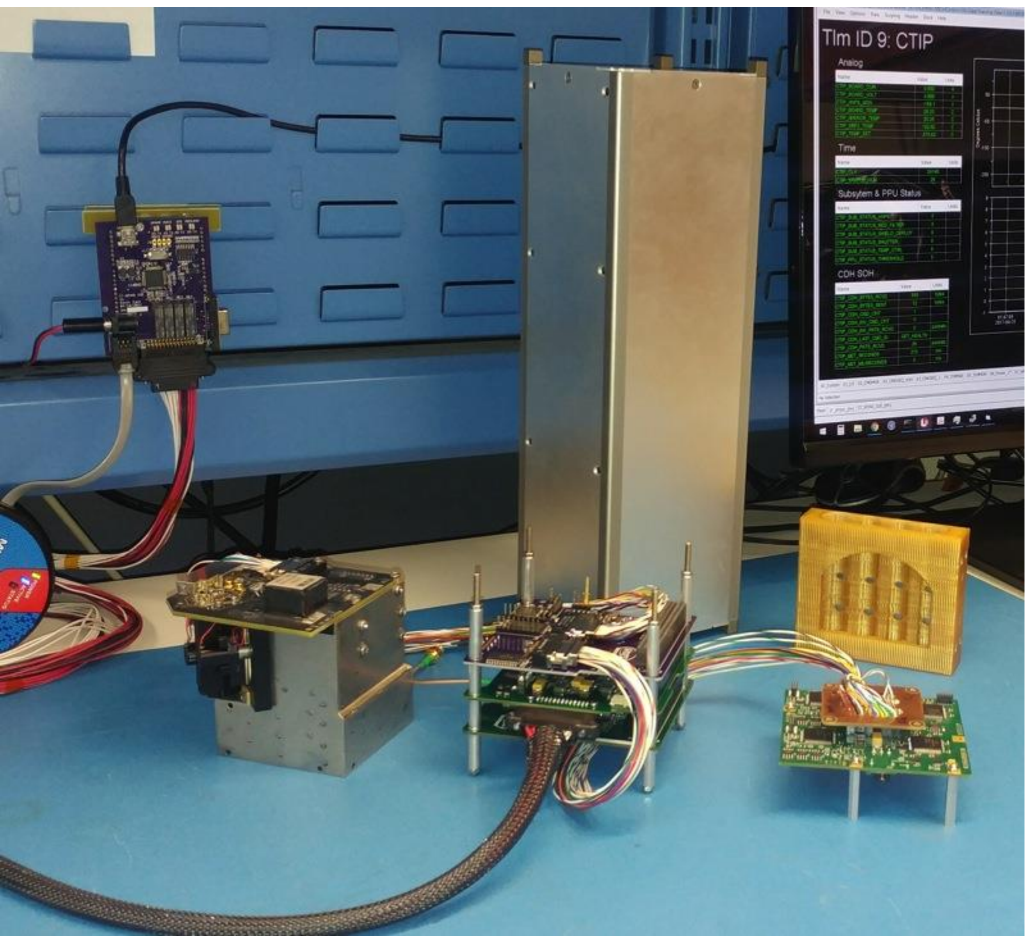
Features:

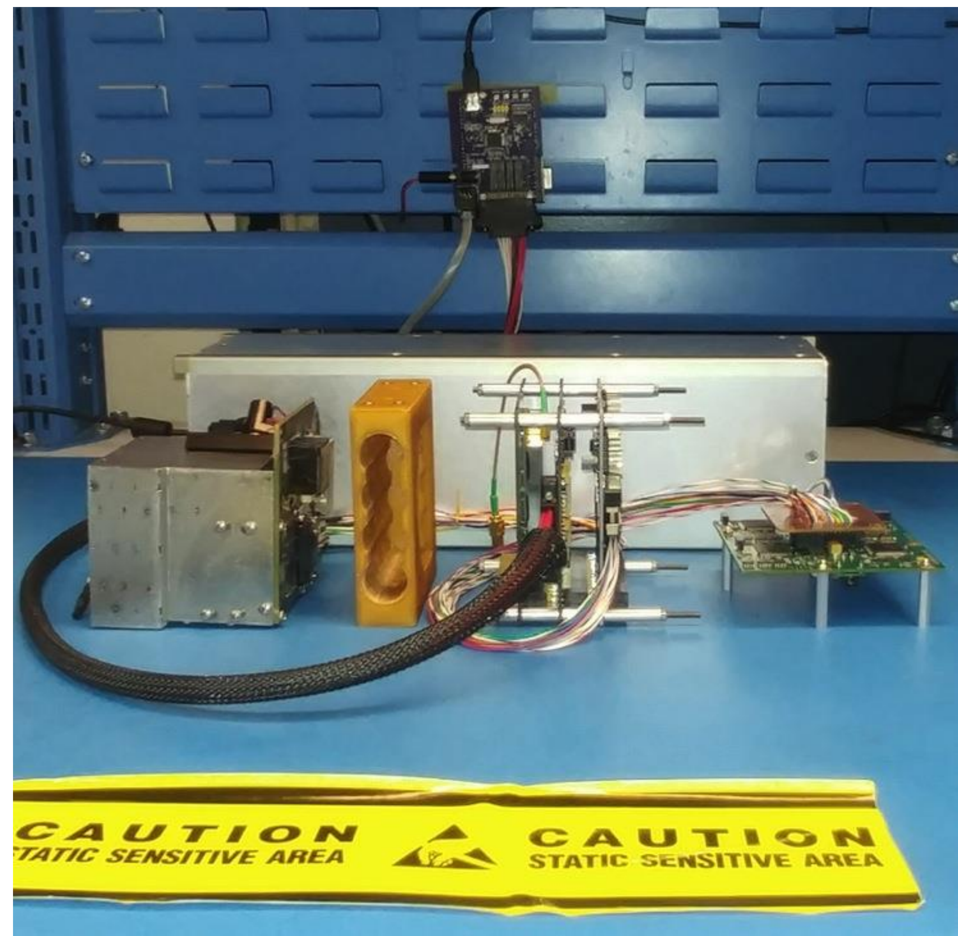
- Foot-Switch Deploy simulated
- Battery Charge
- External Power
- Can Program any PIC on Satellite
- Quad FTDI Chip for GSE status, IT-SPINS GSE Link, and ADCS Telemetry.
- TVAC Chamber Power/Telemetry Link

Flight Subsystem – Full Integration

Status:

- Chassis is currently out to fab.
- 3D printed ULTEM battery bracket complete
- Build-up expected to start by end of May





IT-SPINS ELaNa-18 Launch

Mission manifested with ICEsat-2 on a Delta-II vehicle currently scheduled for a late 2018 launch