TEAM

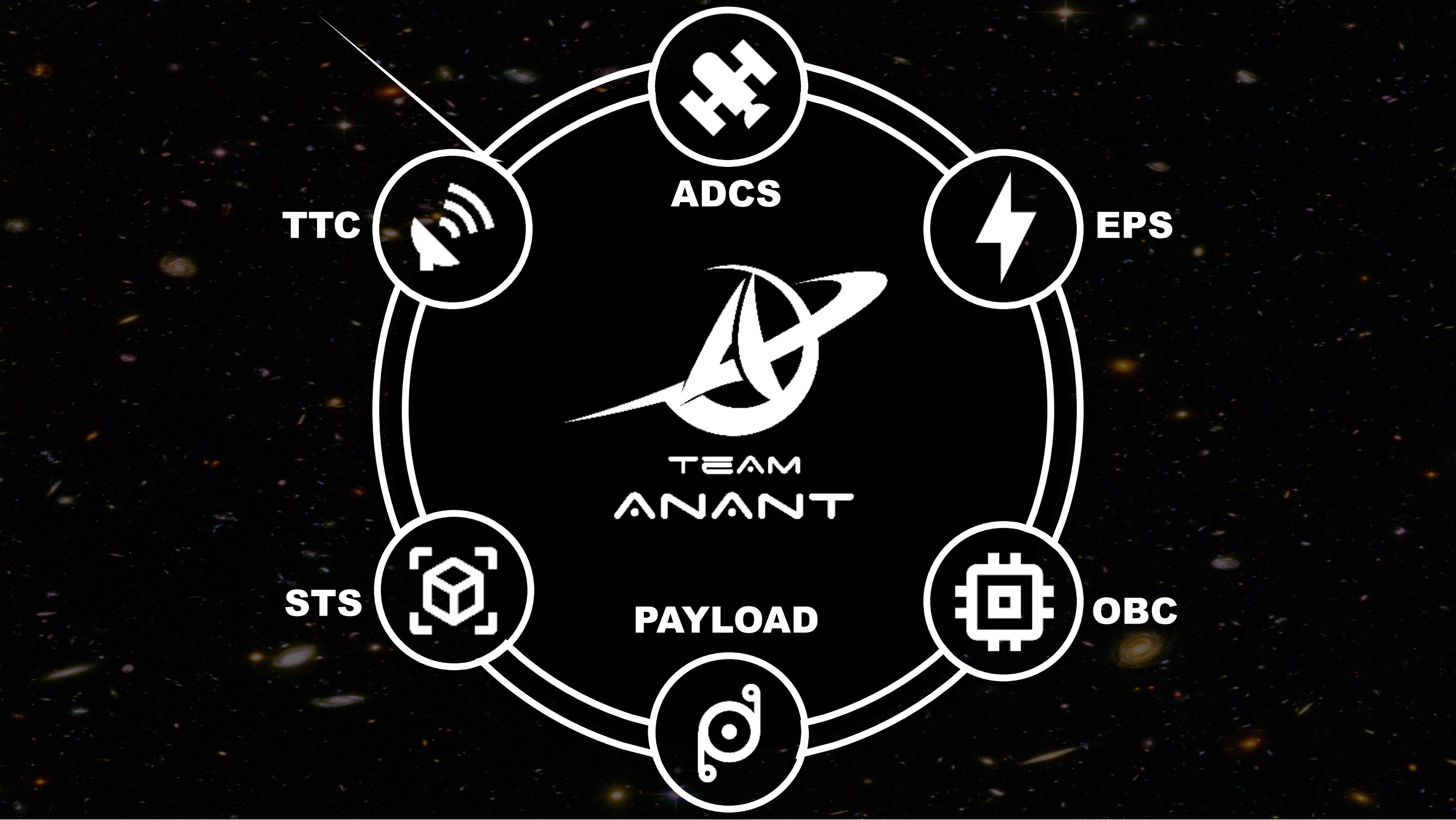
ANANT

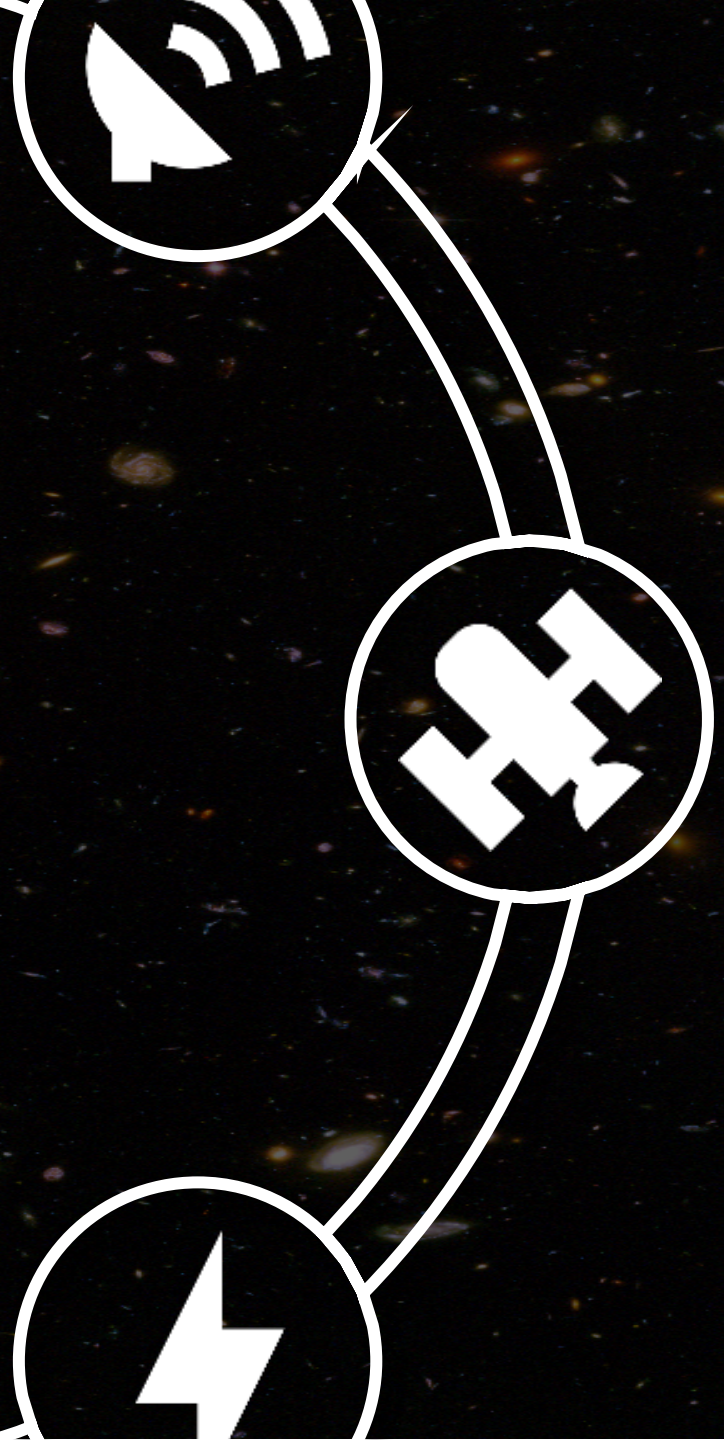
Team Anant is India's only entirely undergraduate, student-run, and self-motivated satellite team.

Our mission is to design, build, and launch a 3U nanosatellite with a multispectral camera.

TEAM ANANT

SUBSYSTEMS


ADCS
TTC
EPS
TEAM
ANANT
STS
PAYLOAD
OBC



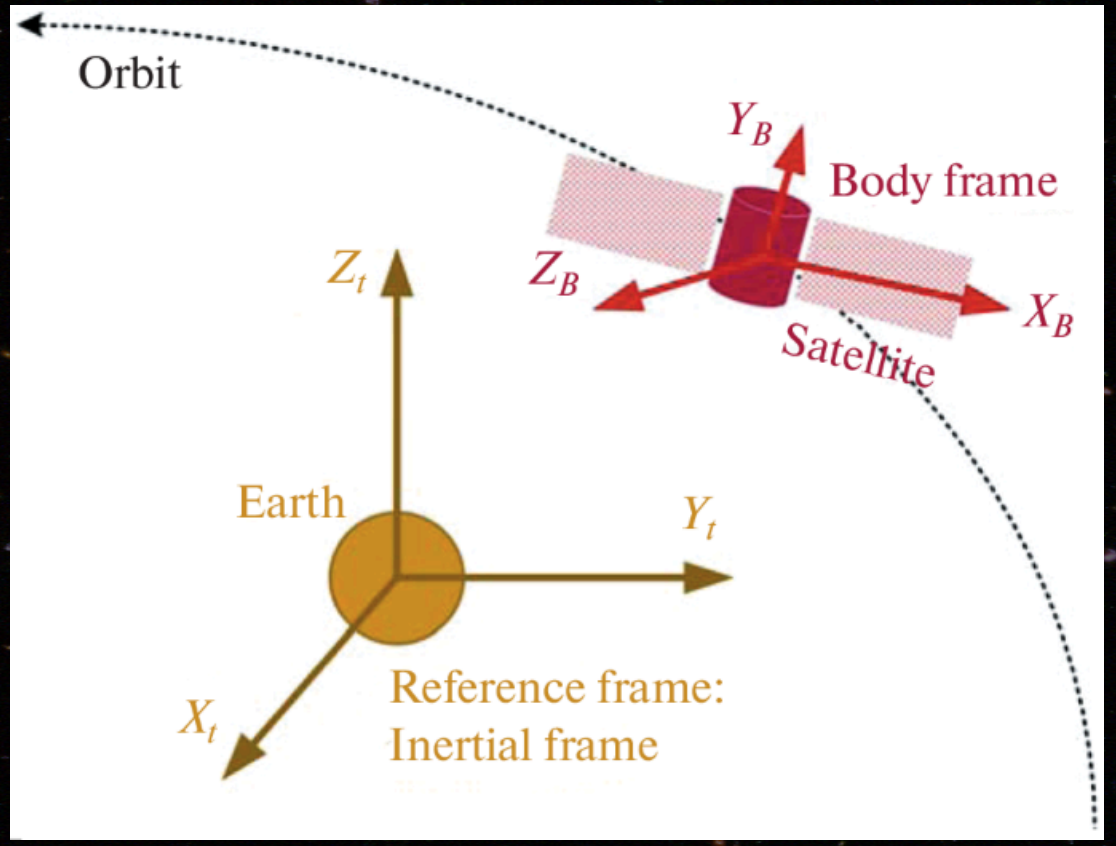
ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM

The Attitude Determination and Control Subsystem (ADCS) stabilizes and orients the satellite using sensors and actuators, enabling precise maneuvers for sun pointing, ground station tracking, and imaging.

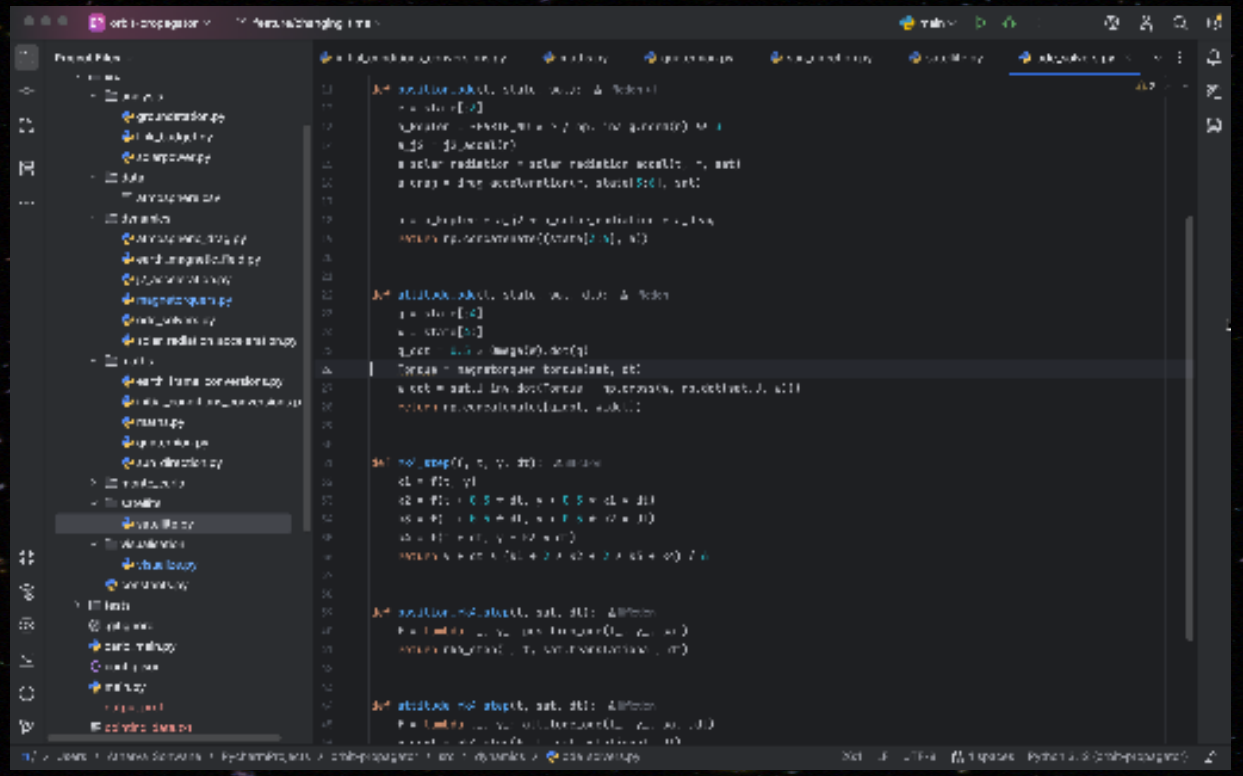
What is attitude?

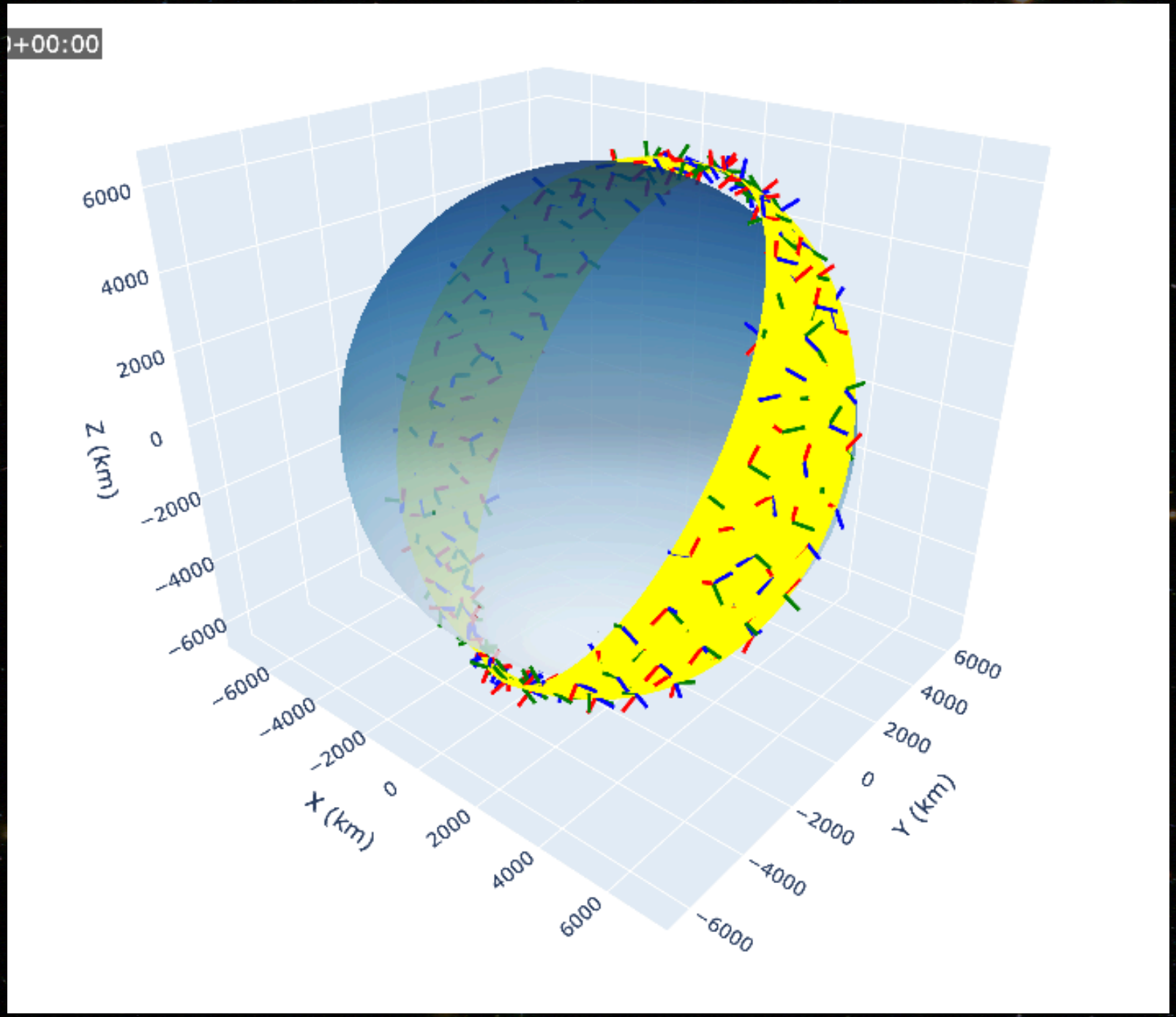
Attitude: description of the angular position/3d orientation of an object relative to a reference frame.

We use various sensors to figure out satellite's orientation eg. Sun sensor, gyroscope, magnetometer, etc.

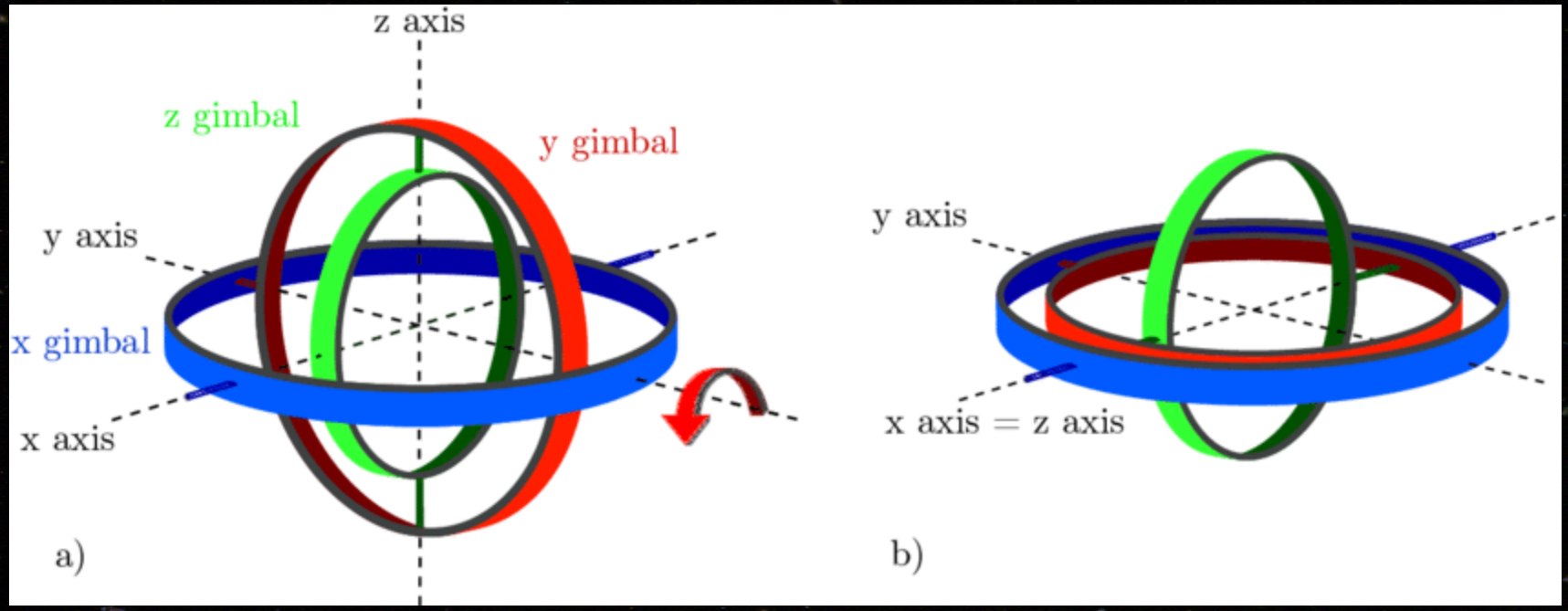


Navigation




0+00:00
6000
4000
2000
0
−2000
−4000
−6000
Z (km)
−6000
−4000
−2000
0
2000
4000
6000
X (km)
6000
4000
2000
0
−2000
−4000
−6000
Y (km)

