Bouchet Low-Earth Alpha/Beta Space Telescope (BLAST)

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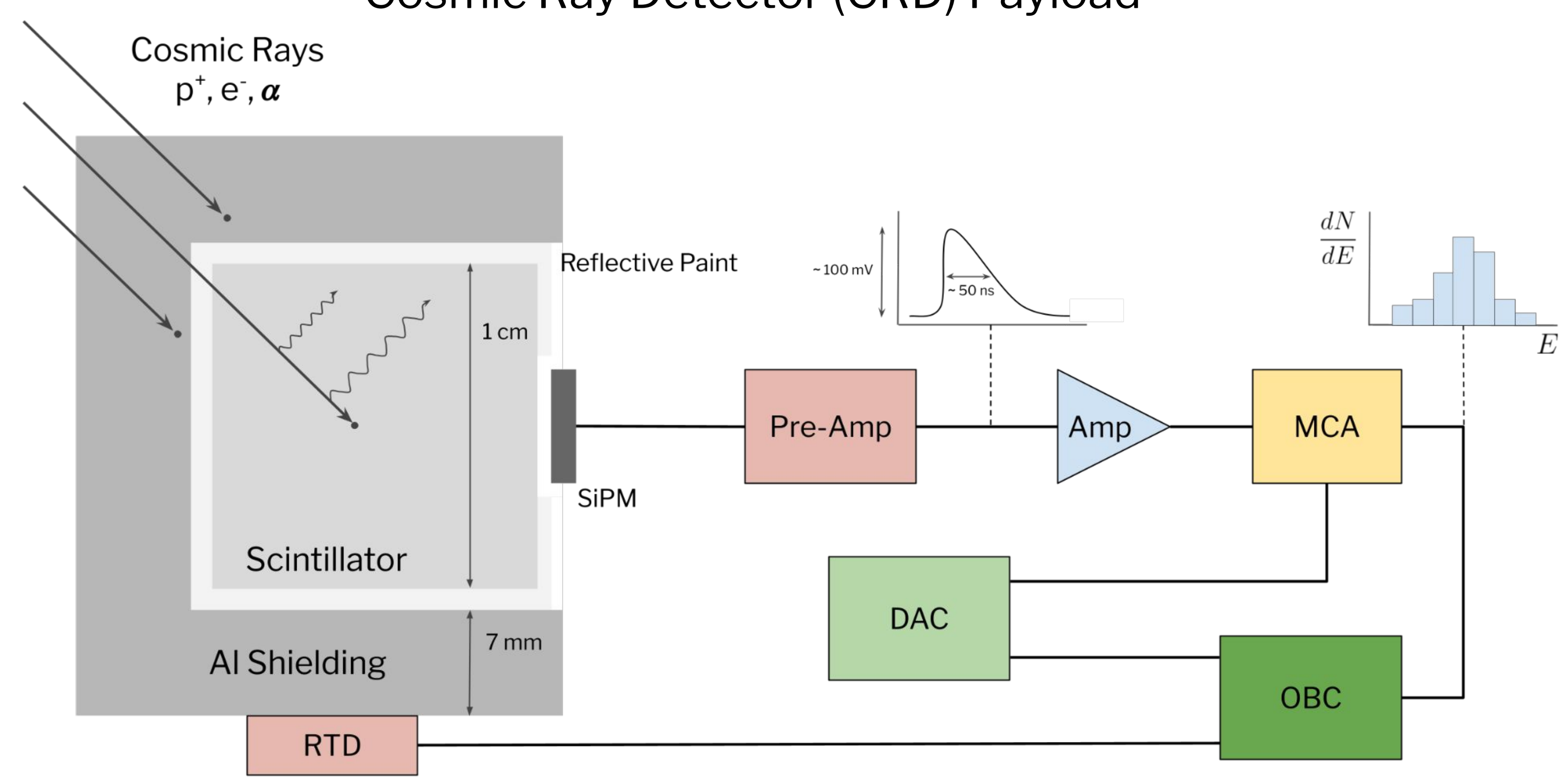
Introduction

BLAST is a student-developed 2U Cosmic Ray Detector CubeSat that will be launched to Low Earth Orbit through the NASA CubeSat Launch Initiative (CSLI), planned for 2023. Developed entirely by Yale undergraduates, the project aims to construct Yale's first CubeSat. The mission is to study high-energy protons in cosmic rays beyond the atmosphere. BLAST is built with commercial computer, power, radio and active attitude control systems and will fly a custom Cosmic Ray Detector and Gravity Gradient Boom.