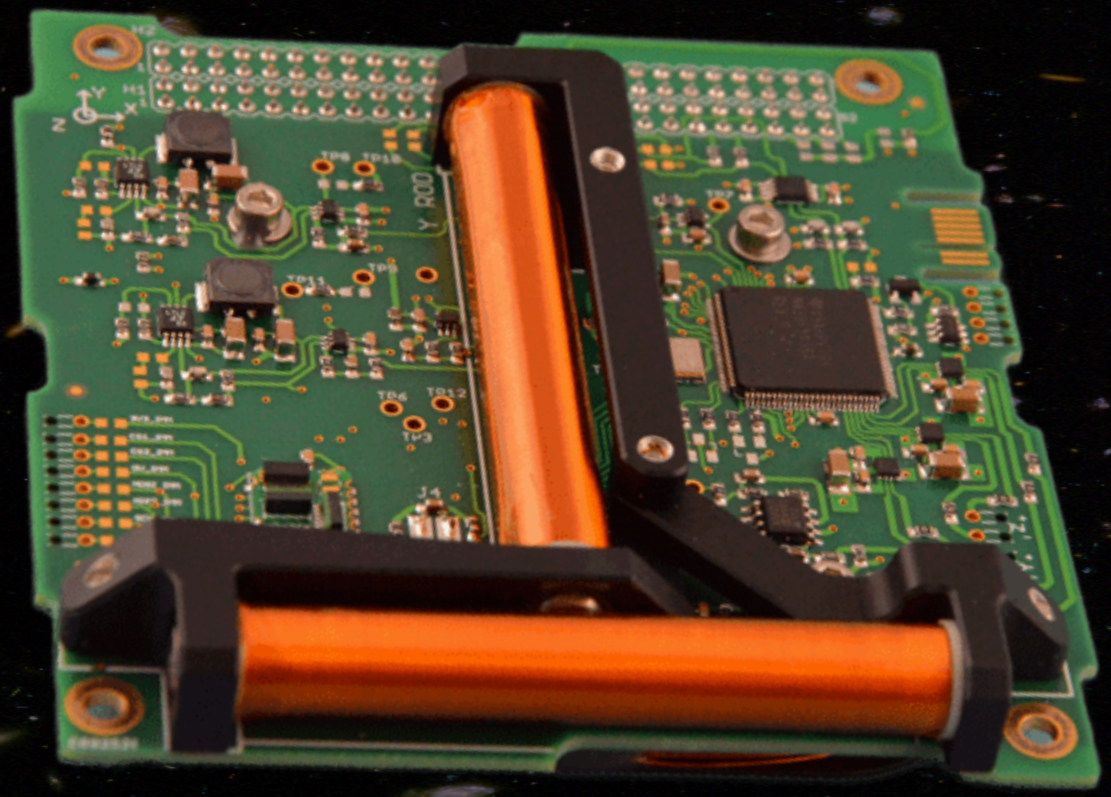
Controls



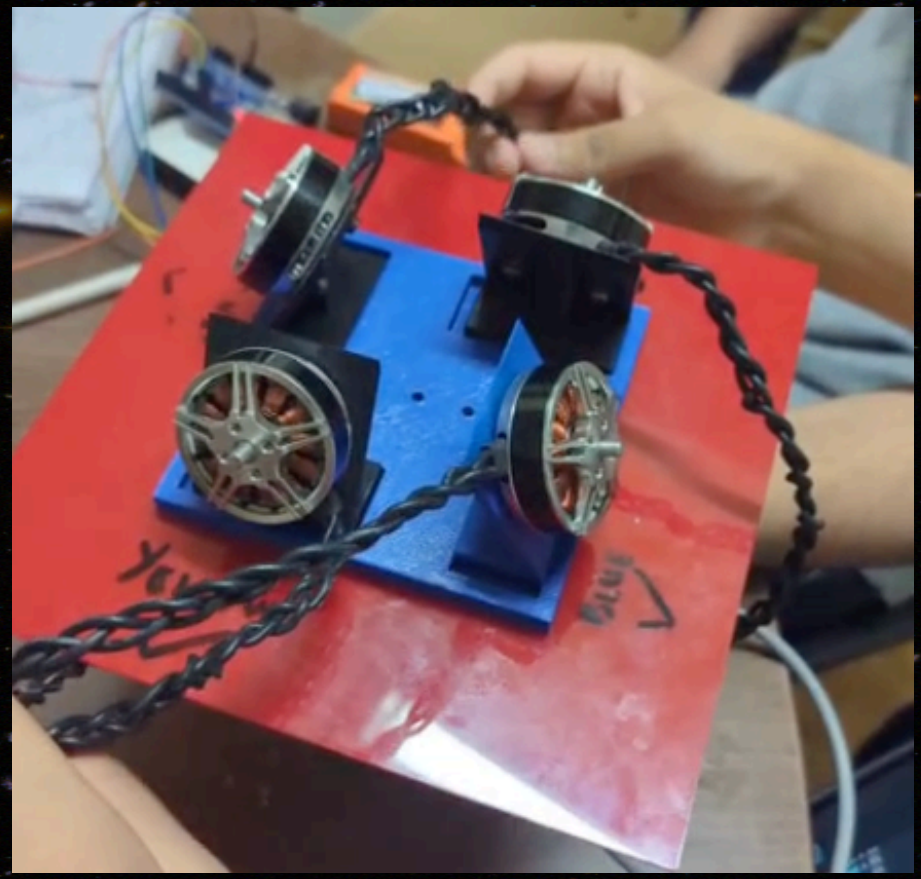
Control Modules:

- Magnetorquers
- Reaction Wheels

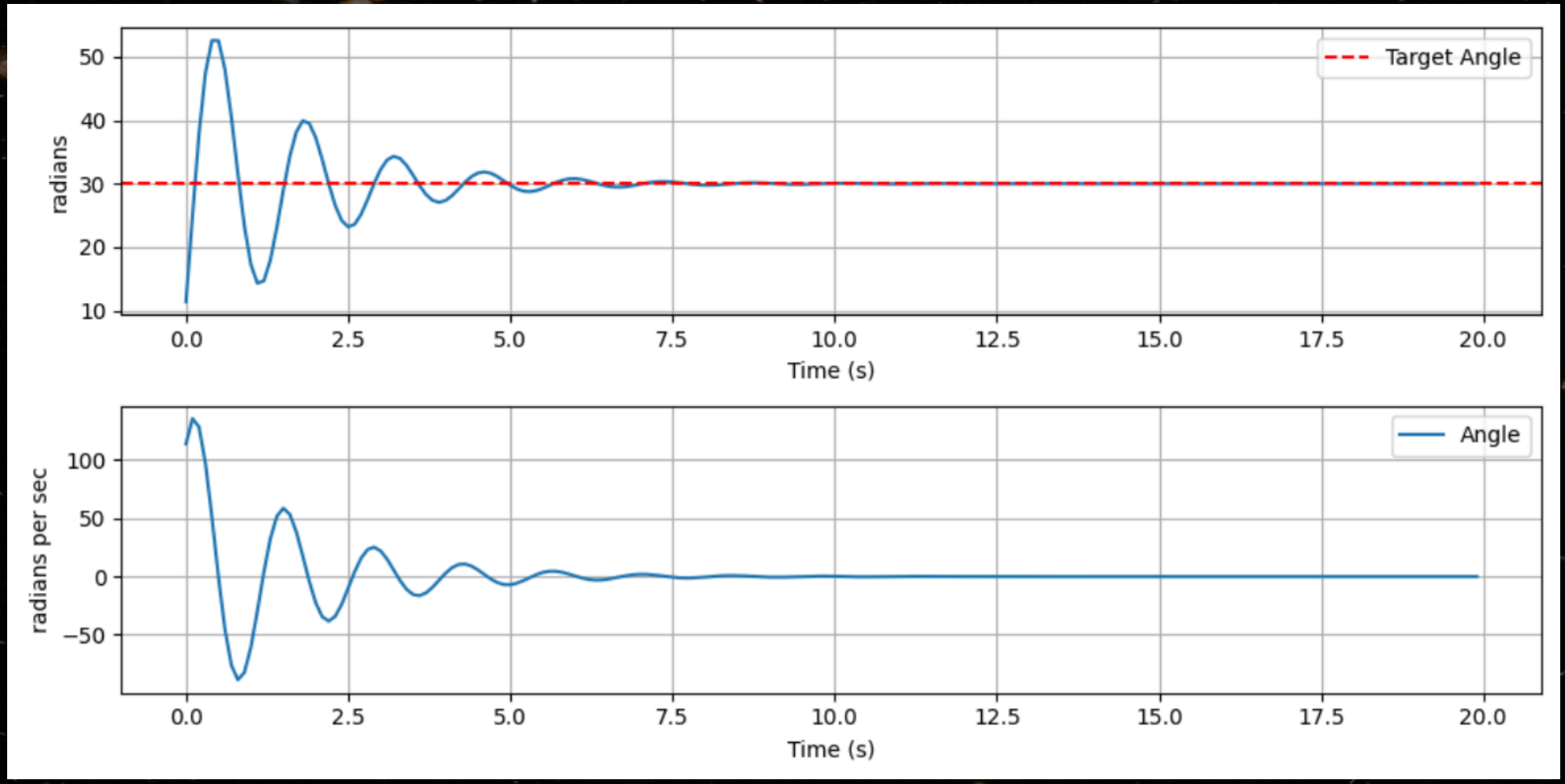
Magnetorquers



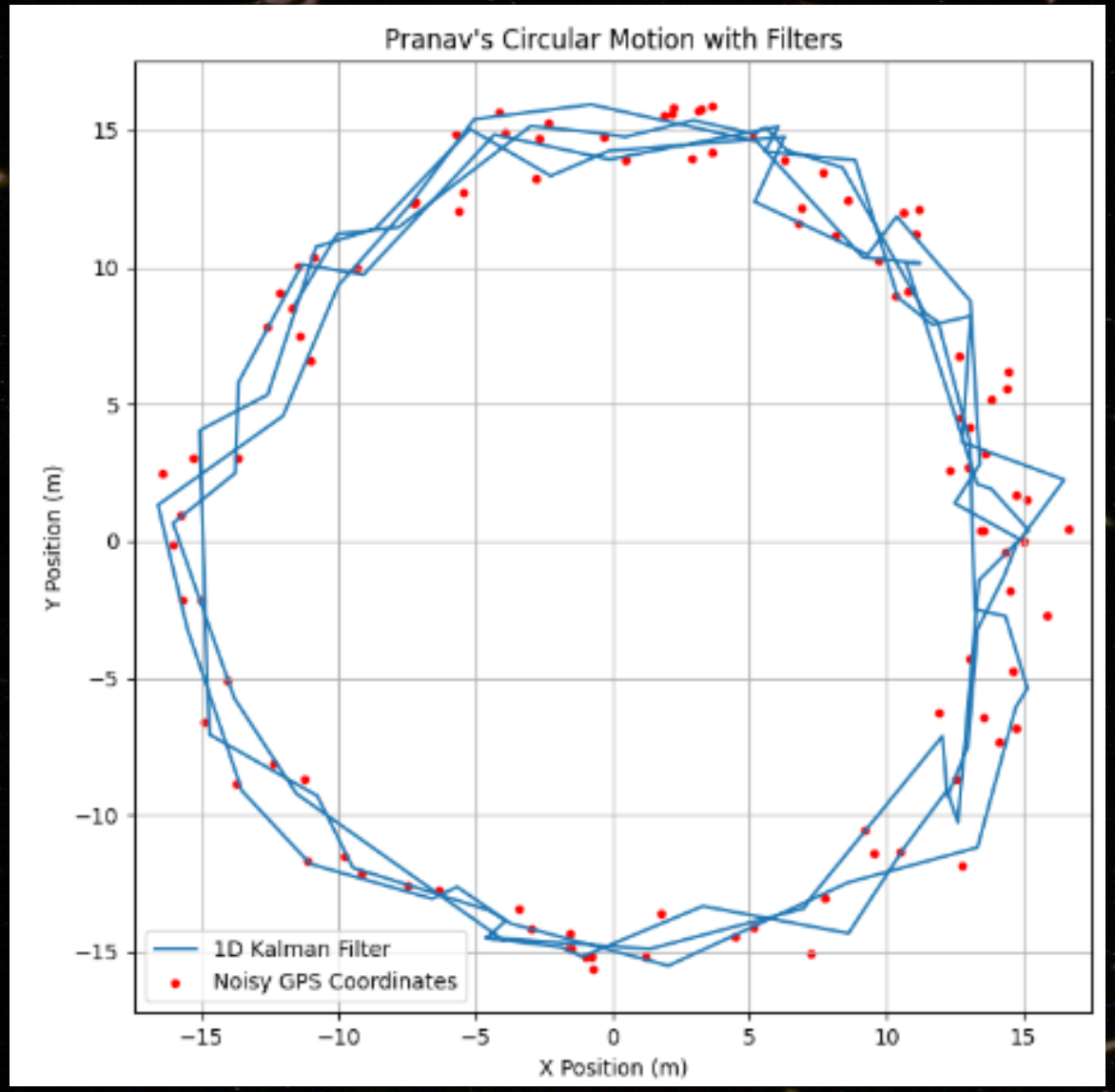
Reaction Wheels



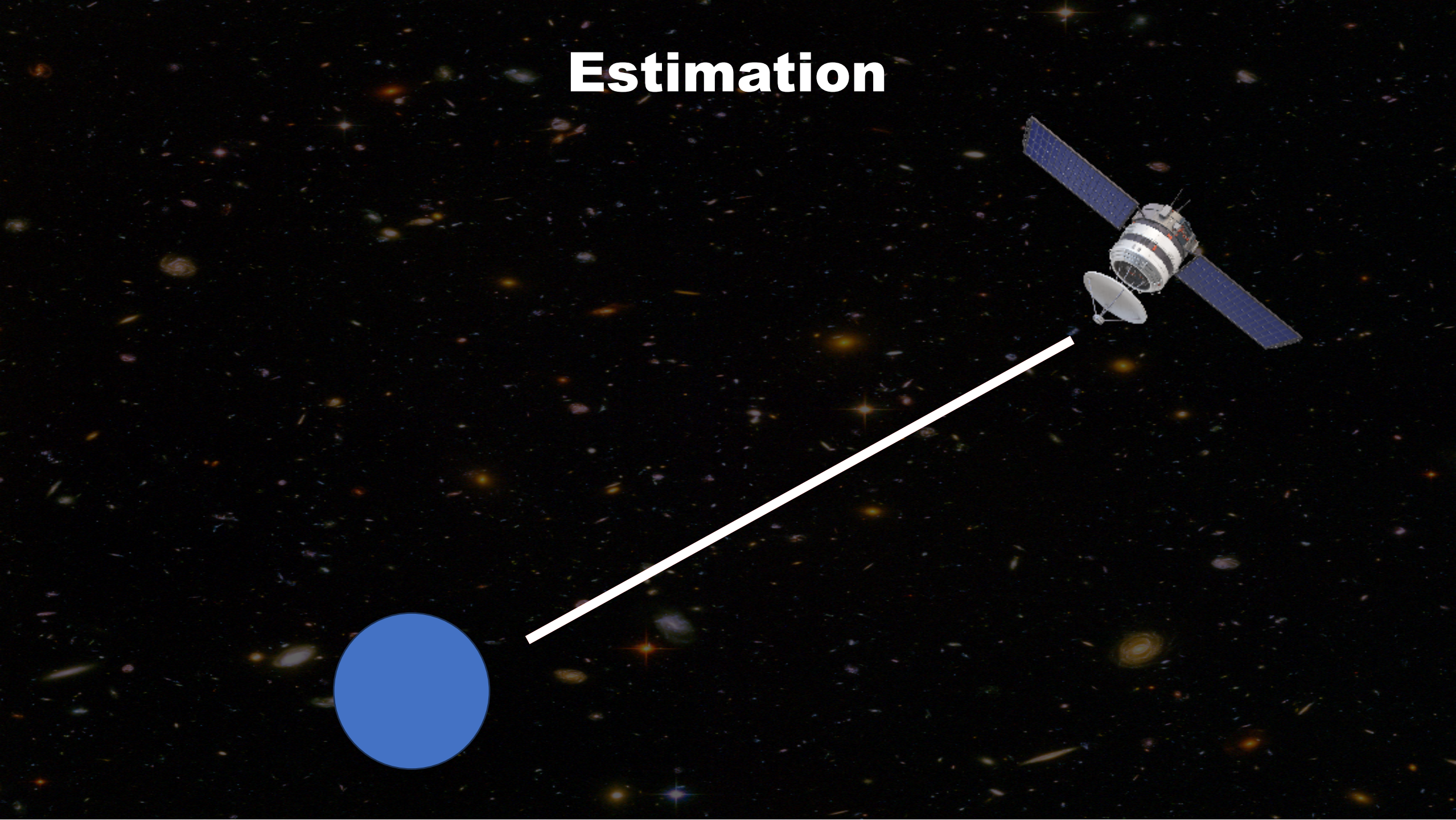
Control Algorithms

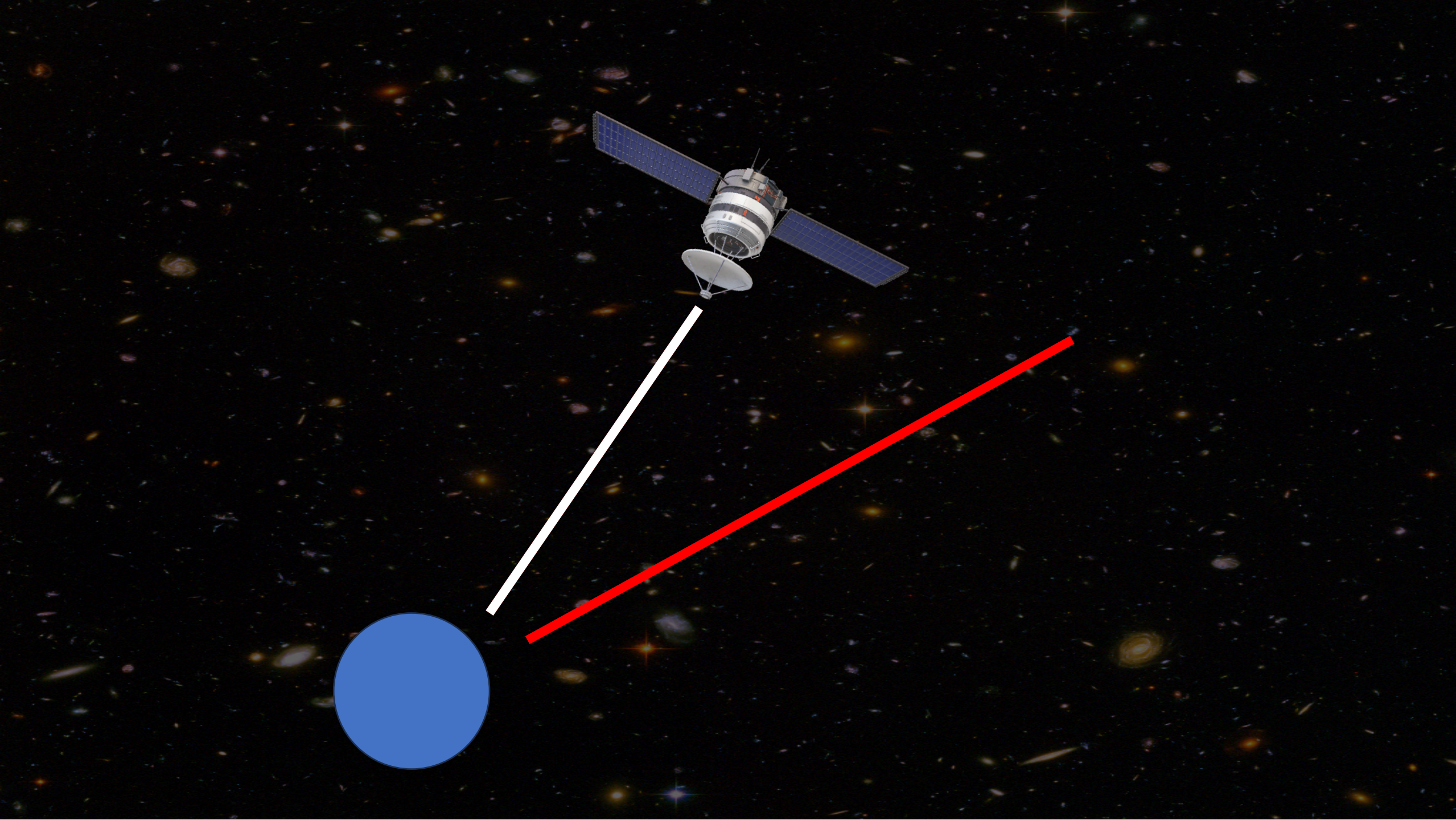


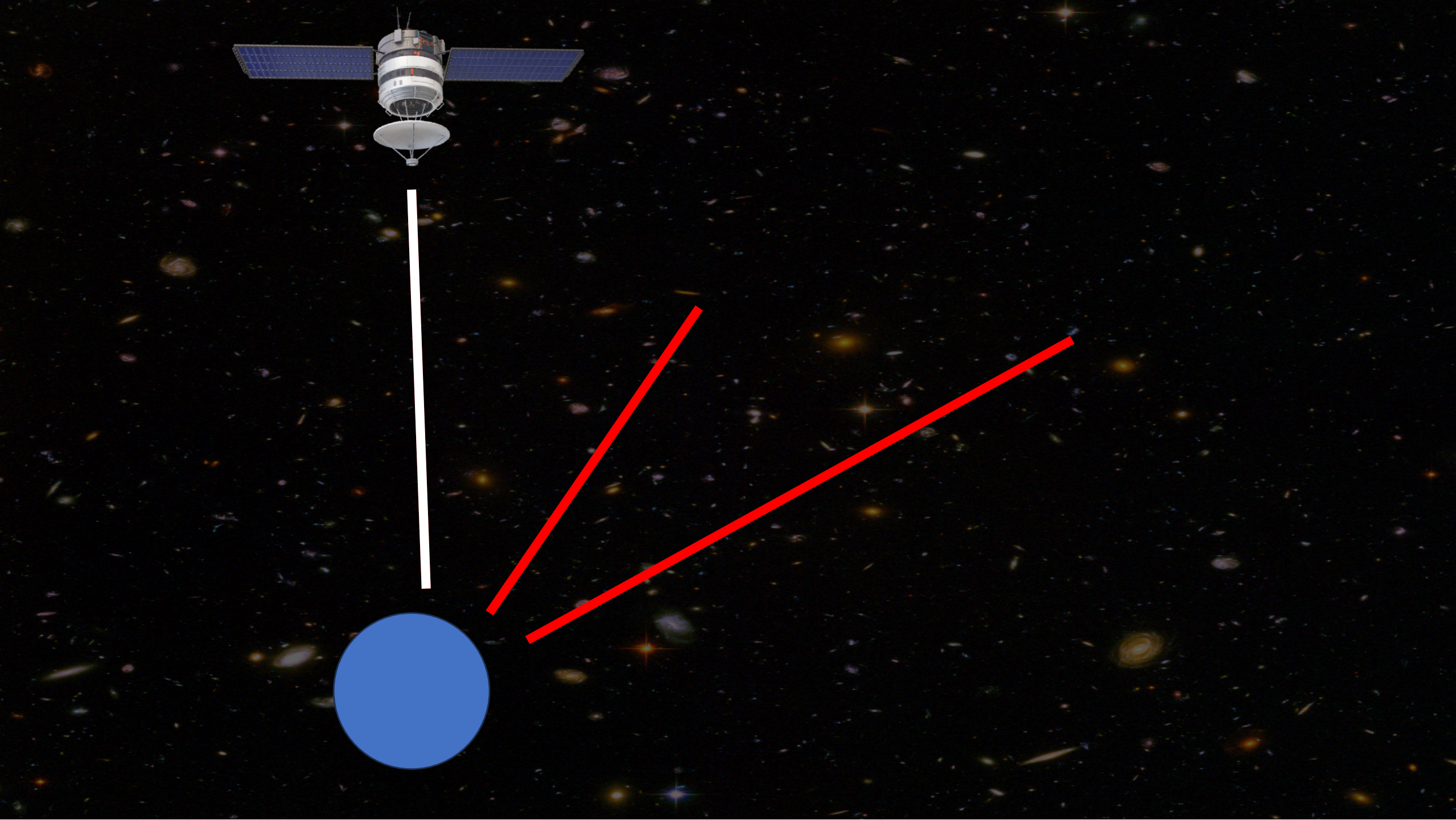
Estimation

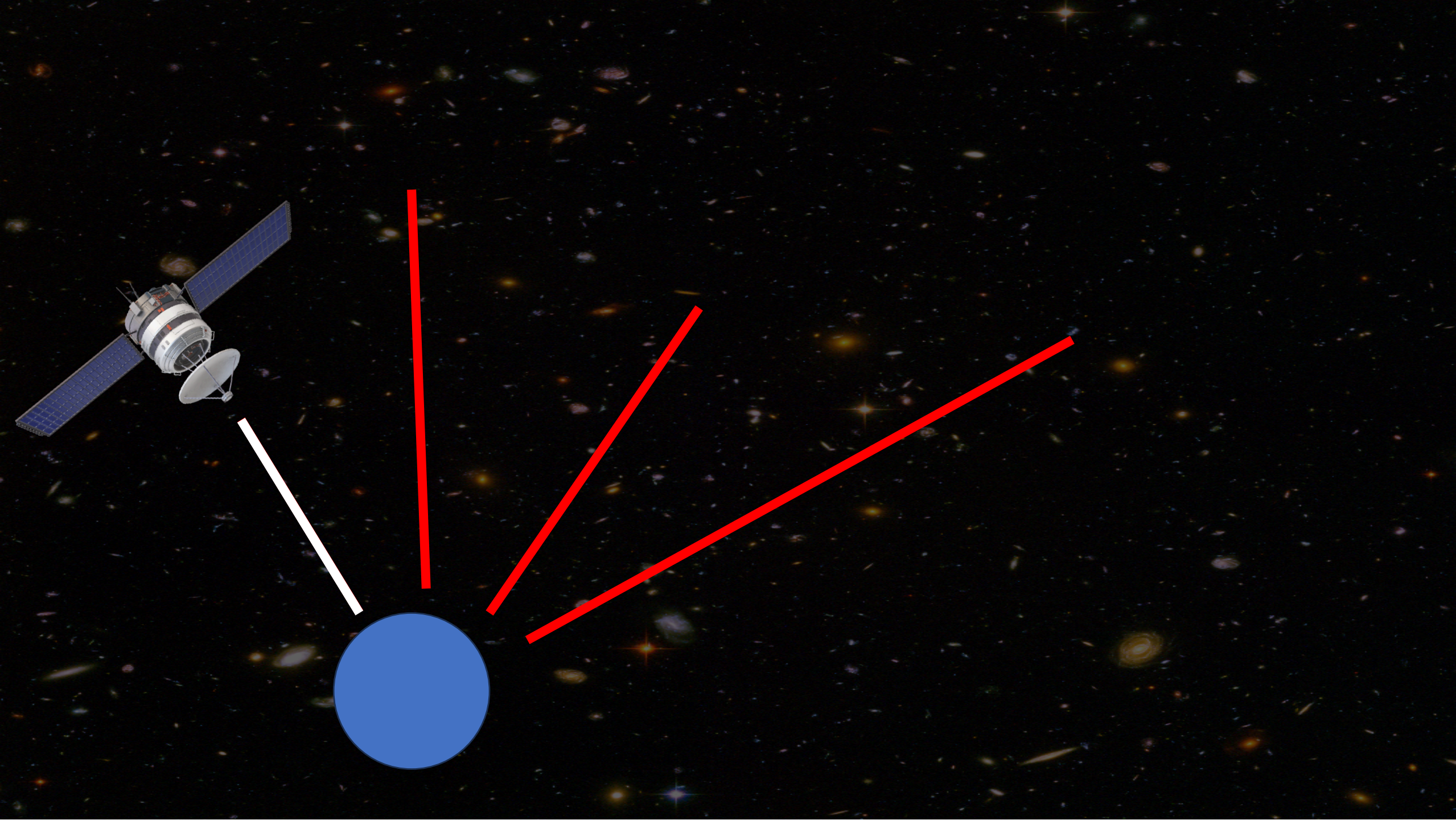

Pranav's Circular Motion with Filters
Y Position (m)
X Position (m)
15
10
5
0
−5
−10
−15
−15
−10
−5
0
5
10
15
1D Kalman Filter
Noisy GPS Coordinates

Estimation









What we need to do:

- Data Filtering
- Data Prediction

Math is Fun!

It is necessary to understand physical systems.

You cannot solely rely on intuition sometimes.

$$A_{321}(\phi,\theta,\psi) = A(\mathbf{e}_1,\psi)A(\mathbf{e}_2,\theta)A(\mathbf{e}_3,\phi)$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\psi & s\psi \\ 0 & -s\psi & c\psi \end{bmatrix} \begin{bmatrix} c\theta & 0 & -s\theta \\ 0 & 1 & 0 \\ s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} c\phi & s\phi & 0 \\ -s\phi & c\phi & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} c\theta\, c\phi & c\theta\, s\phi & -s\theta \\ -c\psi\, s\phi + s\psi\, s\theta\, c\phi & c\psi\, c\phi + s\psi\, s\theta\, s\phi & s\psi\, c\theta \\ s\psi\, s\phi + c\psi\, s\theta\, c\phi & -s\psi\, c\phi + c\psi\, s\theta\, s\phi & c\psi\, c\theta \end{bmatrix} \quad (2.164)$$

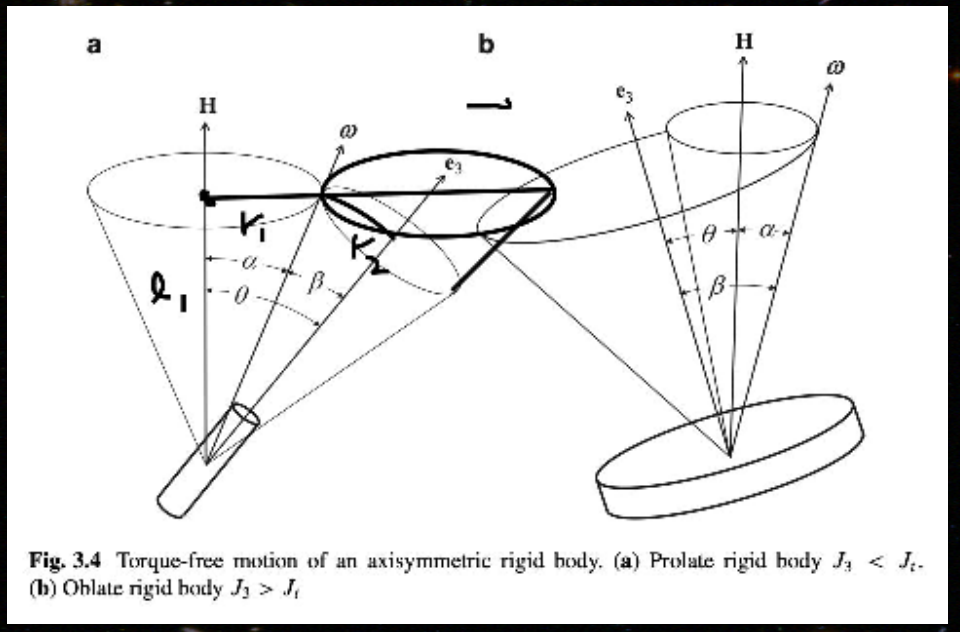
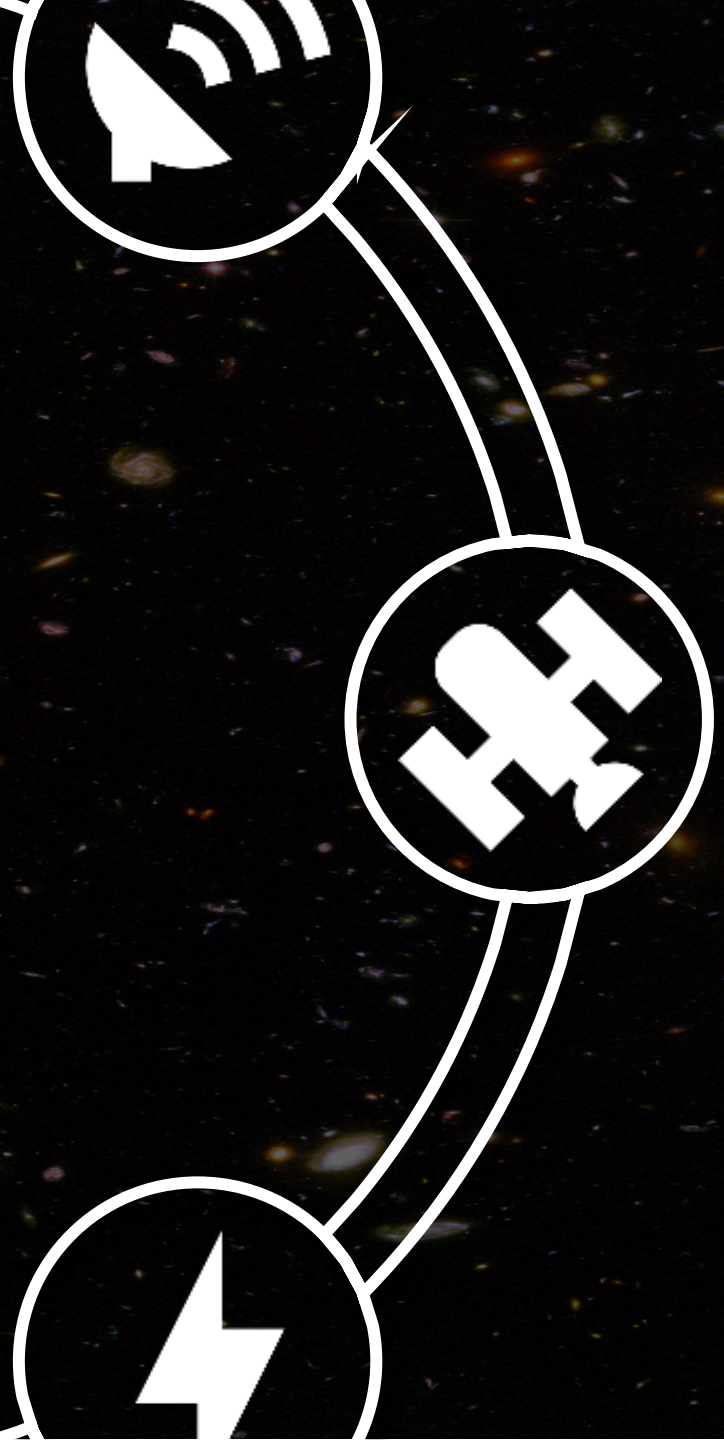


Fig. 3.4 Torque-free motion of an axisymmetric rigid body. (**a**) Prolate rigid body $J_3 < J_t$. (**b**) Oblate rigid body $J_3 > J_t$

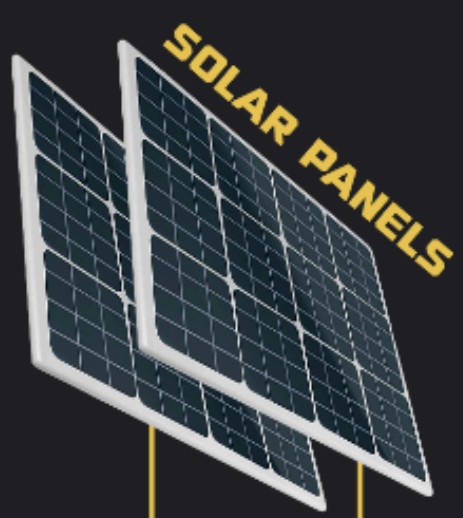


ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM

The Attitude Determination and Control Subsystem (ADCS) stabilizes and orients the satellite using sensors and actuators, enabling precise maneuvers for sun pointing, ground station tracking, and imaging.

ELECTRICAL AND POWER SUBSYSTEM

EPS, which stands for Electrical and Power subsystem, is mainly responsible for Generation, Storage and Distribution of power to the components of the various subsystems of the satellite.



SOLAR PANELS

SUN

BATTERY CHARGER

LITHIUM-ION BATTERIES

POWER CONDITIONING

VOLTAGE REGULATORS / DC TO DC CONVERTERS

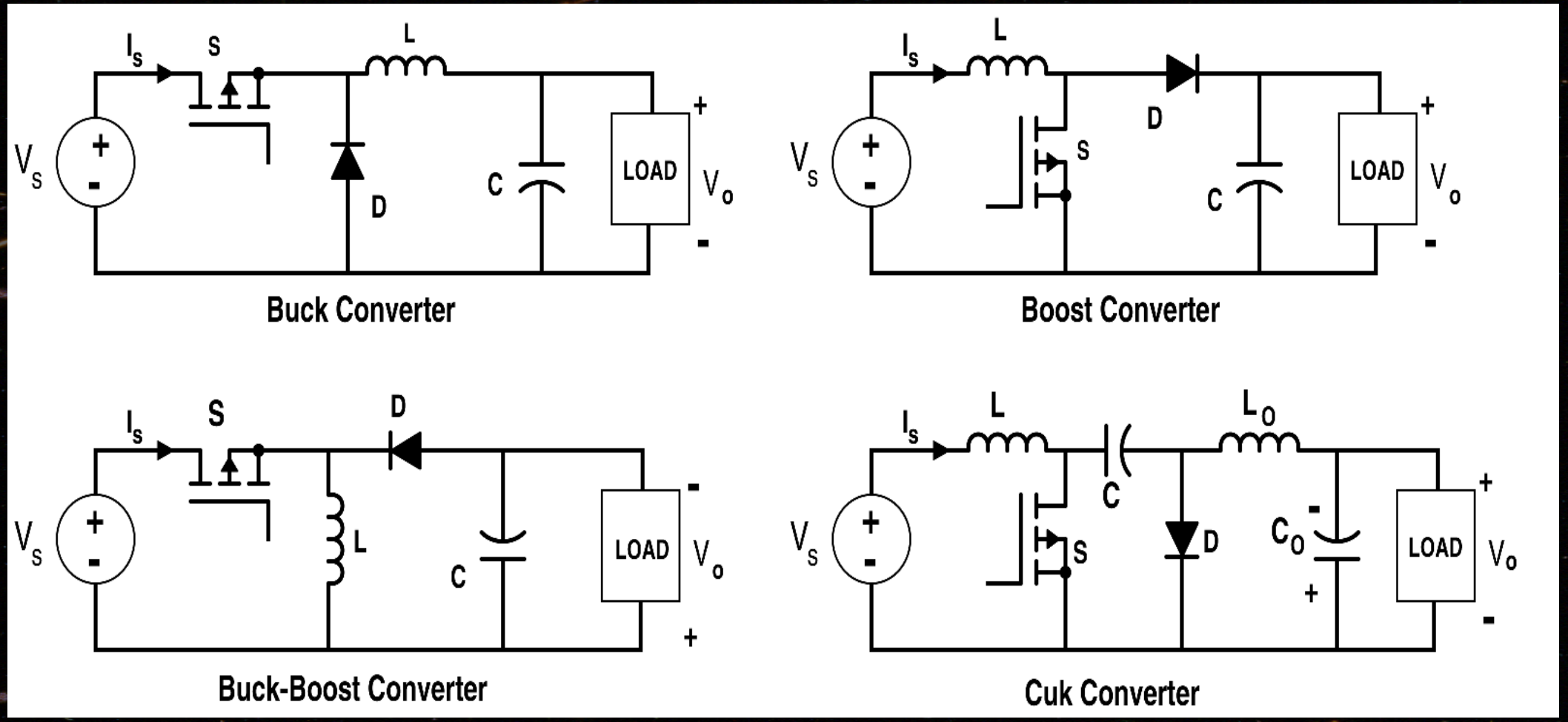
LOW / HIGH VOLTAGE DC

DEVICES USED TO STEP DC VOLTAGES UP AND DOWN:

- Buck Convertors
- Boost Convertors
- Buck-Boost Converters

ALGORITHMS USED IN THE BATTERY MANAGEMENT SYSTEM:

- MPPT (Maximum Power Point Tracking)


I_S
S
L
V_S
+
-
D
C
LOAD
+
V_o
-
Buck Converter
I_S
L
D
V_S
S
C
LOAD
+
V_o
-
Boost Converter
I_S
S
D
V_S
L
C
LOAD
-
V_o
+
Buck-Boost Converter
I_S
L
L_O
C
V_S
S
D
C_O
LOAD
+
V_o
-
Cuk Converter

Power Budget and Datasheets

- The EPS needs to formulate a POWER BUDGET: wherein it decides how much power is to be given to which subsystem under which MODE OF OPERATION.
- DATASHEETS are then read to decide upon the specification of the various components to be used in the CubeSAT mission.