Key Figures

- **Size**: 2U, 10x10x20 cm
- **Mass**: 3.6 kg (~2 kg body, ~1.6 kg Tip Mass)
- **Average power**: 2.2 W, 10.4 Wh battery @ 4.1 V
- **ADCS**:
  - 500 mW 3-axis magnetorquer
  - 9 ft Gravity Gradient Boom
  - Magnetometers + sun sensor
- **On-board computer**: STM32F427 w/ Cortex M4 @ 185 MHz, FreeRTOS
- **Radio**: half-duplex 2GFSK transceiver, 19200 bps, 1 W transmit power
- **Payload**: 7-bin scintillator-based Cosmic Ray Detector

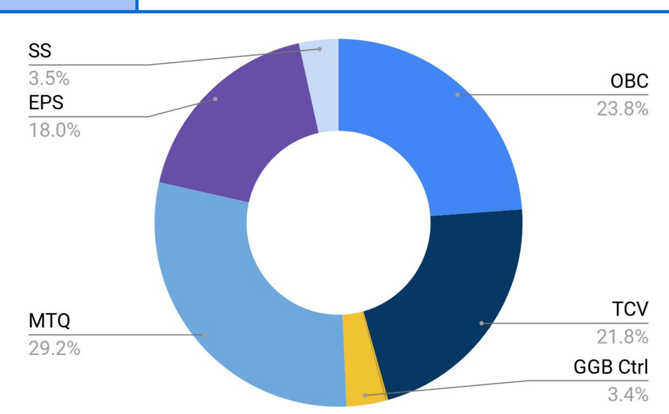
Cosmic Ray Detector (CRD) Payload



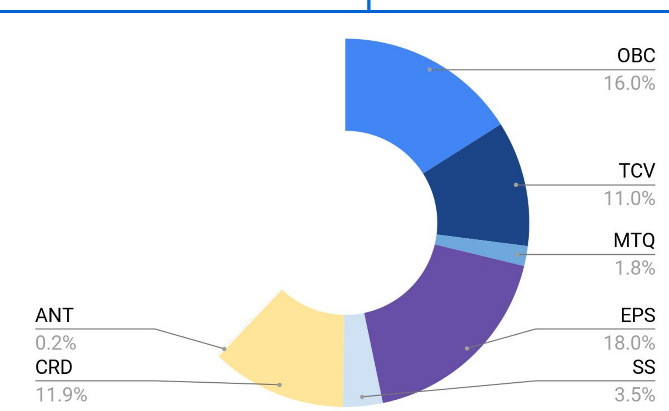
The CRD is the science payload of BLAST tasked with detecting cosmic ray protons trapped in Earth's magnetic field. The proton flux increases by orders of magnitude in the South Atlantic Anomaly (SAA), where the lower Van Allen belt intersects low Earth orbit, and the CRD will use proton flux data to track the evolving size and morphology of the SAA. The detector is made up of a plastic scintillator surrounded by aluminum shielding and custom signal processing circuitry to count the number of events and bin them by energy.

Power Budget

	Mean per-orbit consumption, mWh	Mean power, mW	Mean per-orbit solar panel generation, mWh
Detumbling Phase	2160	1440	2100
Mission Phase	1270	850	2100