Passive Circuit Board Components

Resistor

Capacitor

Inductors

Transformer

Fuse

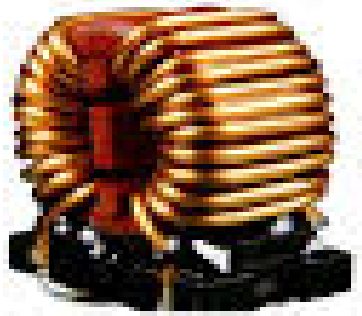
Varistor

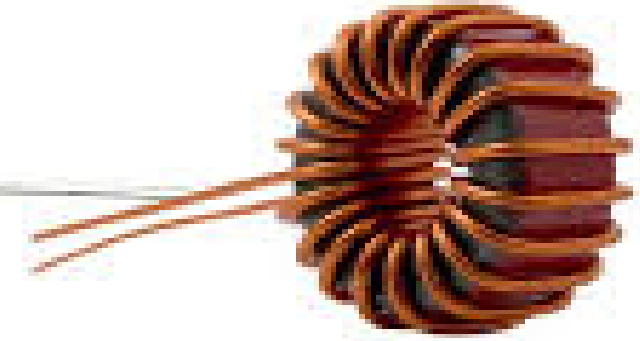
Resistor Network

Thermistor

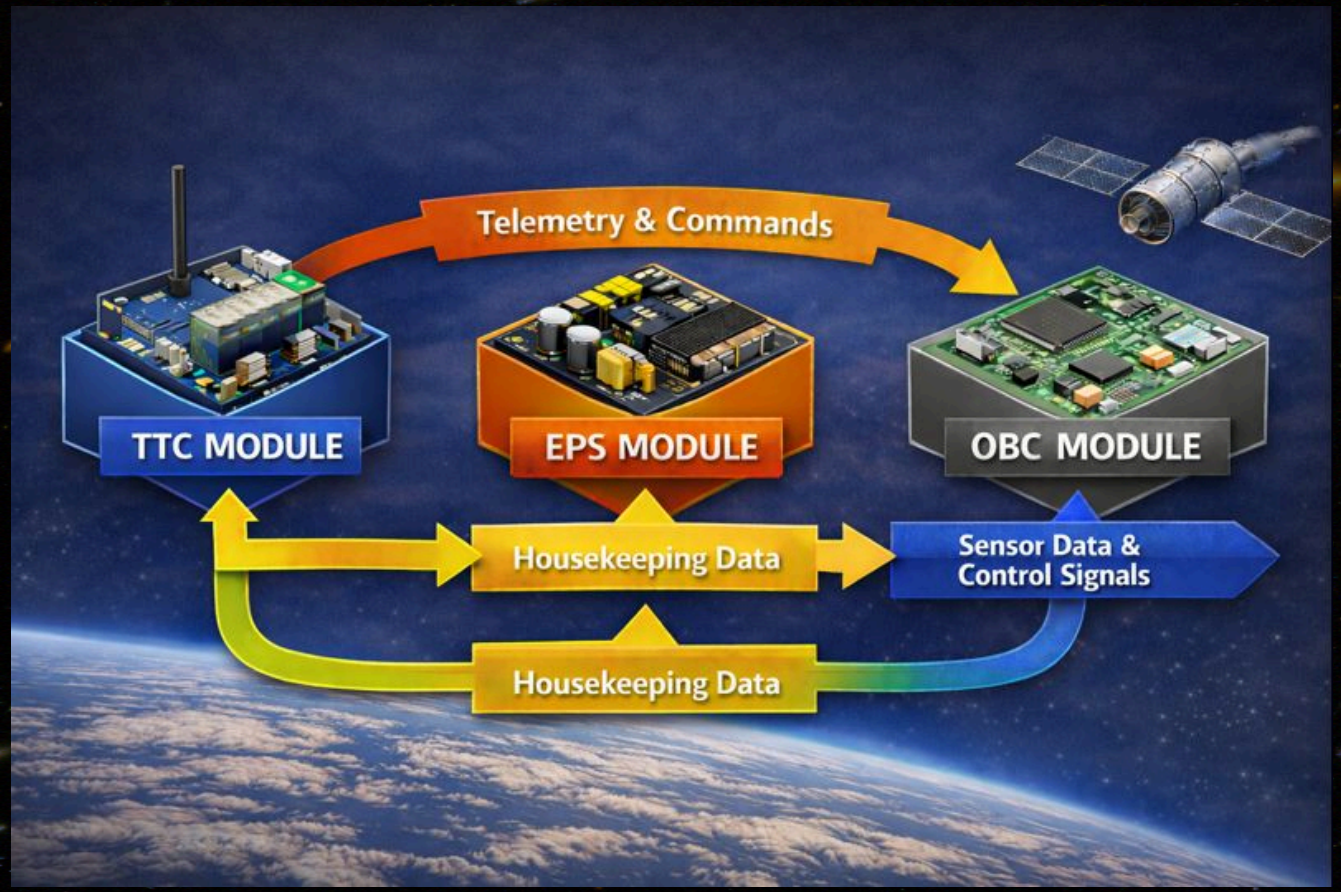
Potentiometer

PCBA



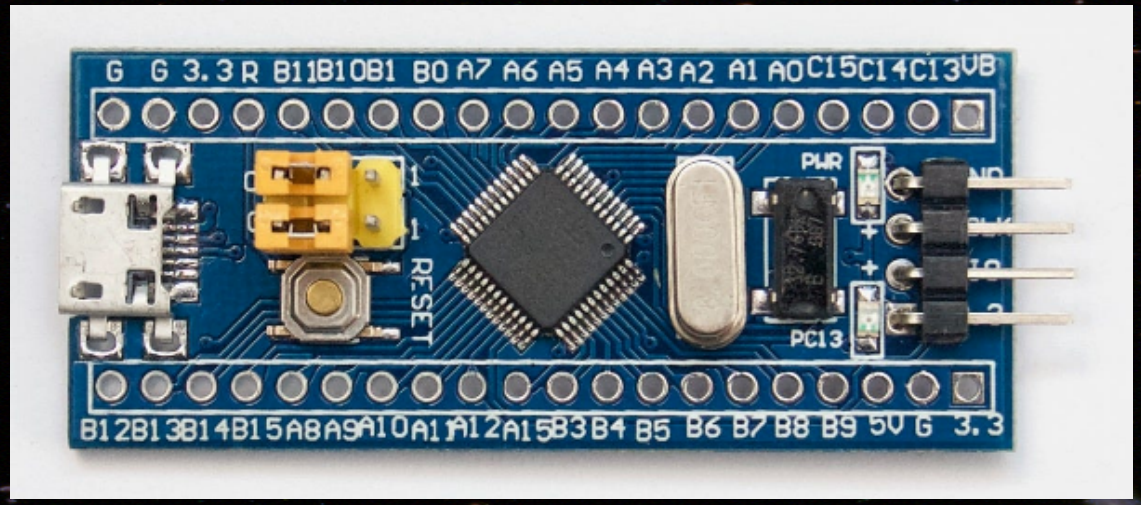


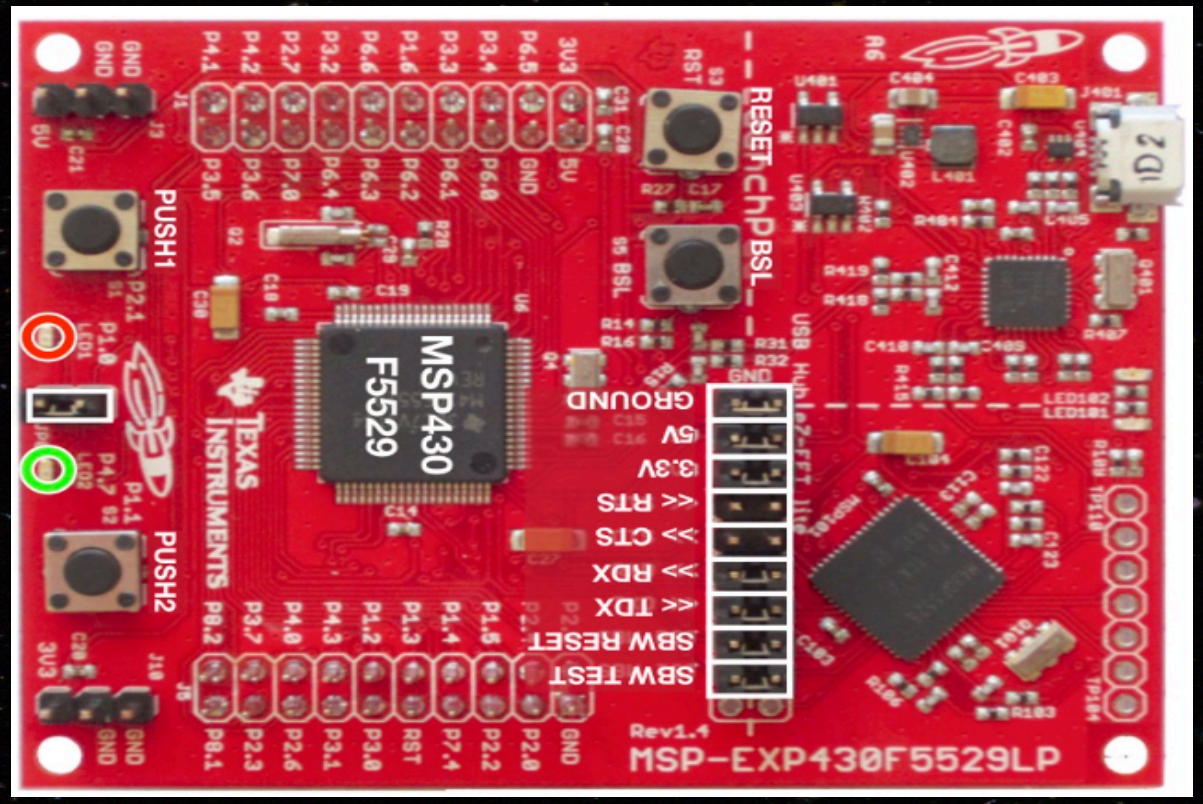
HOUSEKEEPING DATA



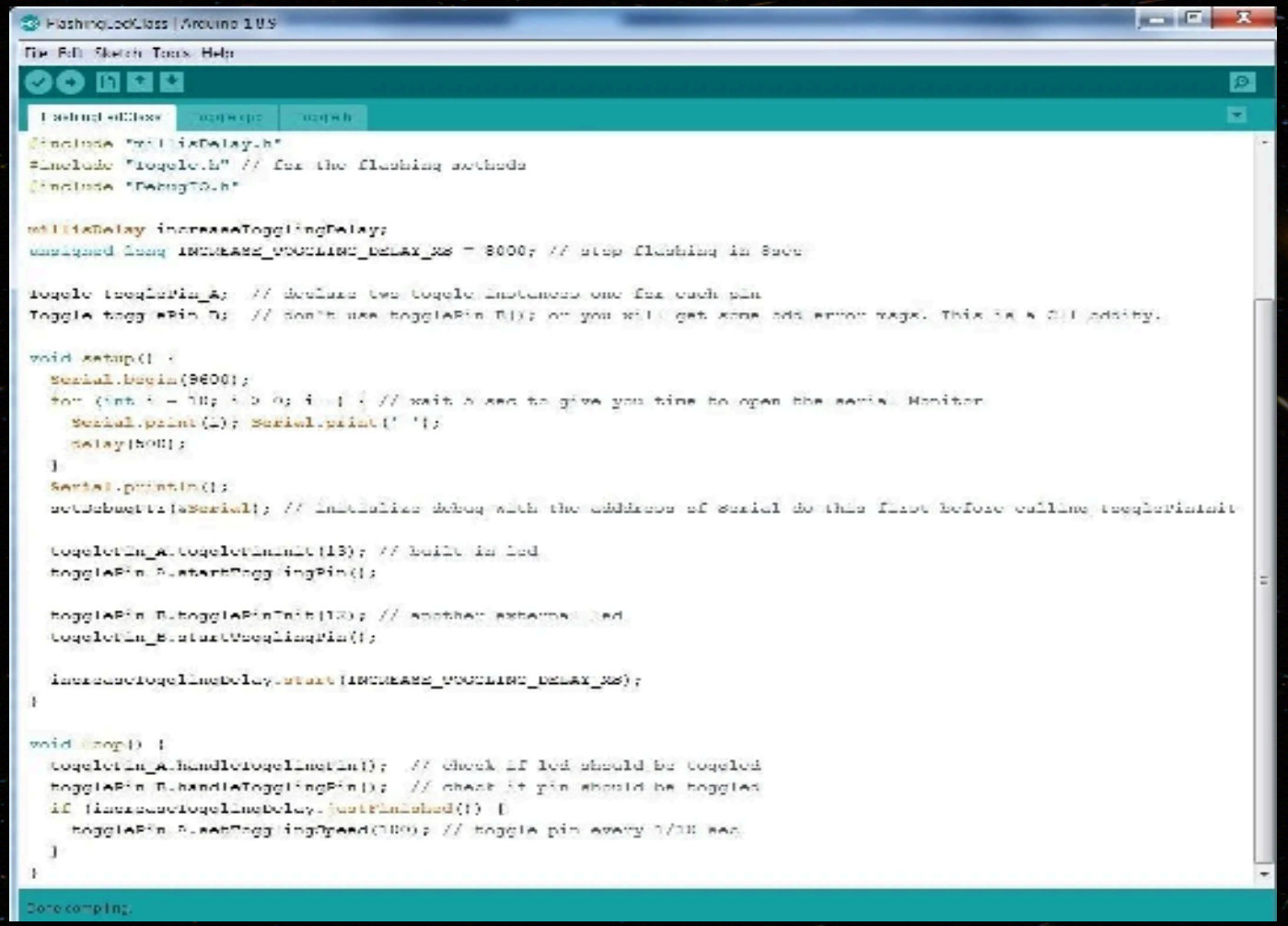
The EPS is also responsible for collecting HOUSEKEEPING DATA from different system sensors to monitor the critical health of the satellite.

EPS MICROCONTROLLER





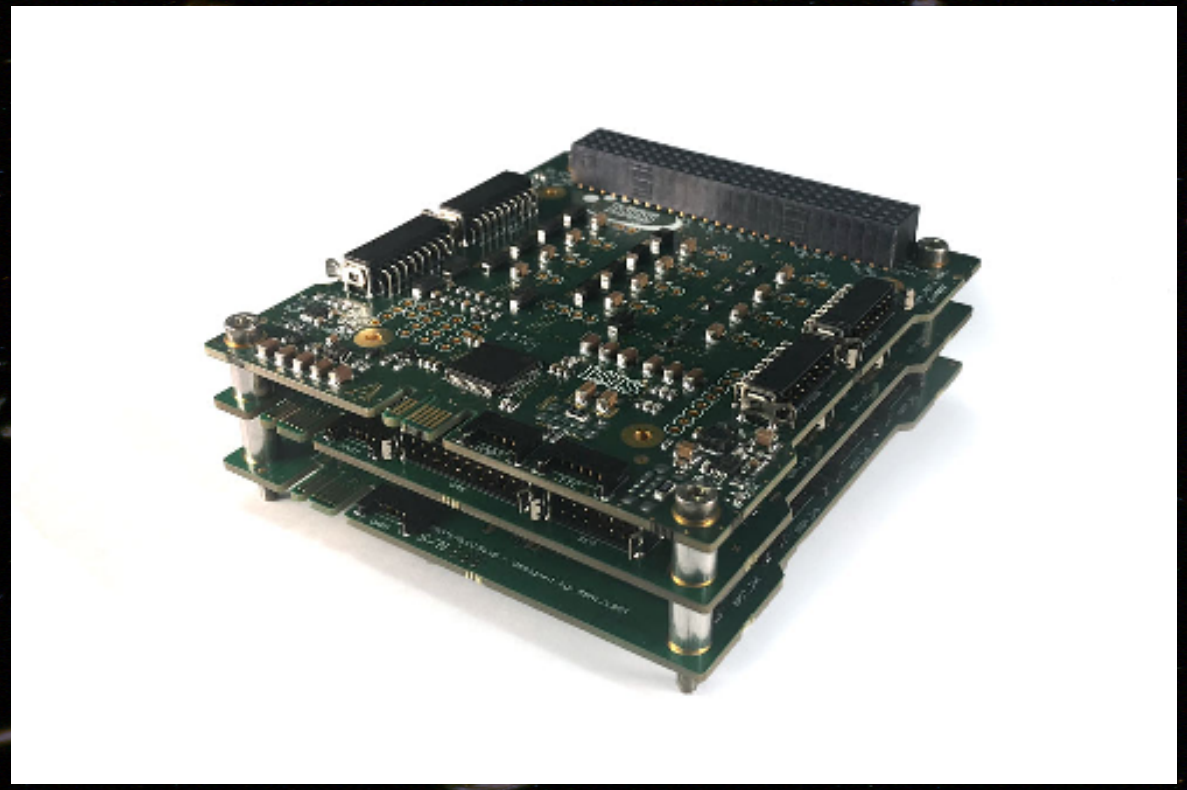
SOFTWARE



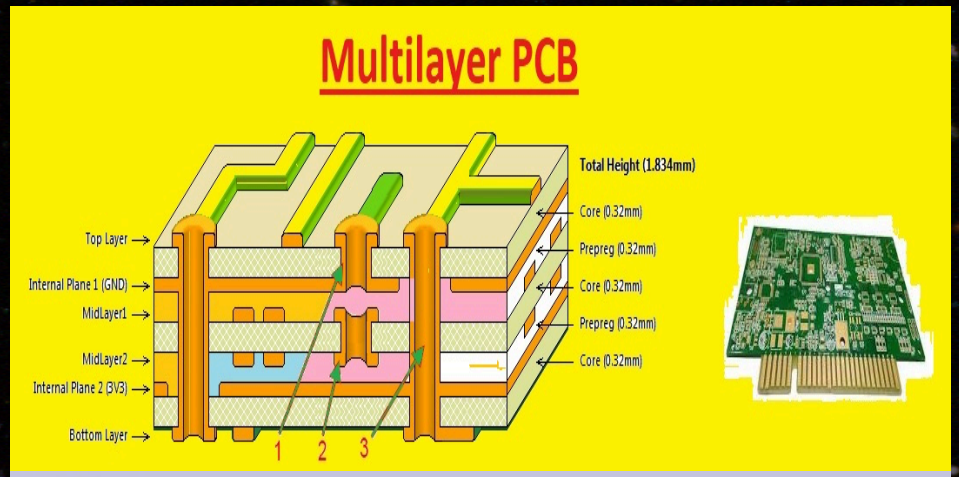
The software used in the satellite is variation of the commonly used language ‘C’ and it’s called ‘Embedded C’.

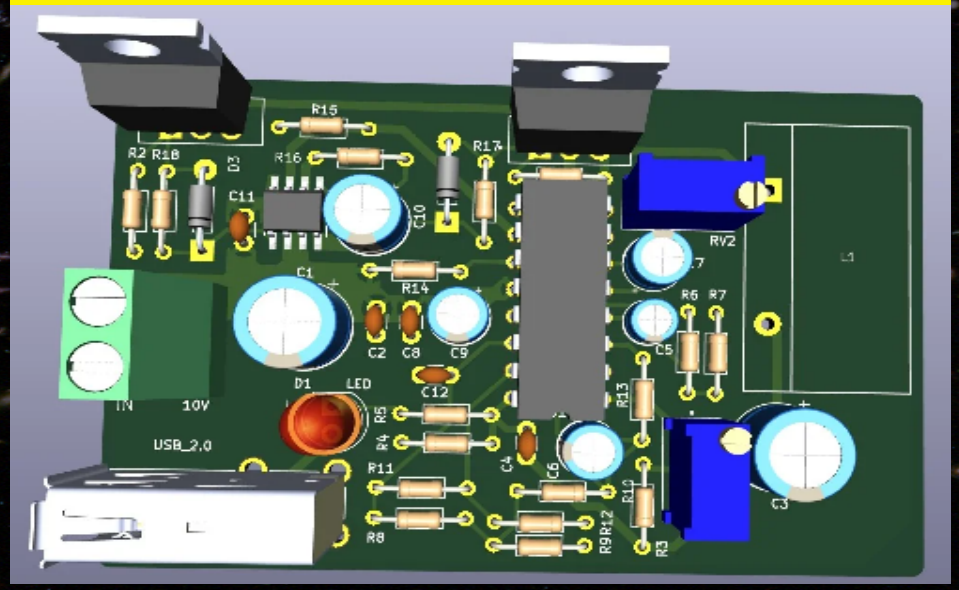
We write Bare Metal Code or Register Level Code to reduce the overall size of the program by avoiding library functions.

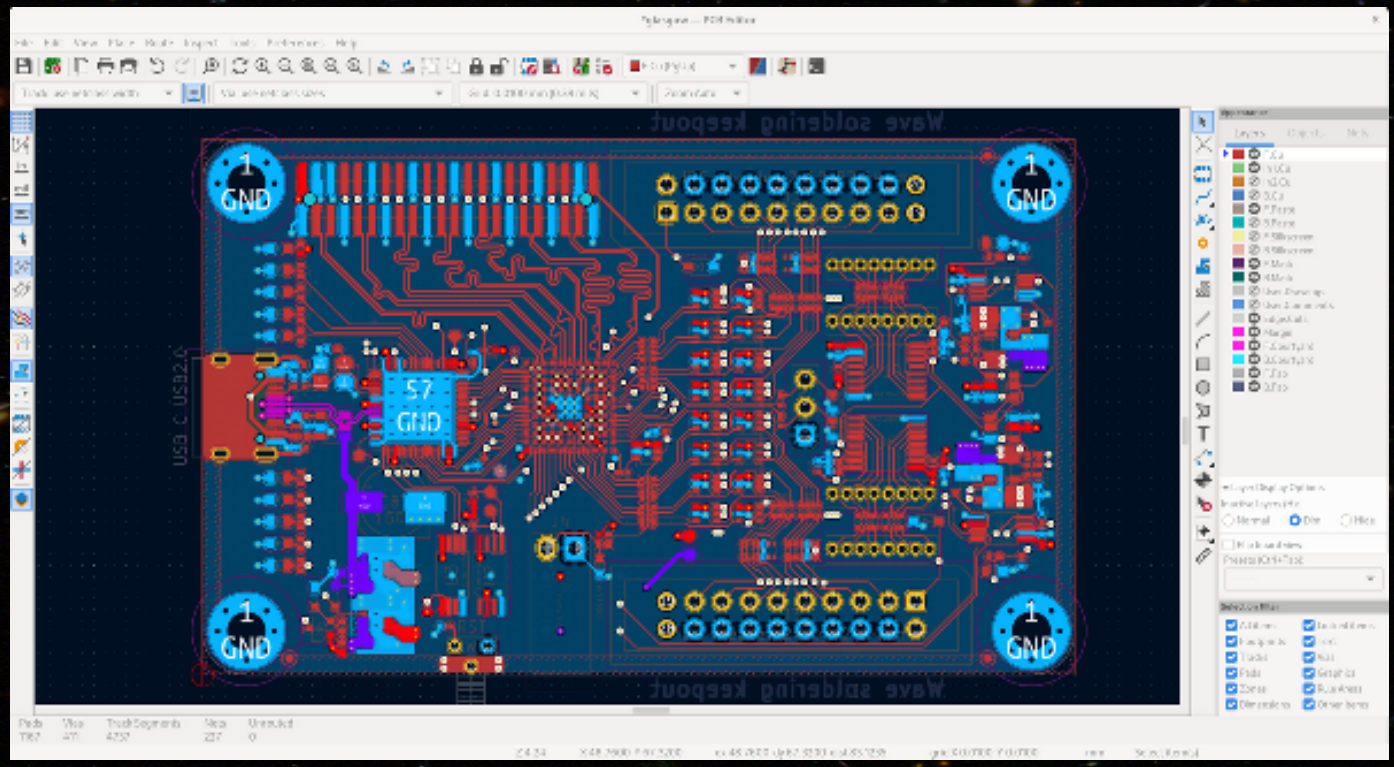
PRINTED CIRCUIT BOARDS



Designing a PCB







ELECTRICAL AND POWER SUBSYSTEM

EPS, which stands for Electrical and Power subsystem, is mainly responsible for Generation, Storage and Distribution of power to the components of the various subsystems of the satellite.

PAYLOAD

The payload consists of the instruments, equipment, and systems on a satellite that perform its specific mission functions.

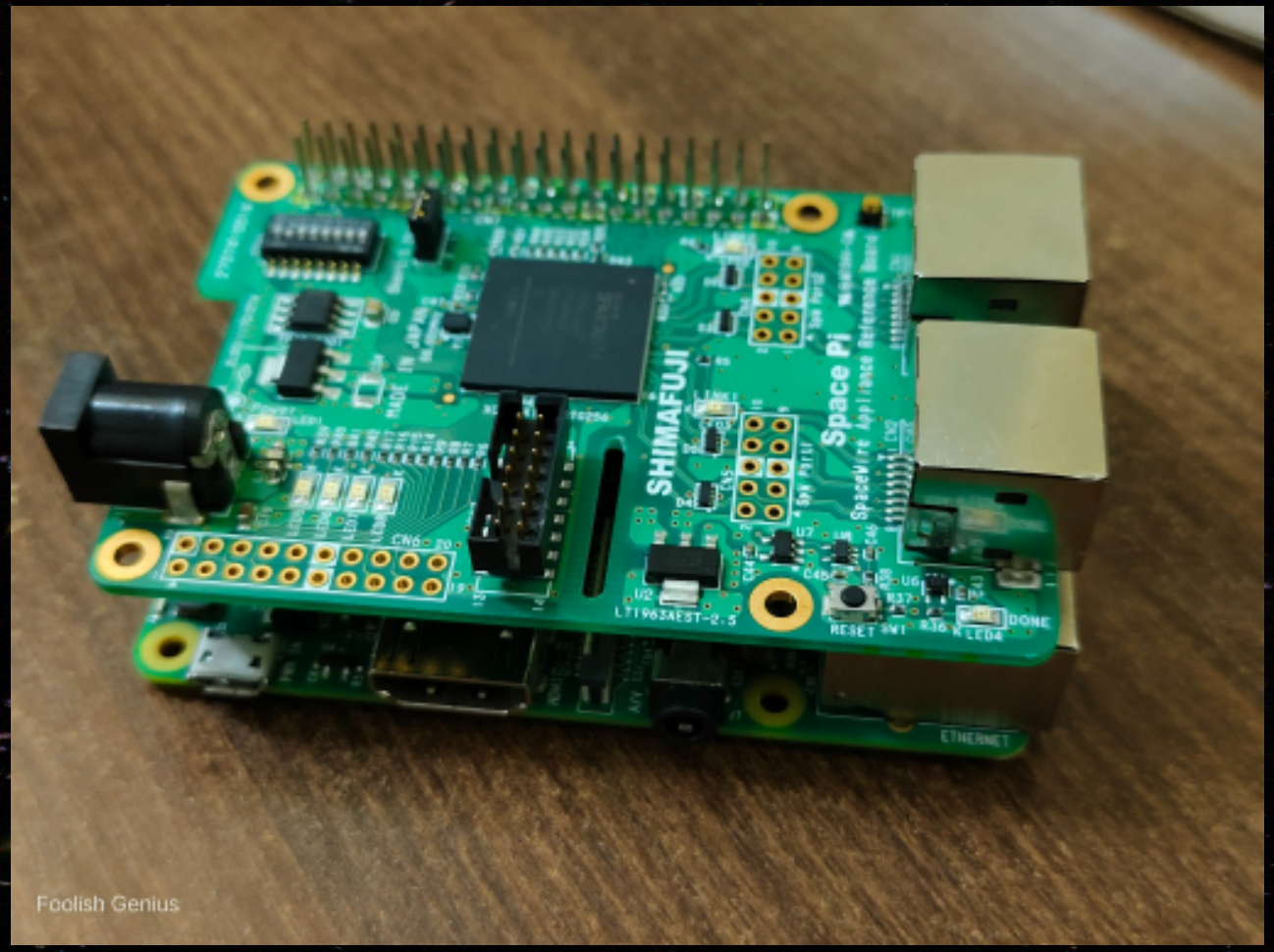
Focus: delivering a multispectral instrument within the strict mass, volume, and power limits of a CubeSat.

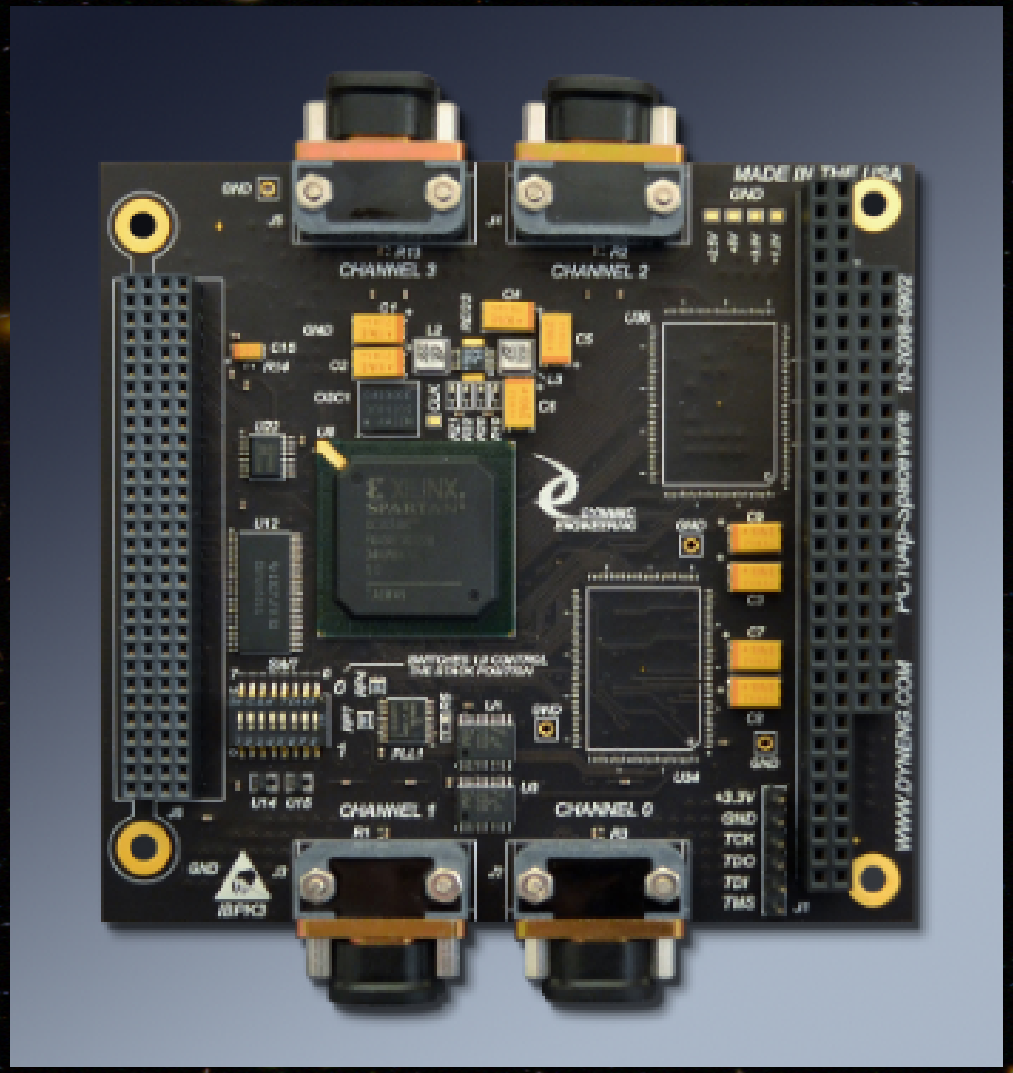
What does this mean for you?

REMOTE SENSING
MACHINE LEARNING
FPGA PROGRAMMING
IMAGE COMPRESSION

How does the Image get to the computer?

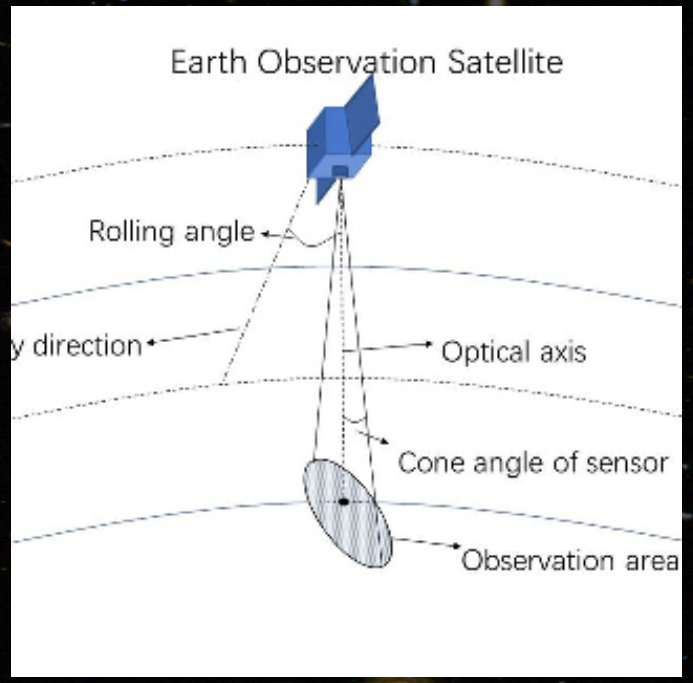
What is an FPGA?

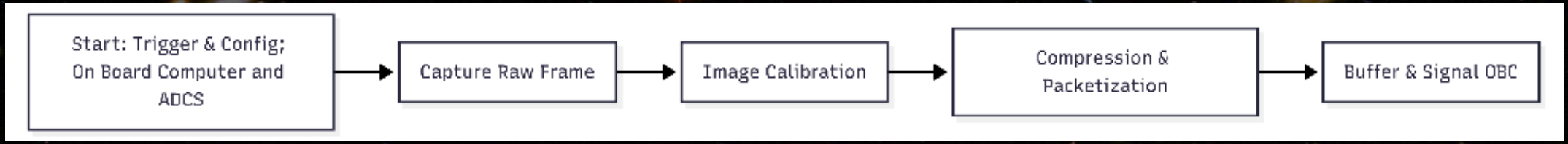




Payload Data Processing

- Satellites compress images before sending them to Earth.
- Sensors scan the Earth strip-by-strip along the orbit
- Neighboring pixels are often similar
- Compression removes repeated information

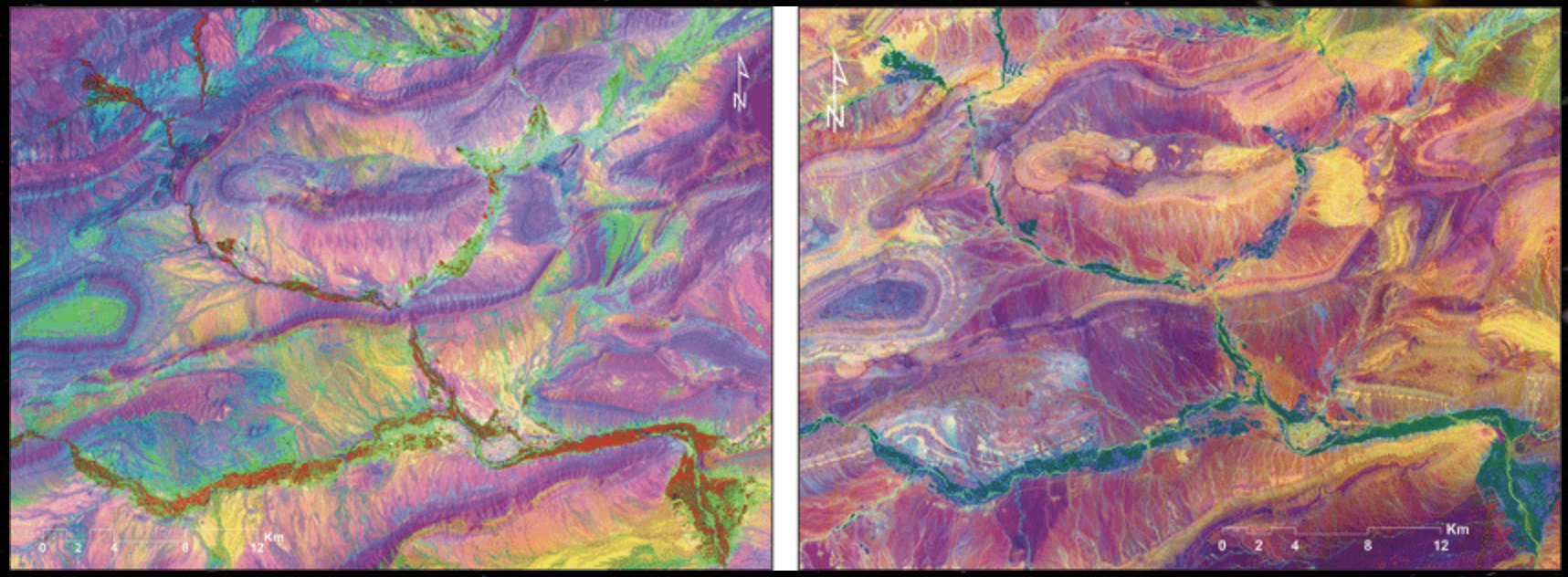




What After that?

After we get the image, we use various image processing techniques to actually get some useful information and conclusions from the image.

Eg:- Applying Radiometric/Geometric/Atmospheric correction



Effects of Image Correction

Corrections

1. **Radiometric Correction**

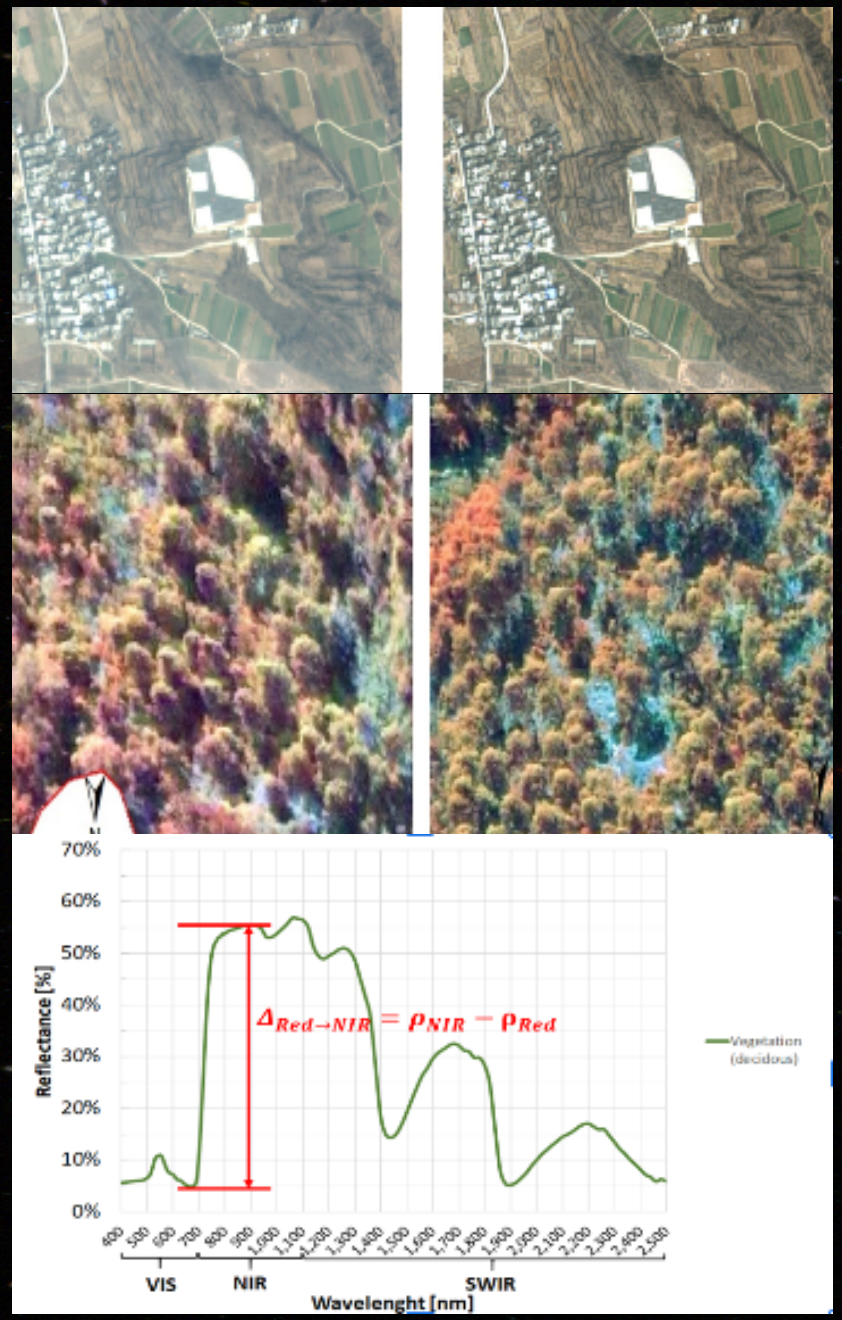
   This fixes errors in brightness and color caused by the sensor or the atmosphere.

2. **Geometric Correction**

   This fixes the shape of the image. Because the Earth is curved and the satellite is moving, raw images are often distorted.

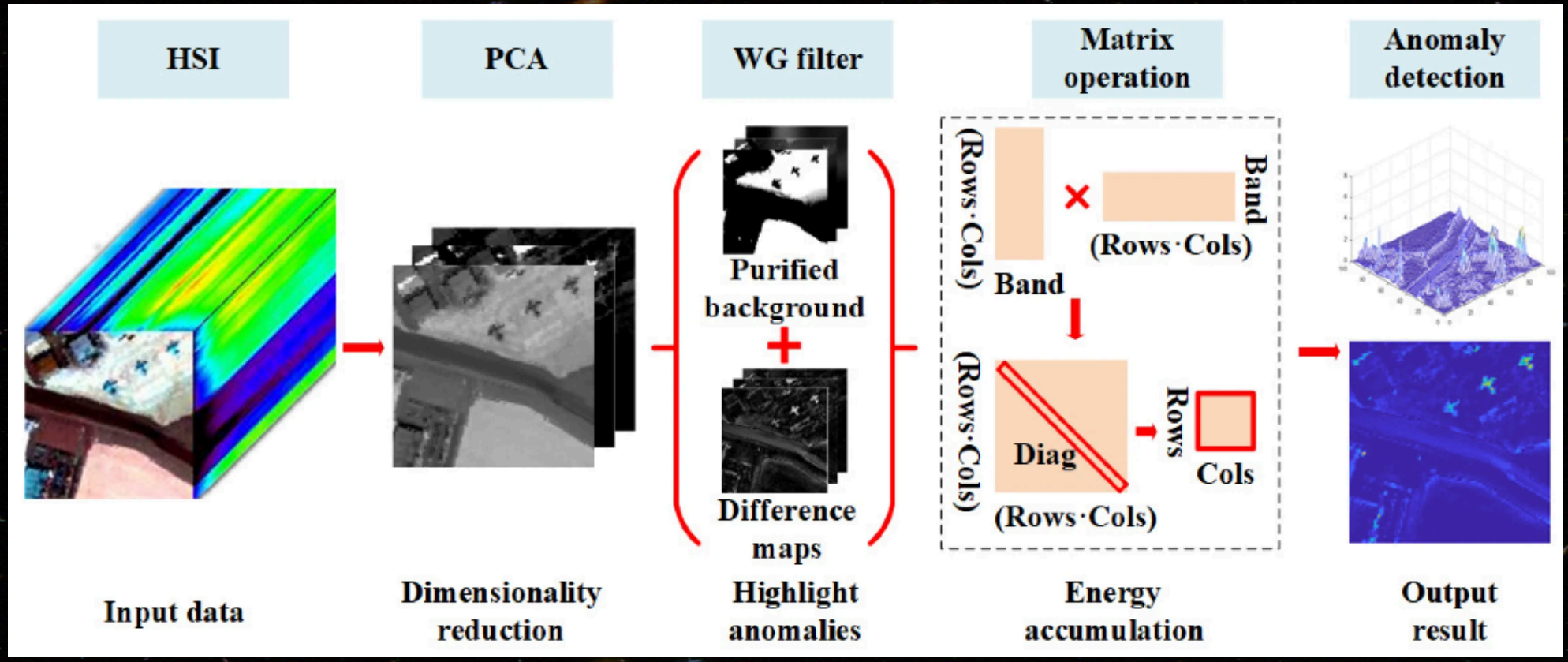
3. **Atmospheric Correction**

   This removes distortions from our images caused by the Earth's atmosphere (scattering, absorption by gases/aerosols).



Training **Machine Learning** models to identify trends in the changing Landscape

We now make use of machine learning to identify man-made changes, vegetation, anomalies, etc!



PAYLOAD

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STRUCTURAL AND THERMAL SUBSYSTEM

The Structure and Thermal Subsystem (STS) protects all components, meeting strict size and weight limits. It withstands launch stresses and regulates temperatures with passive insulation and active heating for sensitive parts.