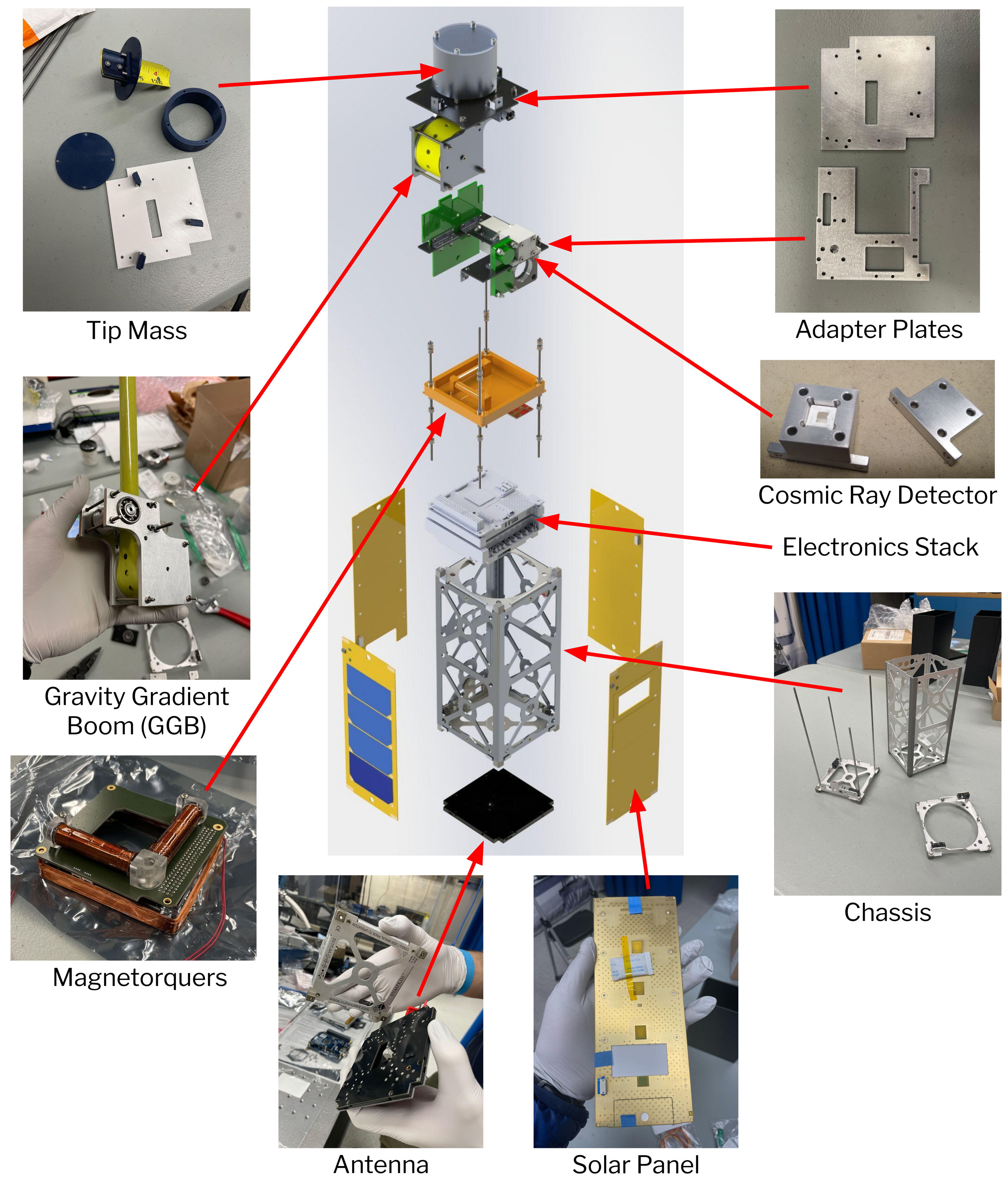


During Detumbling



After Detumbling

Systems Overview



Attitude Determination and Control (ADCS)

ADCS is tasked with detumbling after deployment and pointing the z-axis of the satellite coaxial with the radius of the Earth to maximize radio antenna gain. The satellite will be detumbled by active magnetorquers based on data from magnetometers and a sun sensor. After detumbling, the custom Gravity Gradient Boom (GGB, 9 feet) will be deployed, extending a Tip Mass away from the sat and moving the Center of Gravity away from the Center of Mass, thus creating an effective pendulum where the differential gravitational force induces a restoring torque on the system in the desired direction. The GGB will allow for passive (no power) attitude maintenance.