Structural and System-Level Analysis

Loads experienced

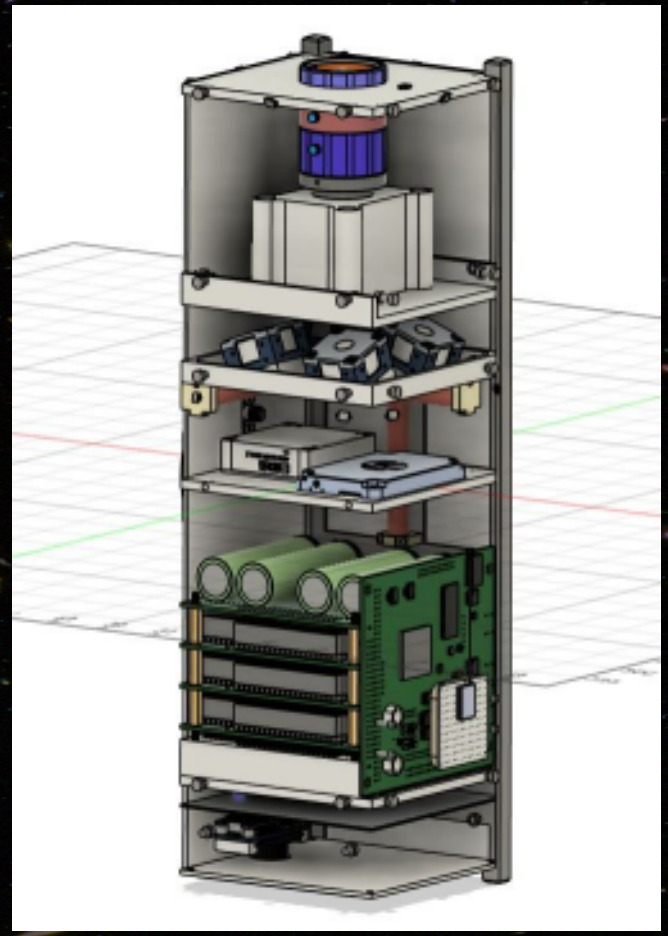
- Static Loads (high acceleration),
- Vibration loads
- Acoustic and shock loads during liftoff & separation

Structural Requirements

- Maintain alignment
- Prevent joint loosening
- Limit deformation

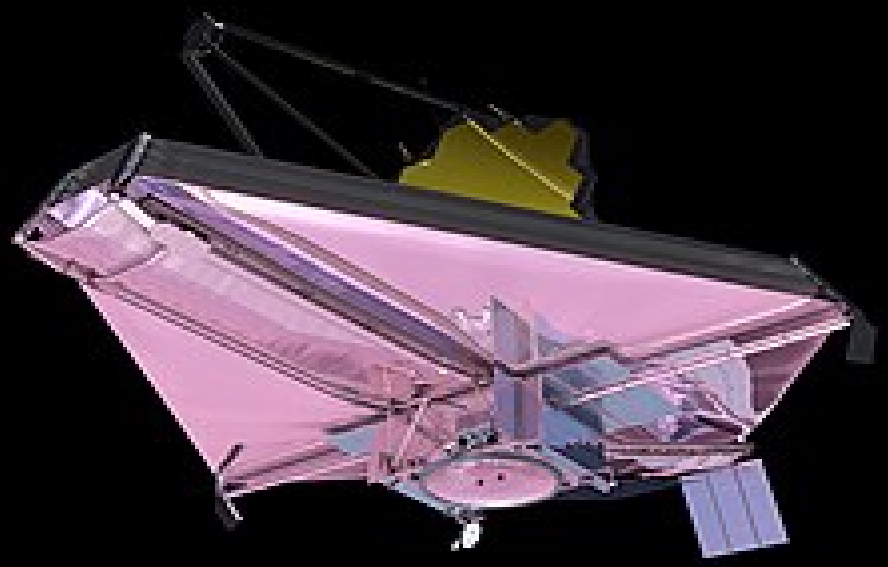
Design Choice

- **Monoblock Aluminium 6061-T6 primary structure**
- **Minimal joints → continuous load paths**



Significance of Vibrations Loads

THERMAL ENVIRONMENT AND CONTROL



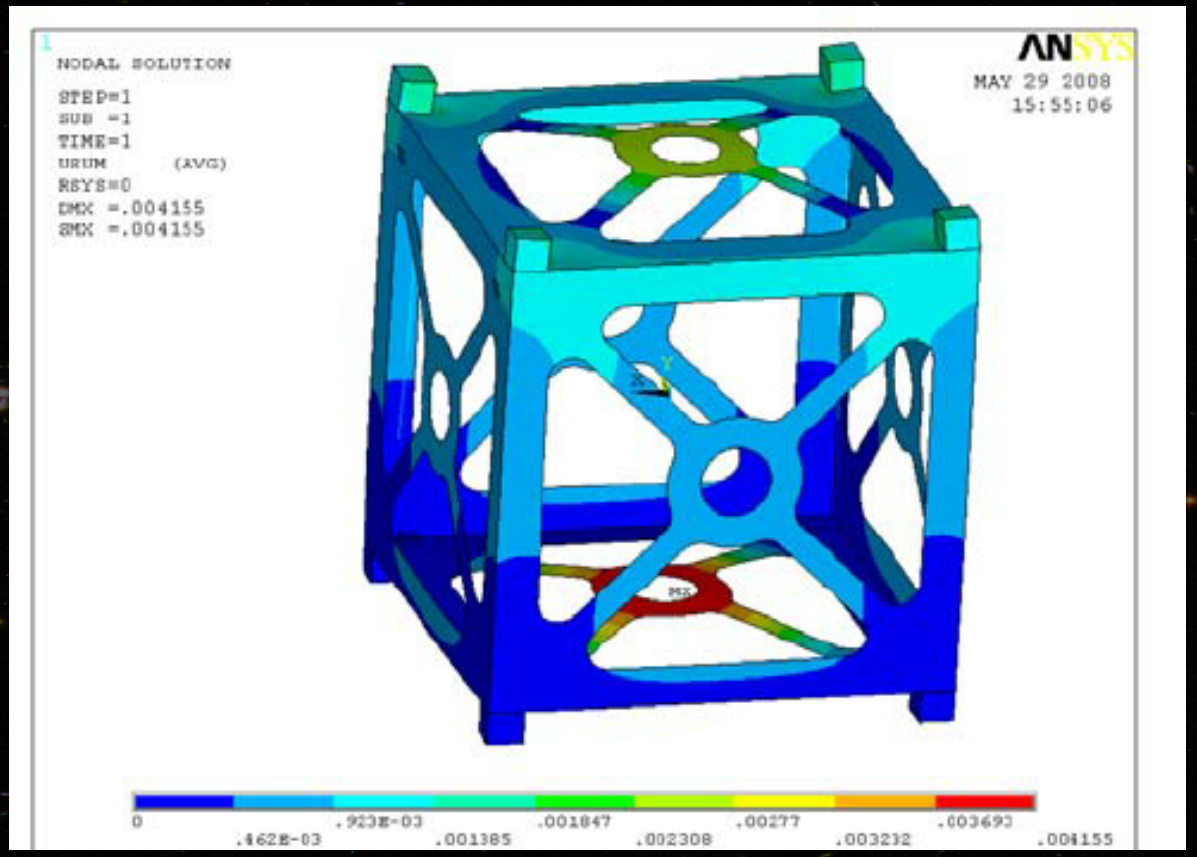
Sunshield for the James Webb Telescope

- **5-layer sunshield** blocks heat from Sun, Earth, and Moon.
- Reduces temperature by **~300°C** from hot side to cold side.

  Keeps telescope and instruments below **~40–50 K.**

Thermal Environment and Control

- Orbital thermal cycling between sunlit and eclipse phases
- Temperature limits driven by batteries and electronics
- **Thermal control strategy Managing Extremes: –40°C to +85°C**



Thermal Protection

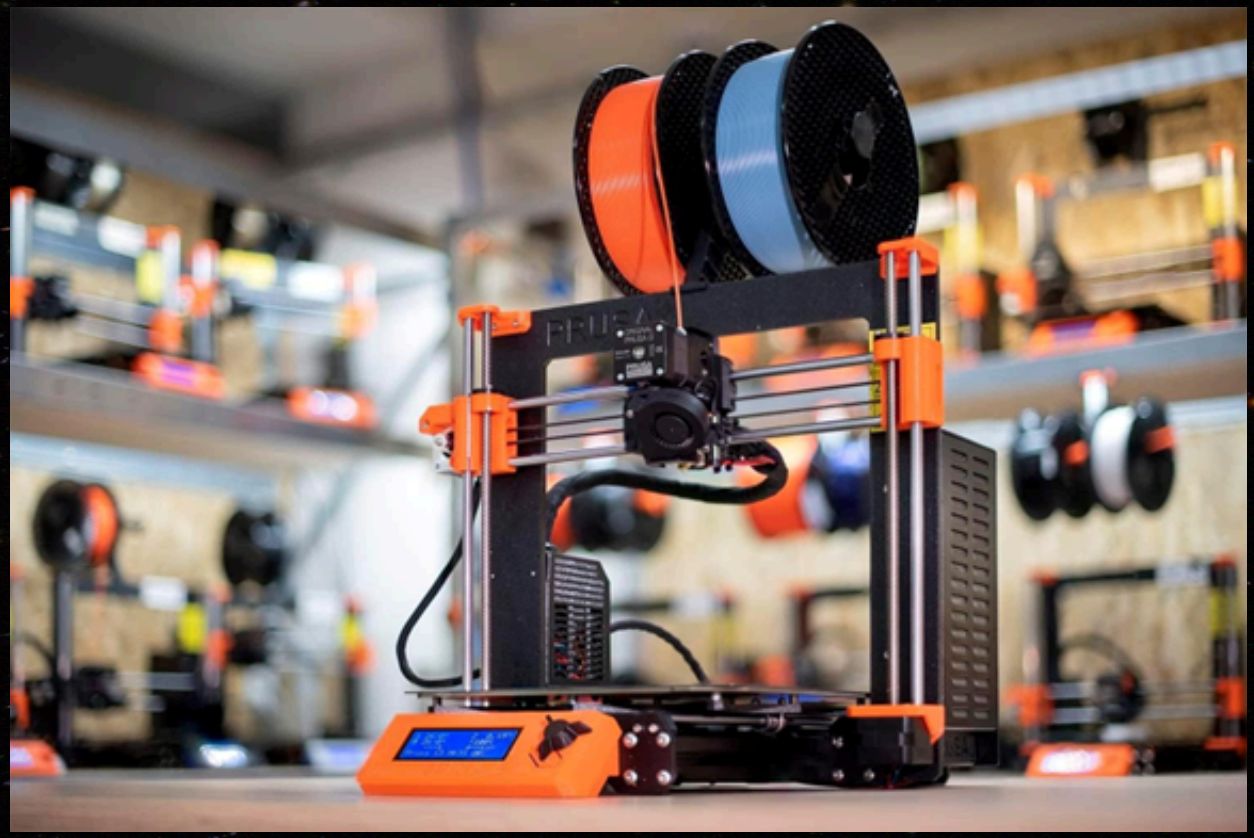
- Sensors monitor temperature
- Heaters prevent batteries from getting too cold
- Black interiors spread heat
- MLI reduces heat loss
- Treated rails maintain thermal stability

Manufacturing and Integration

Design constrained by:

- Manufacturability
- Tolerances
- Assembly access

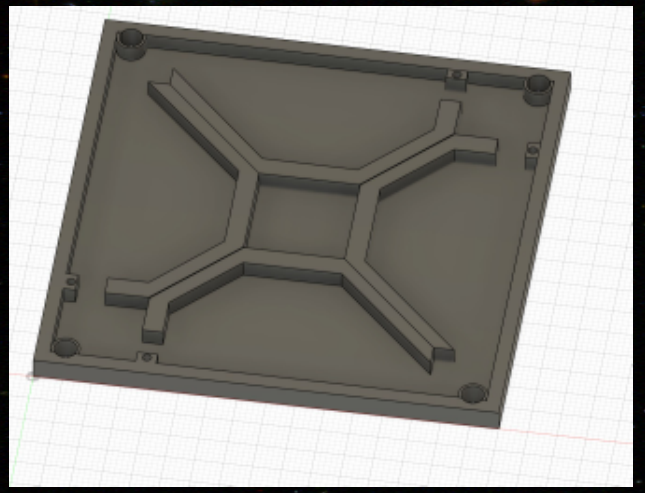
STS interacts with all subsystems during integration and precision machining used for flight hardware



Previous Projects by STS

Antenna Deployment

- Nylon wire restraint
- Burn-wire release in orbit
- Passive dipole deployment
- Deployer-independent



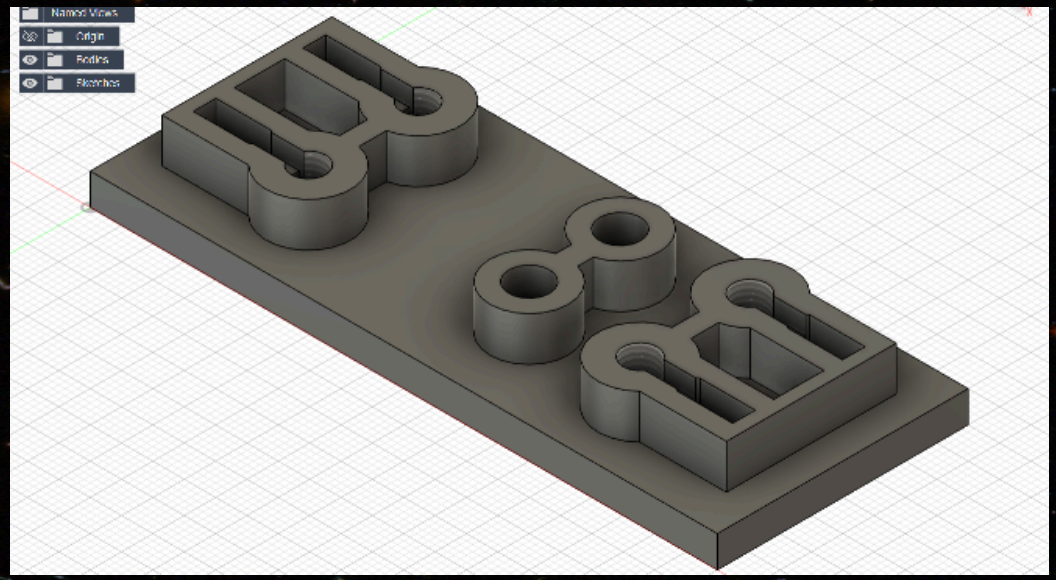
Gimbal Setup

- **Design & integration in progress**
- **Enables controlled pointing**

Application you need to ace

What You Will Learn

- Advanced CAD (Fusion 360 / SolidWorks) — from concept to manufacturing drawings
- FEA & Thermal Analysis (ANSYS) — predict how designs behave under extreme conditions
- Prototyping (3D printing, CNC, machining) — turn your design into physical metal, acrylics



STRUCTURAL AND THERMAL SUBSYSTEM

The Structure and Thermal Subsystem (STS) protects all components, meeting strict size and weight limits. It withstands launch stresses and regulates temperatures with passive insulation and active heating for sensitive parts.

TELEMETRY, TRACKING AND COMMAND

The Telemetry, Tracking, and Command (TTC) subsystem maintains a reliable satellite-ground link using UHF and VHF bands, handling data transmission and commands during short, high-data-rate passes.

Telemetry: Downlinking of data from the satellite to the ground station.

Tracking: Locating the position of the satellite in the orbit to ensure that the ground station antennas stay pointed towards the satellite.

Command: Uplink data/instructions from the ground station to the satellite.

What is This Data?

Primary Data:

- The image that is downlinked from the satellite to the ground station.
- Large, mission-critical data so requires compression and encoding

Beacon:

- Simple, low-power signal sent continuously
- Announces the satellite is alive, stable, and reachable
- Transmits housekeeping data

Errors!?

Details:

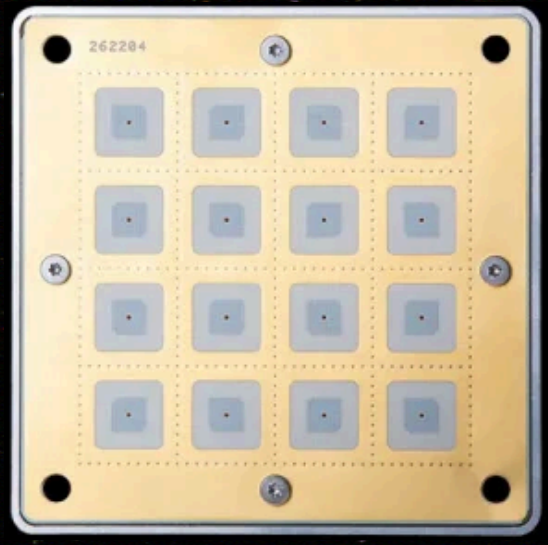
On 08/20/2020, at 10:31:12 AM Eastern Time, [redacted], date of birth [redacted], Home telephone number [redacted] Residential address [redacted] Essex, New York 12739, called the FBI National Threat Operations Center (NTOC) to report he was contacted by [redacted], date of birth [redacted], home address [redacted] Manhattan, New York 10023, who is a victim of Jeffrey Epstein.

Details:

On 08/20/2020, at 10:31:12 AM Eastern Time, Vatsal Goyal of birth 31/02/2006, Home telephone number, +91 9441696969 dential address Vatsal Goated Essex, New York 12739, called the FBI National Threat Operations Center (NTOC) to report he was contacted by [redacted], date of birth [redacted] home address [redacted] Manhattan, New York 10023, who is a victim of Jeffrey Epstein.

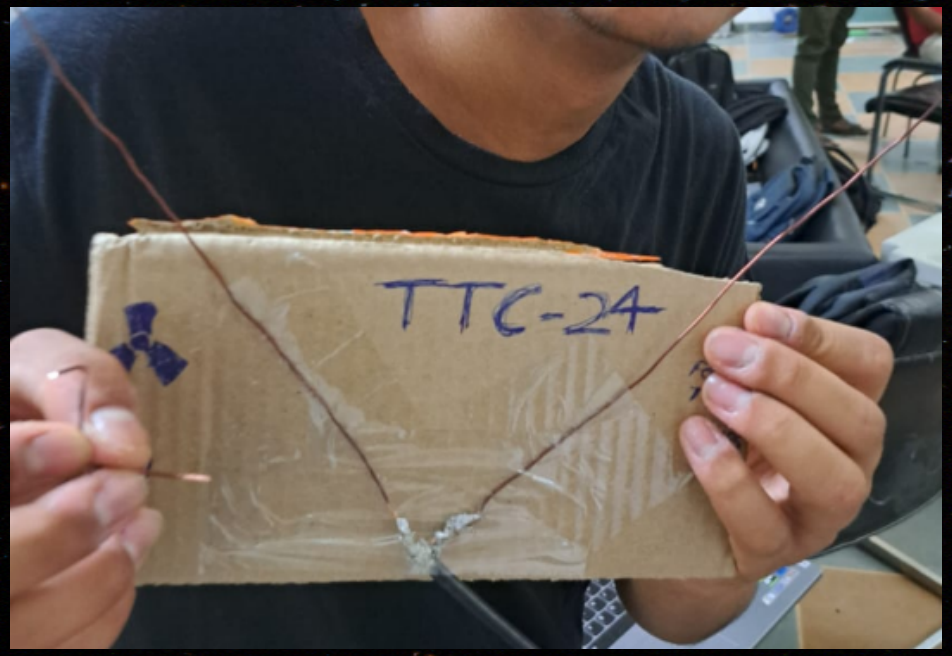
Antennas

Metal objects used to radiate electromagnetic waves for transmitting information



Stuff we have made

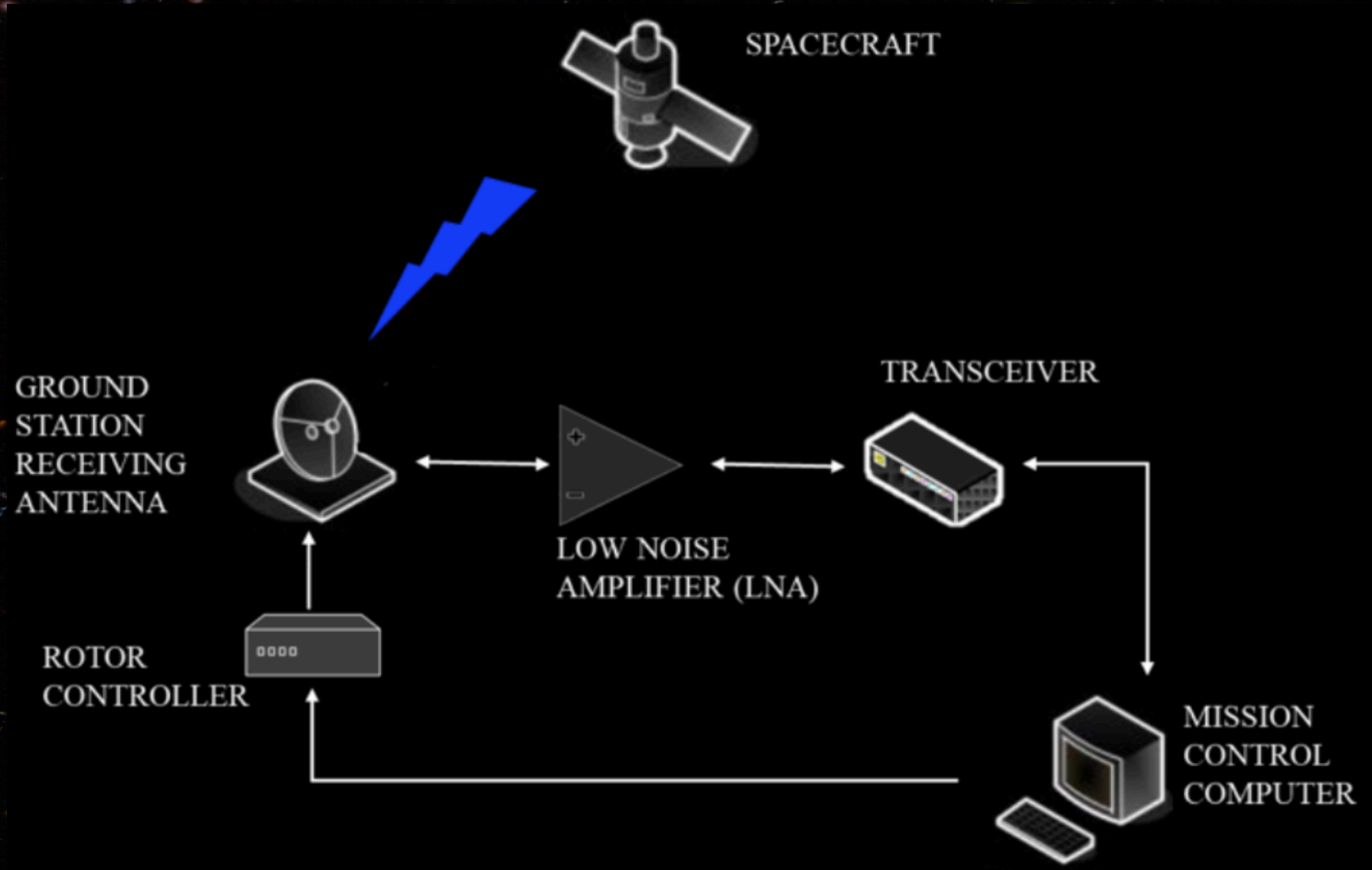
- Cool Biquad Antenna
- Even cooler Yagi antenna