Acknowledgements

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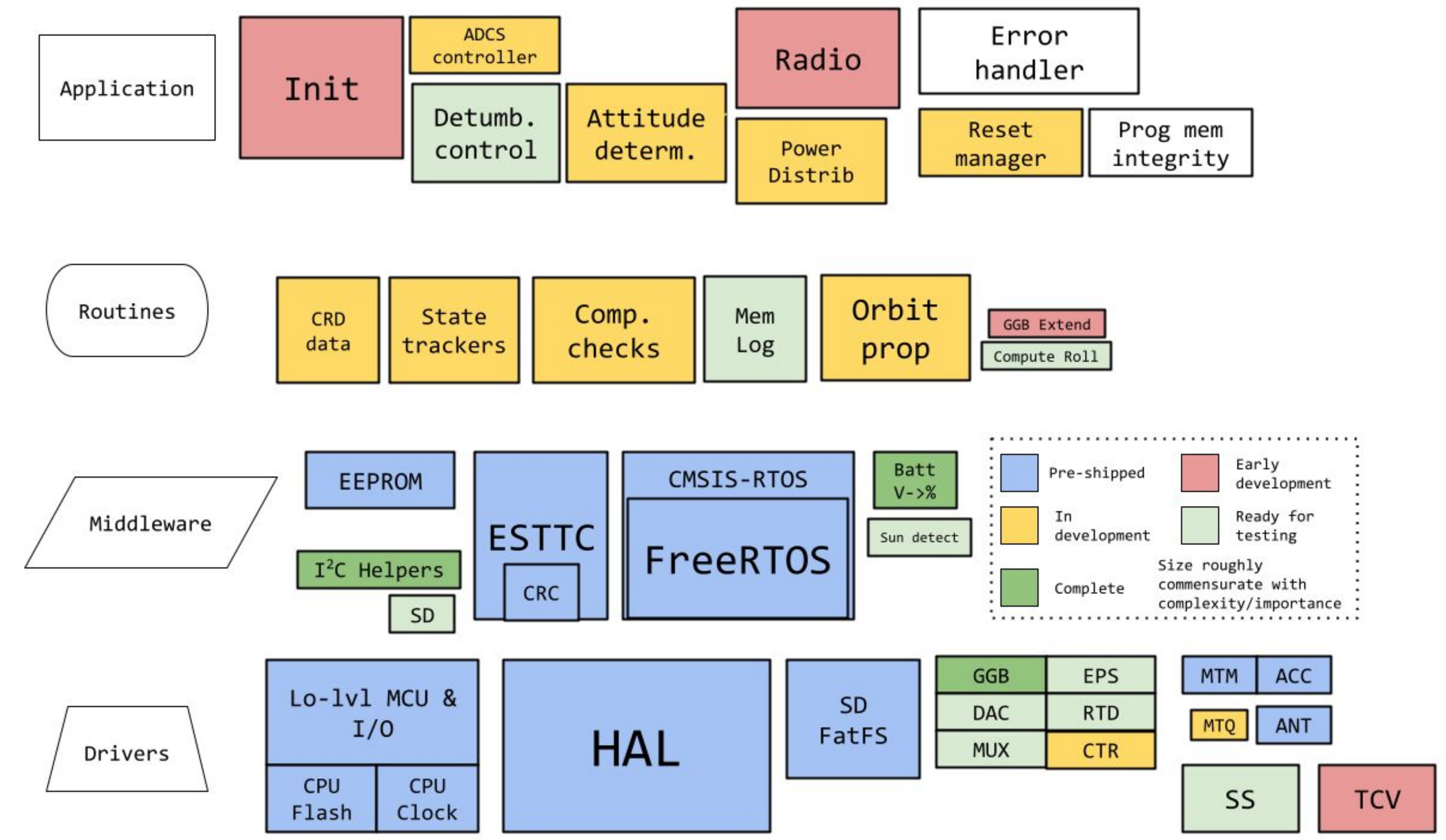
Flight Software



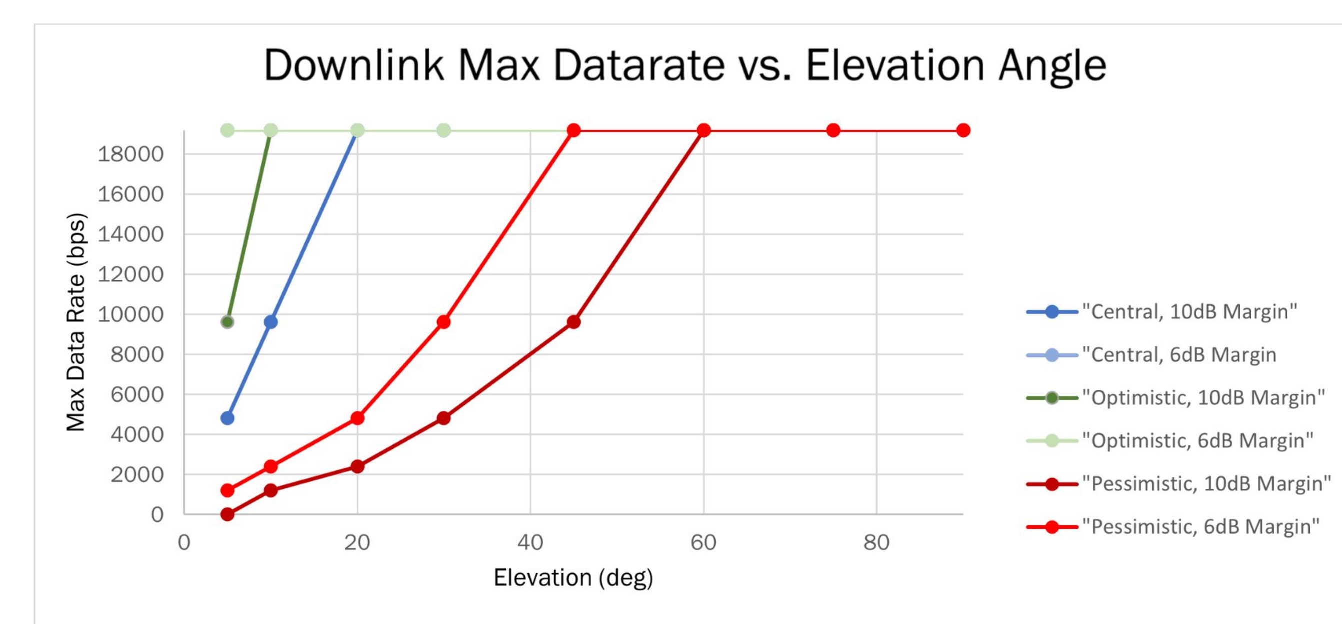
Bottom-up development approach:

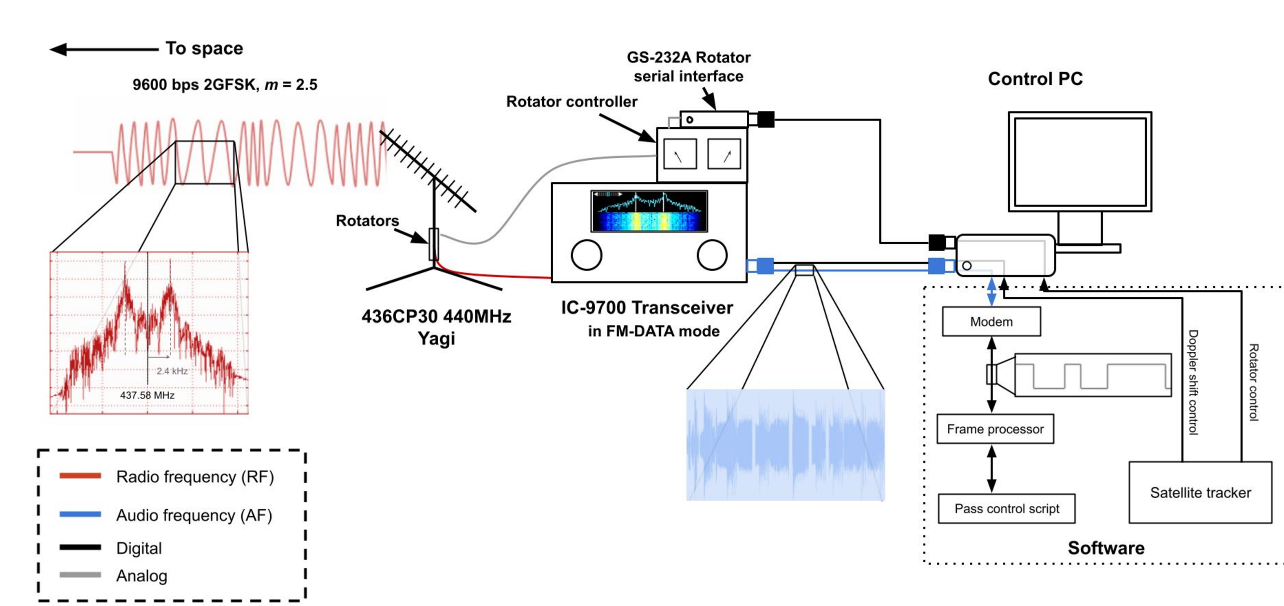
- Drivers wrap hardware capabilities
- Middleware provides common data manipulation, communication between higher-level processes
- Routines perform isolated, periodic tasks
- Applications run persistently and execute complex control logic

Software challenges:

- Tolerating hardware faults
- Concurrency, multiple running instances
- Managing volatile runtime memory vs. persistent storage
- Inter-process communication and centralized mission state machine
- Prioritization of real-time processes, scheduling maintenance

Radio





Ground Station Signal Pathway

Y-IEEE Space Station