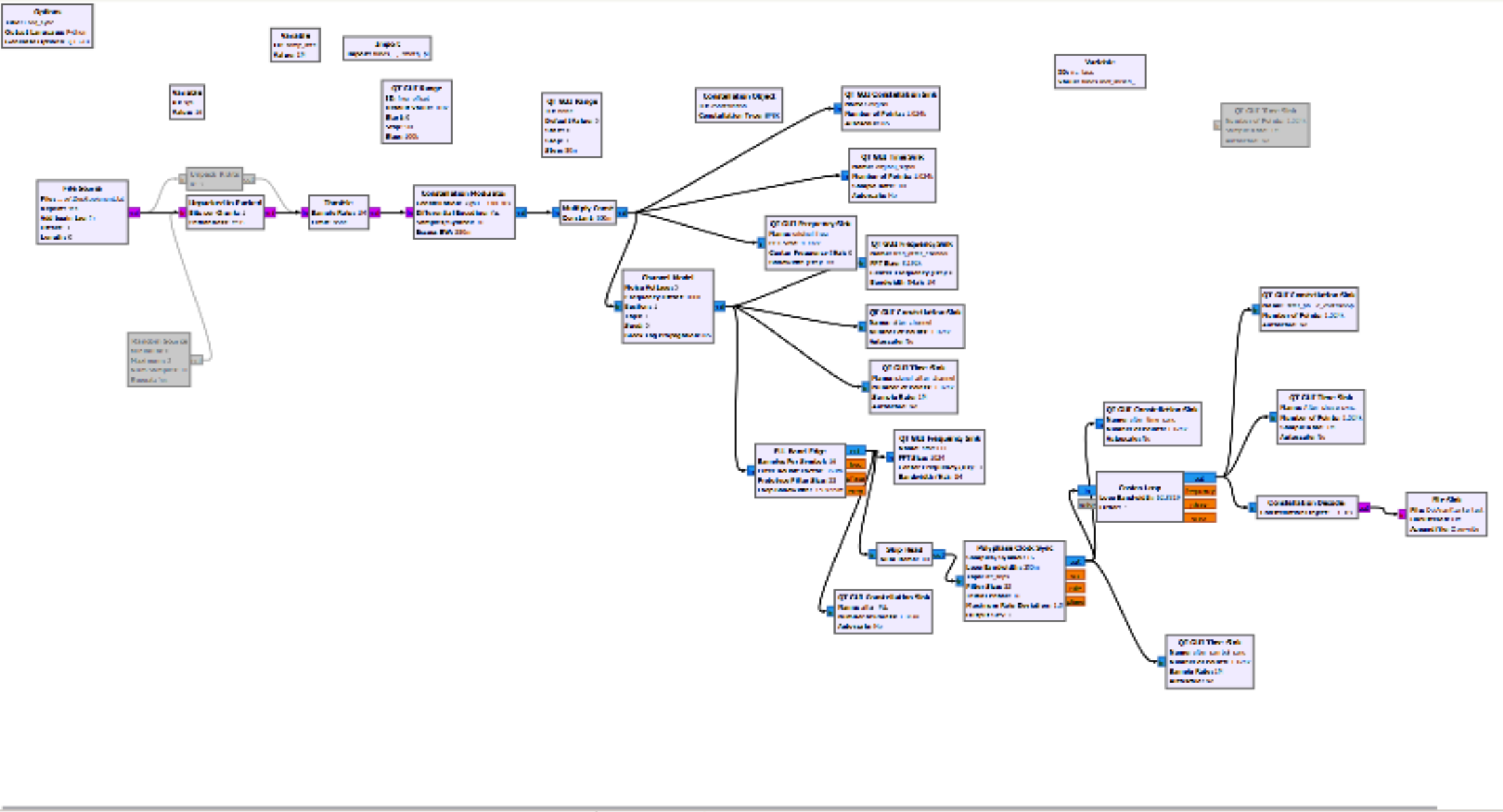
Ground Station

- We need a ground station to communicate with our satellite
- It must have a strong, directional antenna as well as signal and data processing capabilities
- It must be programmed to point toward the satellite

Ground Station System Flowchart



File Edit View Run Tools Help



- ADS-B
- Advanced File
- Core
  - ADALM 2000
  - Audio
  - Boolean Operators
  - Byte Operators
  - Channel Models
  - Channelizers
  - Coding
  - Control Port
  - Debug Tools
  - Deprecated
  - Digital Television
  - Equalizers
  - Error Coding
  - File Operators
  - Filters
  - Fourier Analysis
  - GUI Widgets
  - Impairment Models
  - Industrial I/O
  - Instrumentation
  - IO Correction
  - Level Controllers
  - Math Operators
  - Measurement Tools
  - Message Tools
  - Misc
  - Modulators
  - Networking Tools
  - OFDM
  - Packet Operators

Loading: "C:\Users\hp\OneDrive\Documents\Arduino\freq_correction.grc"
>>> Done

ID	Value
Imports	
	from gnuradio.filter import firdes

Ground Station Hardware

Antenna

Rotator

Software Defined Radio

TELEMETRY, TRACKING AND COMMAND

The Telemetry, Tracking, and Command (TTC) subsystem maintains a reliable satellite-ground link using UHF and VHF bands, handling data transmission and commands during short, high-data-rate passes.

ON BOARD COMPUTER

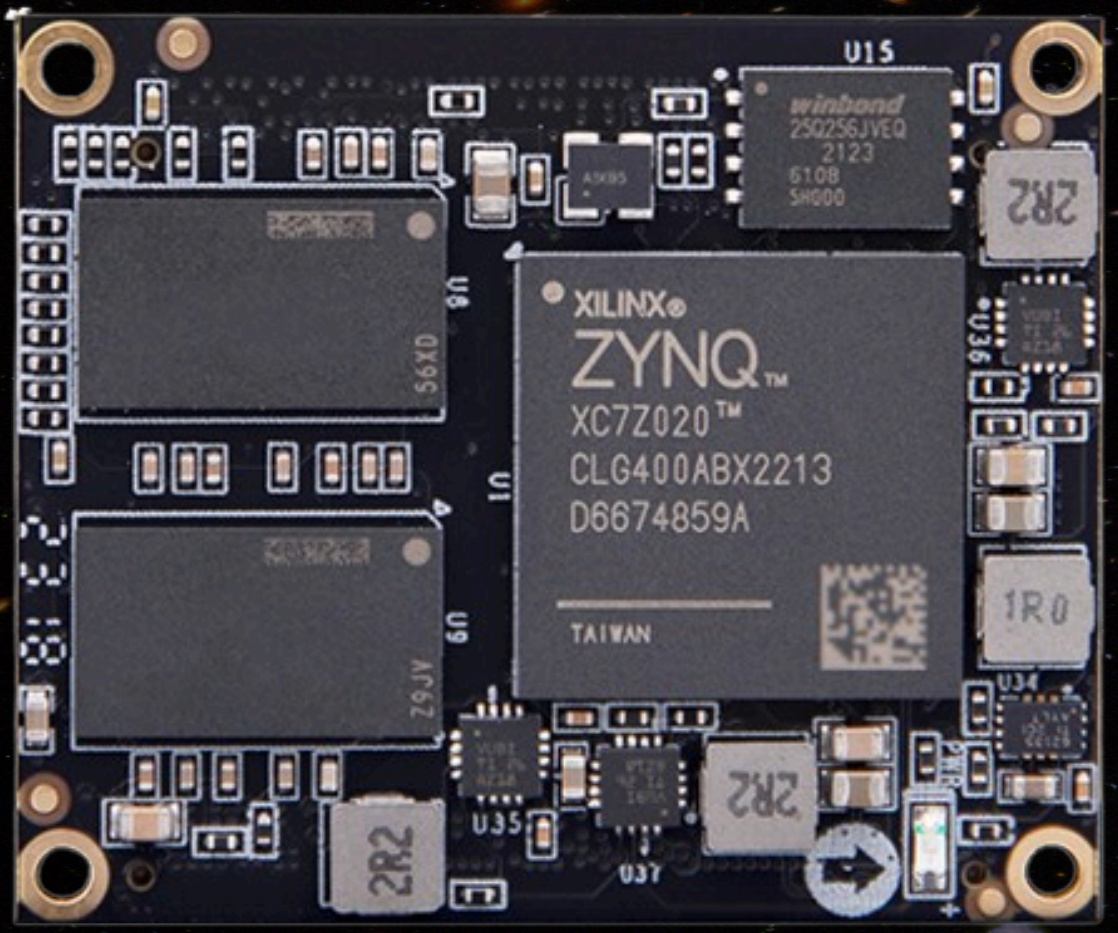
The On Board Computer (OBC) coordinates all subsystems using a power-efficient System-on-Chip with a microprocessor for management and an FPGA for camera interfacing.

CODE FLIGHT PLAN

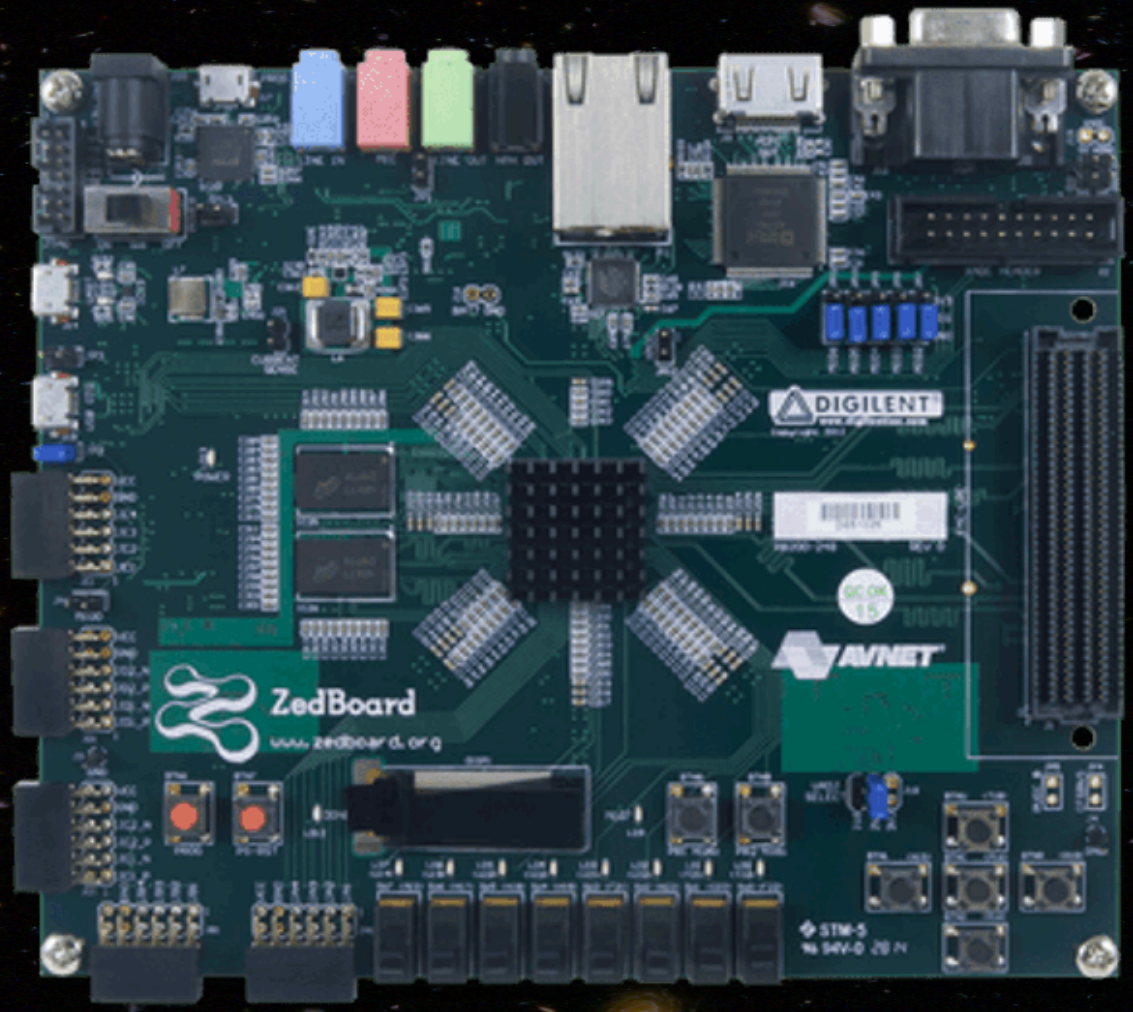
INTERFACE SENSORS

PROGRAM FPGAs

BUILD OS

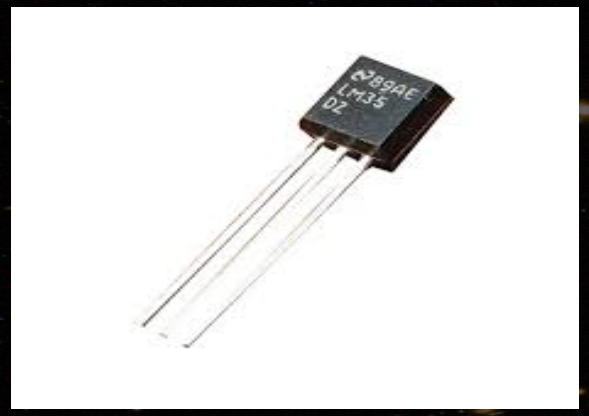


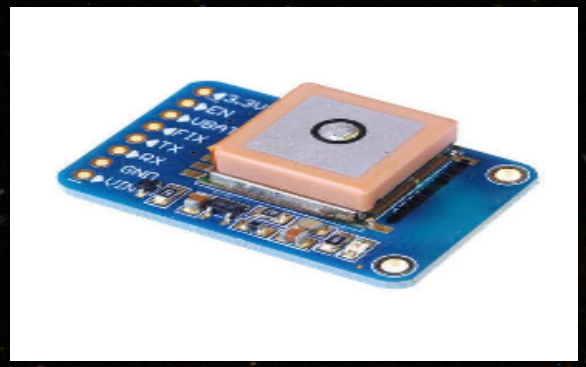
FPGA CHIP

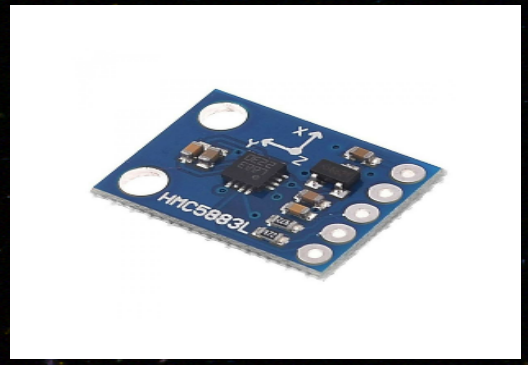


Dev Board (ZedBoard)

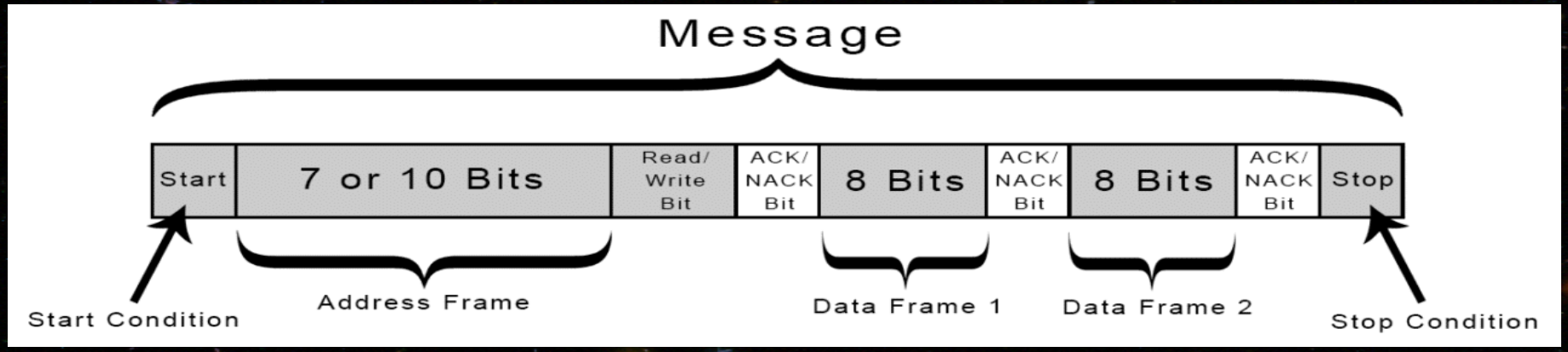
SENSOR INTERFACING



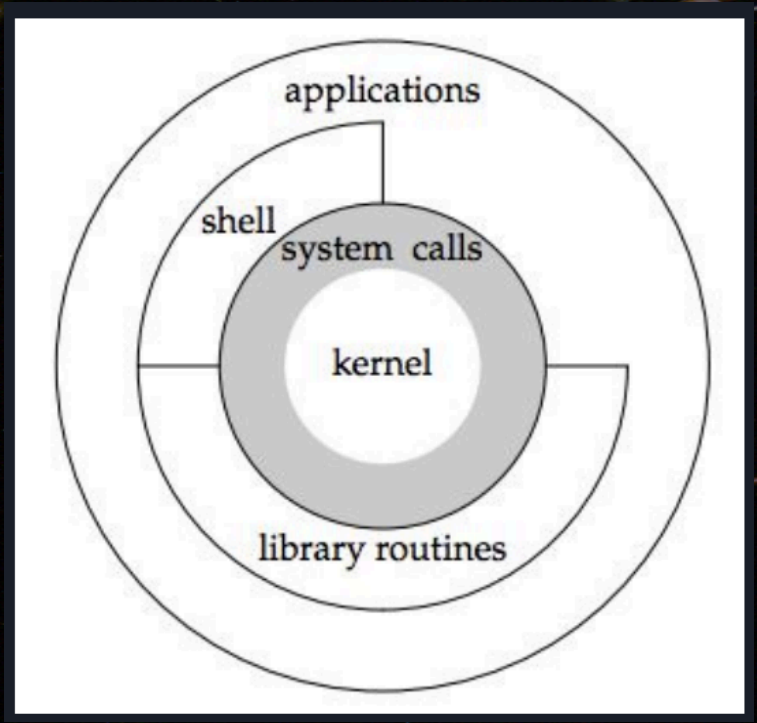


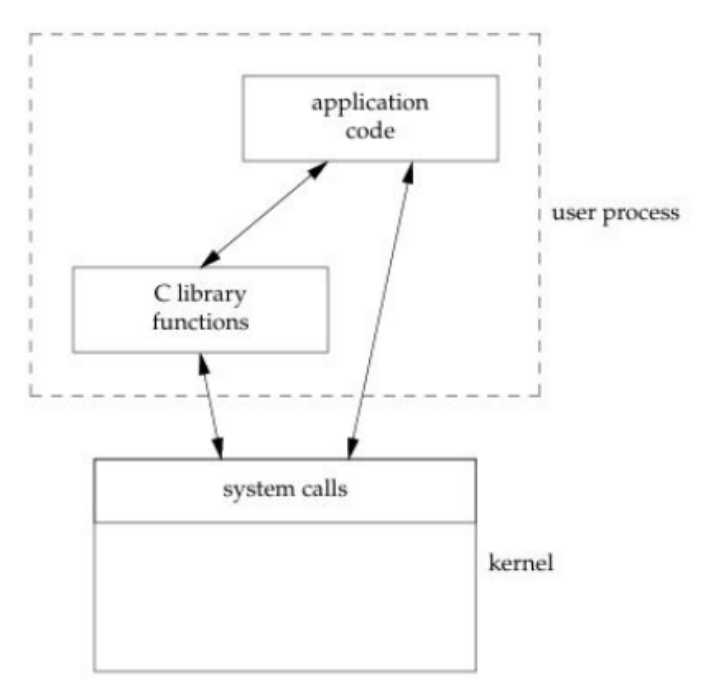


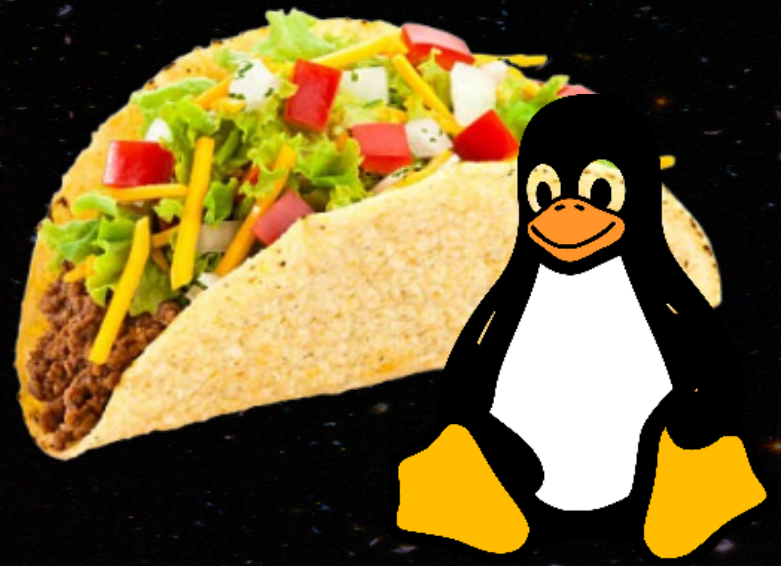
Communication Protocols



Operating System



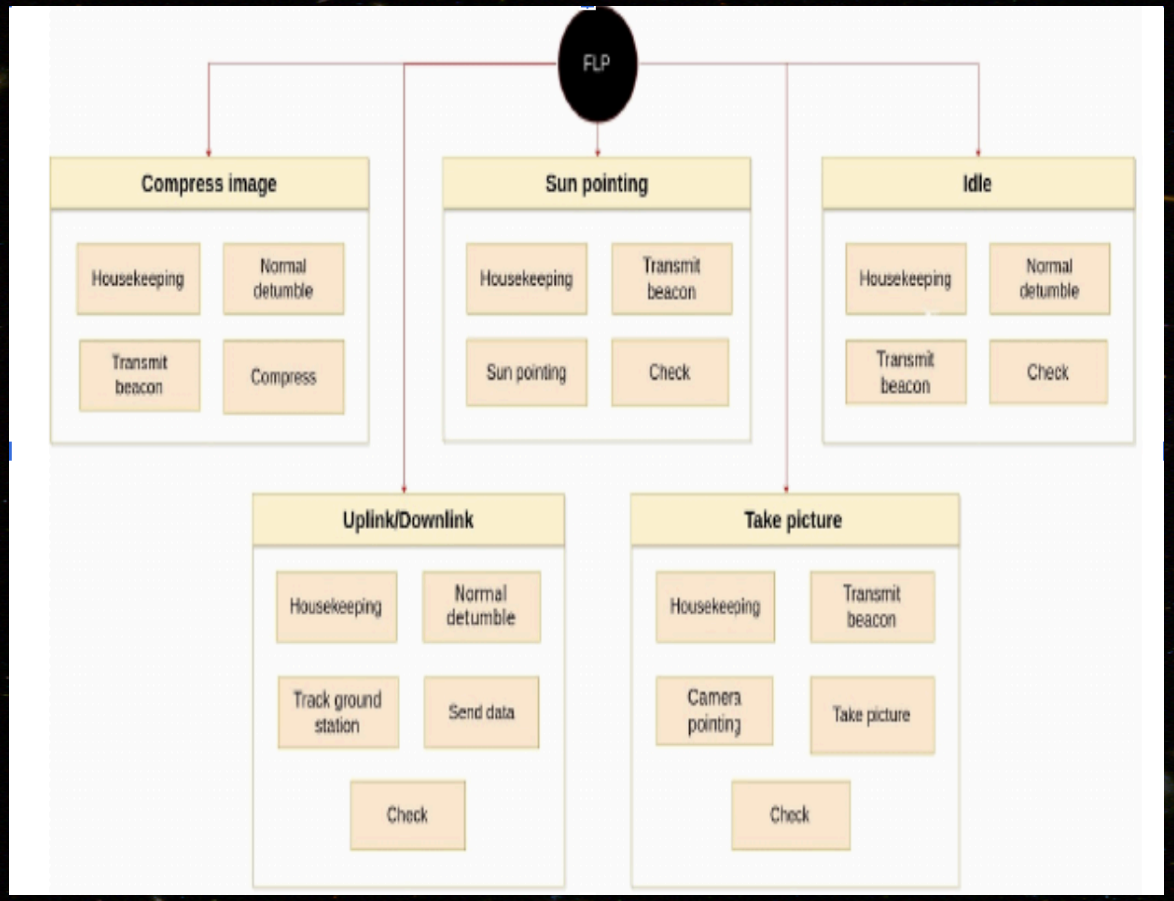




TACOS - Team Anant
Cubesat Operating System

Modern OS Architecture

FLIGHT PLAN



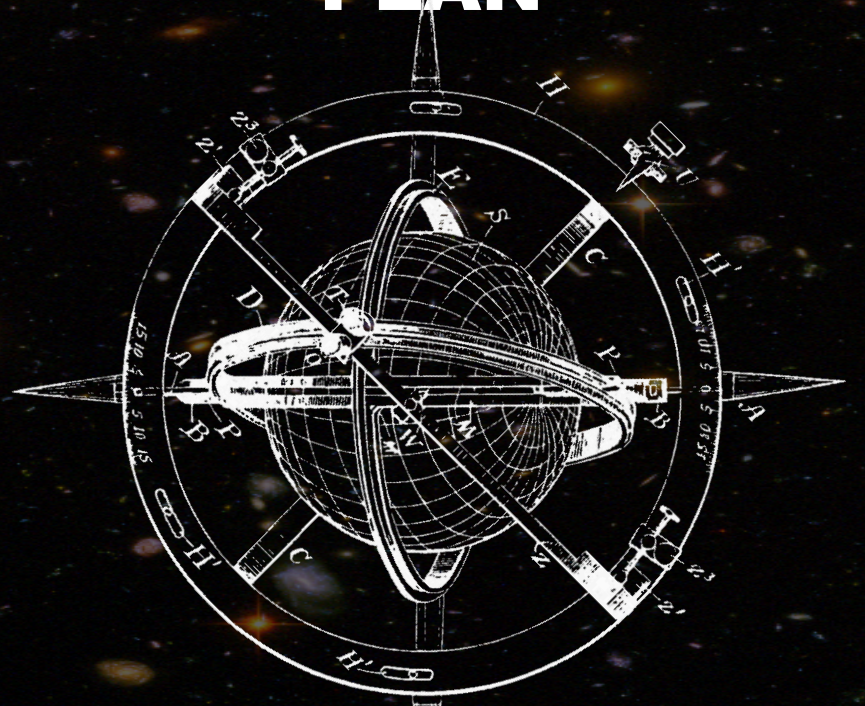
	Present State		Inputs			Next State		Outputs				
Present-State Symbol	G_1	G_0	*Start*	A_2	A_3	G_1	G_0	*set_E*	*clr_E*	*set_F*	*clr_A_F*	*incr_A*
S_idle	0	0	0	X	X	0	0	0	0	0	0	0
S_idle	0	0	1	X	X	0	1	0	0	0	1	0
S_1	0	1	X	0	X	0	1	0	1	0	0	1
S_1	0	1	X	1	0	0	1	1	0	0	0	1
S_1	0	1	X	1	1	1	1	1	0	0	0	1
S_2	1	1	X	X	X	0	0	0	0	1	0	0

State Table

Why OBC?

CODE FLIGHT PLAN

INTERFACE SENSORS



PROGRAM FPGAs

BUILD OS

ON BOARD COMPUTER

The On Board Computer (OBC) coordinates all subsystems using a power-efficient System-on-Chip with a microprocessor for management and an FPGA for camera interfacing.

TEAM ANANT

Design and Media Team

What We Do

- **Internal work: Posters, standees, video presentations** for the institute's review meets.
- **External-facing work:** Merchandise, recruitment posters and fest promotional posters during APOGEE.
- **Team Anant website**
- Managing the team's **social media presence** (LinkedIn, Instagram) and outreach.

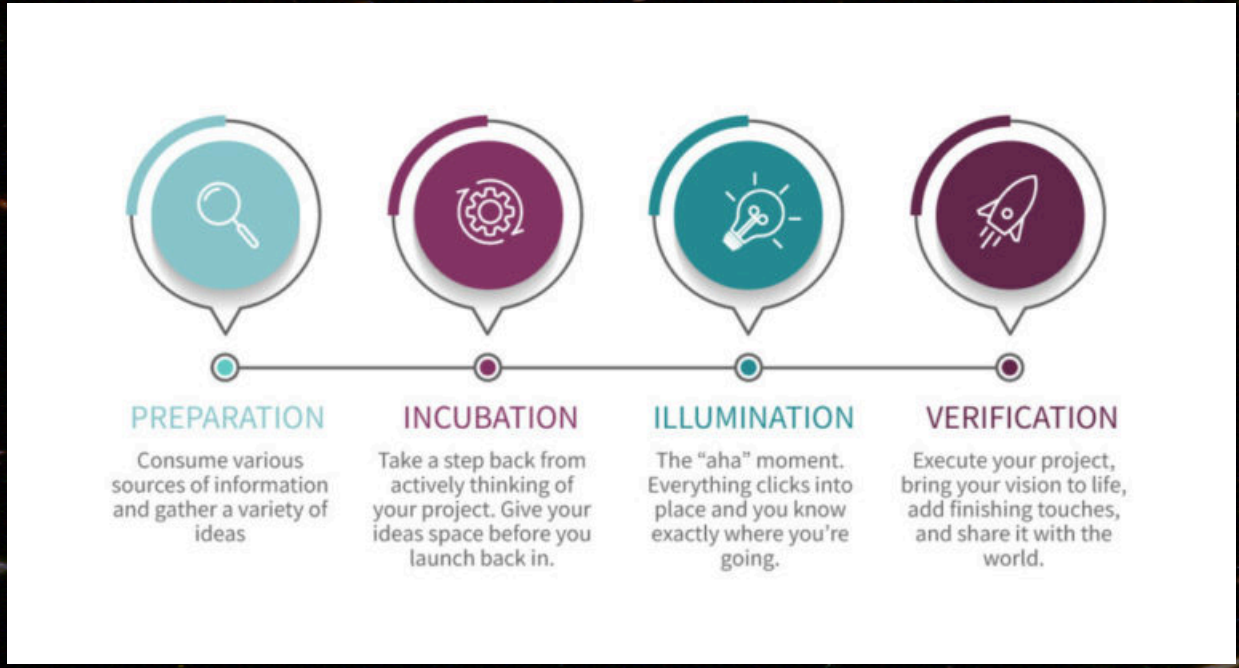
Roles We're Recruiting For

1. **Designers** (posters, standees, merchandise)
2. **Frontend developers** & **UI/UX designers**
3. **Video editors**

- **Four Tasks** will be given with the roles in mind.
- Take help of the **recommended resources** to complete the given tasks effectively.

Design

- Inspiration – Pinterest, Behance, Dribbble
- Observation is important
- Figma, Photoshop, Illustrator, Affinity



WebDev

- Mozilla Developer Network Web Docs
- HTML & CSS
- JavaScript

Video Editing

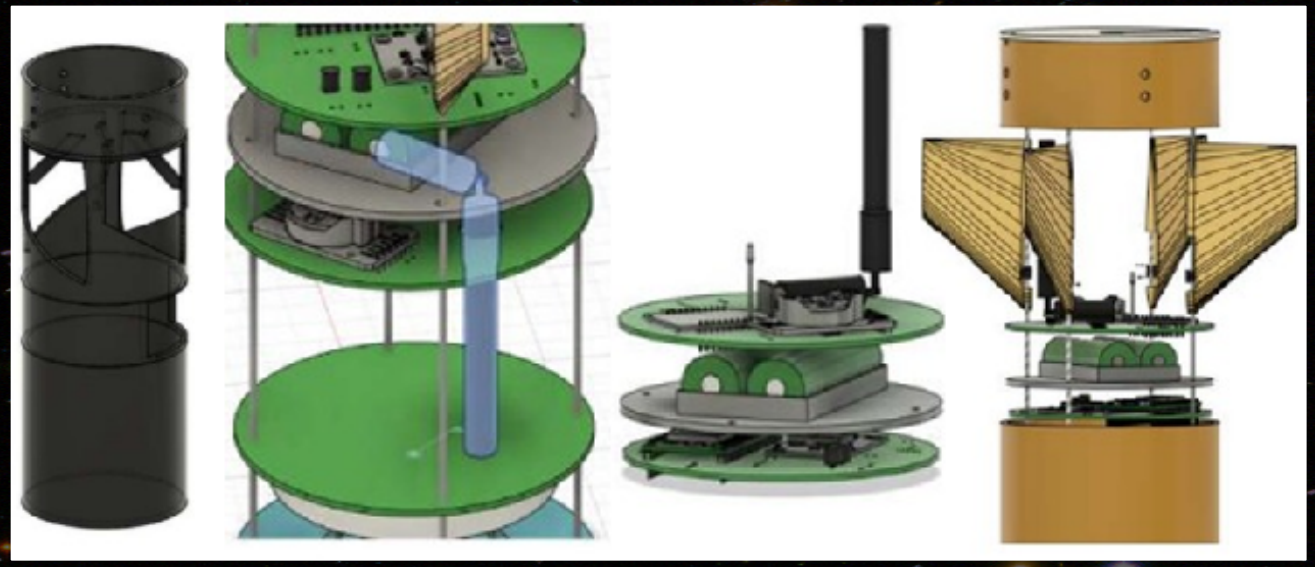
- **Graphic Design** is important
- Motion Graphics, Infographics
- Vox is cool

TEAM ANANT

Design and Media Team

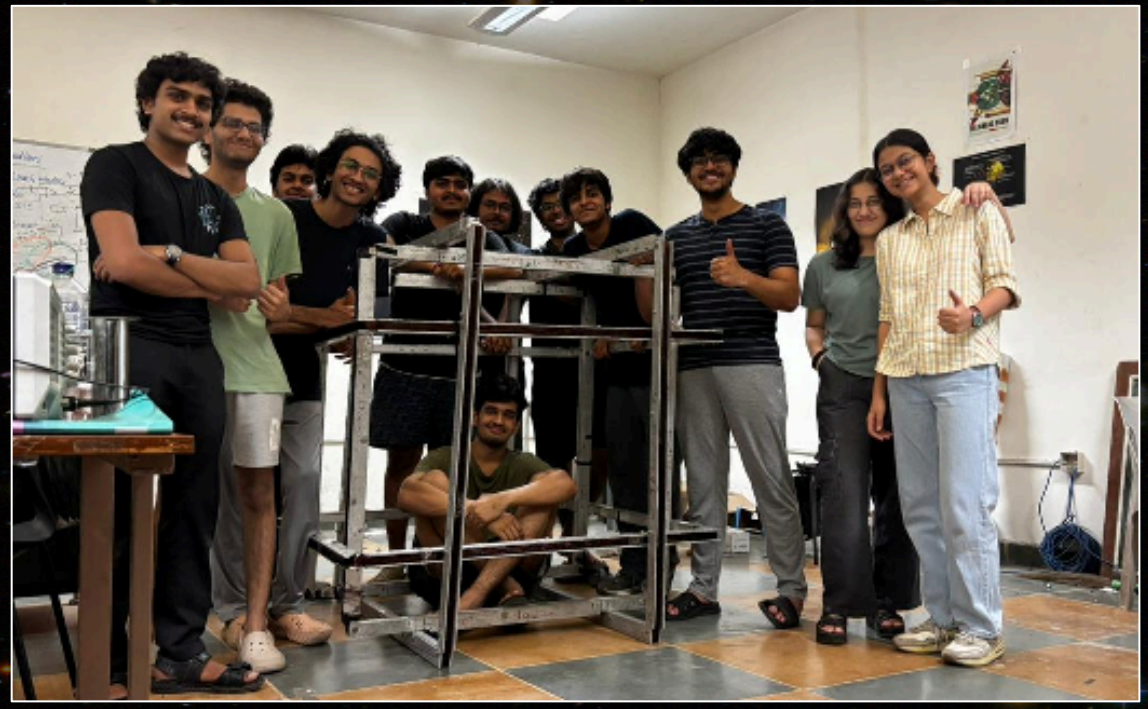
TECHNICAL ACHIEVEMENTS

CANSAT 2024



Our team along with our FIC Dr. Meetha V. Shenoy advanced to the CANSAT 2024 finals with innovative CAD models.

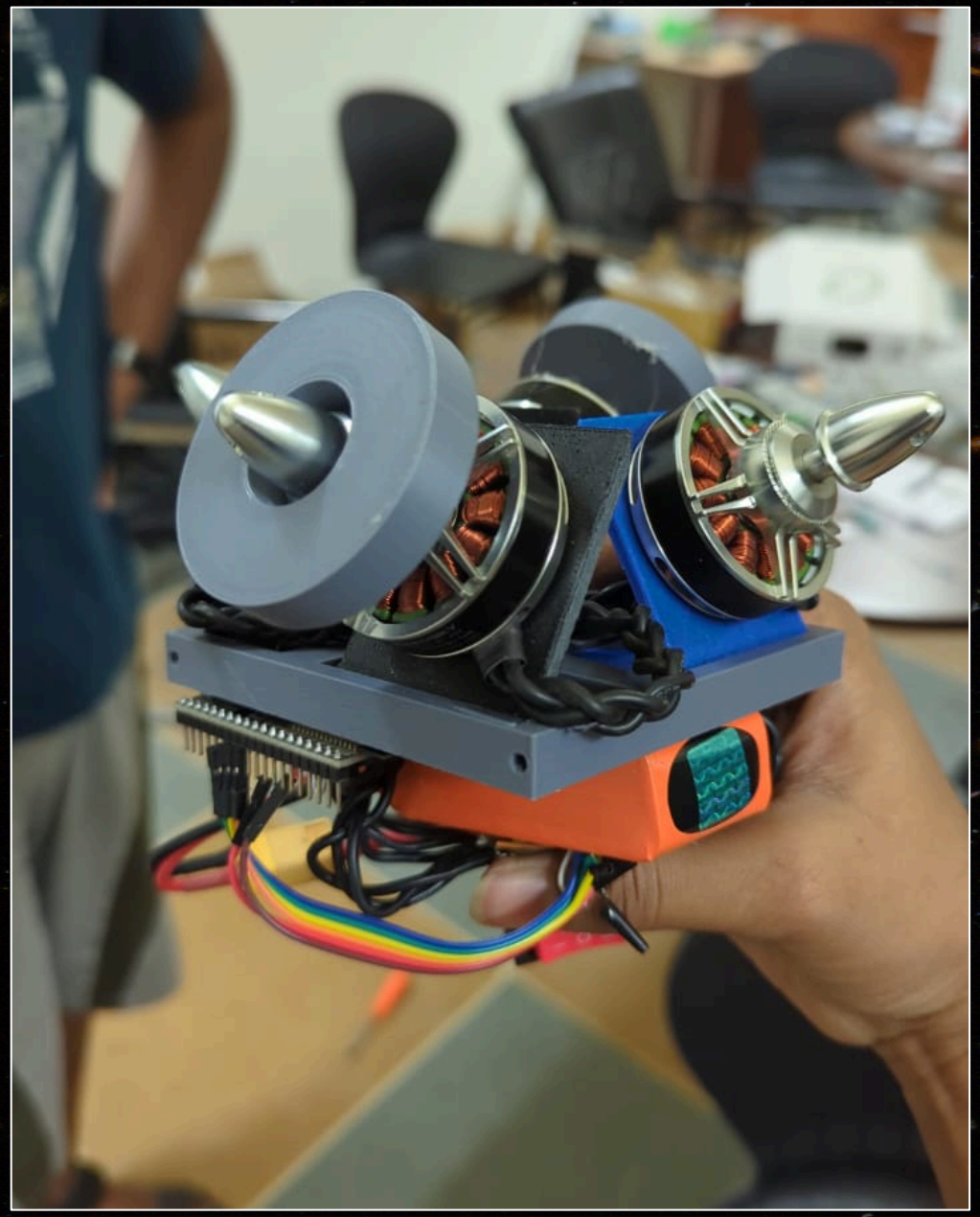
We earned an honorable mention as the only team to implement reaction wheel-based control, showcasing both technical innovation and competitive distinction.



HELMHOLTZ CAGE

We completed the construction of a Helmholtz Cage to test our models in magnetic fields that closely resemble space conditions.

This setup enables us to rigorously simulate and analyze the magnetic environment our systems would encounter in orbit, ensuring accurate and reliable performance validation.



REACTION WHEEL MODULE

The reaction wheels module, designed and built in-house, uses PID-controlled BLDC motors to provide precise rotational control and fine attitude adjustments without propellant.

Integrated with the ADCS, these wheels are essential for accurate orientation during imaging, sun pointing, and ground station tracking.

ADCS 3 AXIS GIMBAL

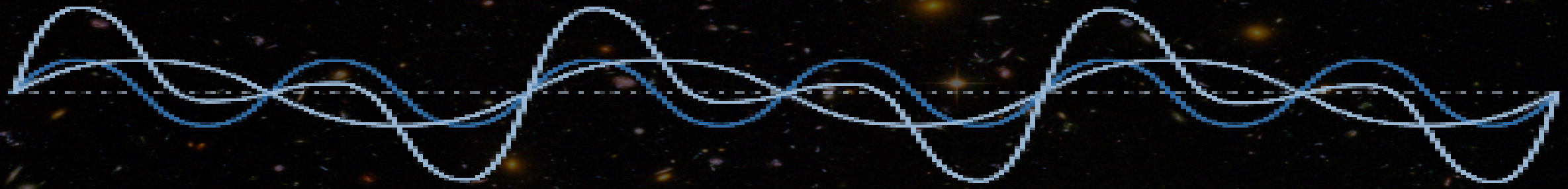
The ADCS gimbal is a 3-axis test bench that can track satellite rotation with high precision down to 0.25 degrees.

It enables hardware-in-the-loop testing and real-time validation of the satellite's attitude control algorithms and actuators, closely simulating on-orbit conditions.


What to expect?

RECRUITMENTS

TIMELINE



ROUND 1
24-hr Test

ROUND 1
Interviews

ROUND 1
Results

PROBATION
LECTURES

PROBATION TASKS

FINAL SYSTEMS AND
SUBSYSTEM INTERVIEWS

RECRUITMENT
RESULTS

ROUND 1 Test

The first screening test to evaluate your fundamental understanding and problem-solving abilities.

- **Start: 17 January 2026, 12 pm**
- **Duration: 24 hours**
- **Open Internet Test**
- **You may attempt the paper for multiple subsystems.**
- **Your current choice does not lock you into the specific vertical.**

Form Link

JOIN FOR UPDATES AND QUERIES

QUESTIONS

TEAM

ANANT