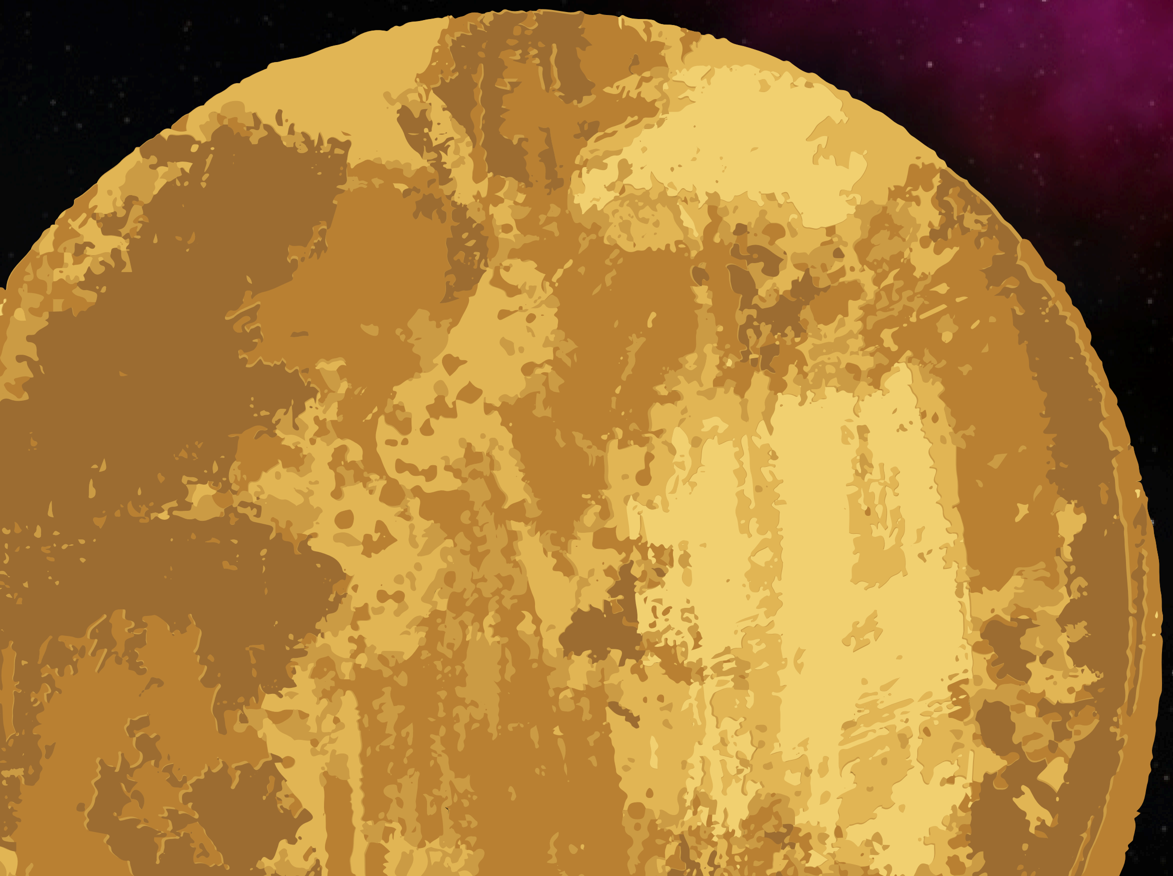
OLYMPUS TECH 2.0

Team:
Spandhana Arun: EP24BT003
Skanda P: CS24BT045
Manushree I.R: EE24BT025

OUR MISSION

We aim to design a CubeSat that will operate within the specified constraints to observe and gather data on the atmosphere of Venus

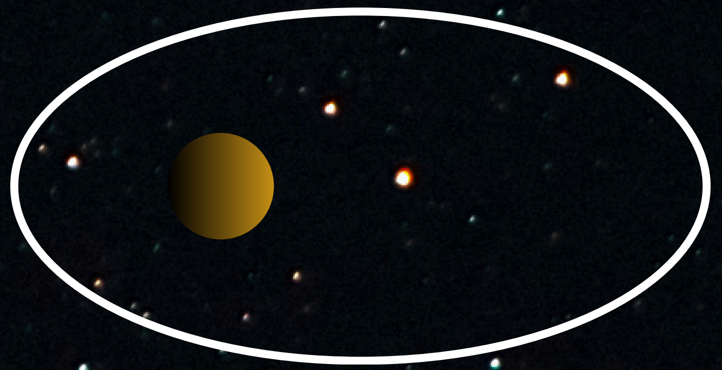


Constraints:

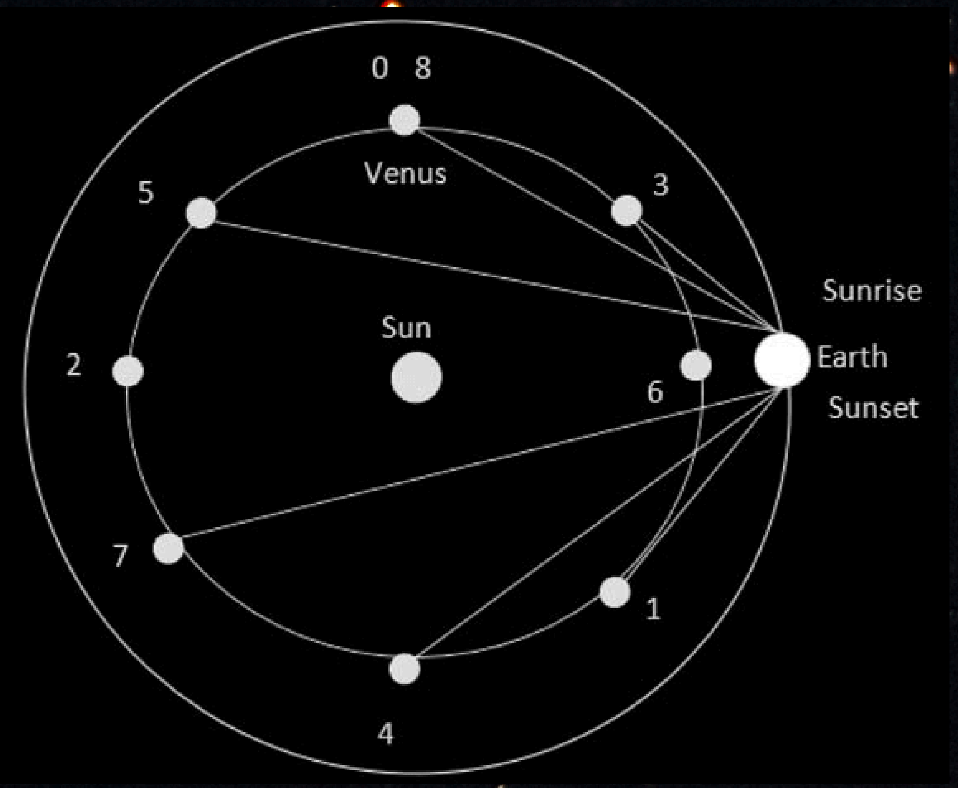
- Corrosive Atmosphere-The atmosphere of Venus is composed of carbon dioxide (96.5%) and contains sulfuric acid clouds
- Extreme temperatures and significant temperature variations in the atmosphere
- Results in complications with electronic devices and mechanical design.
- The 1Kg weight constraint

CHOICE OF ORBIT- deployed into the highly elliptical orbit(HEO)

- **Extended observation time and proximity to venus**: In a highly elliptical orbit, the CubeSat can spend a significant amount of time at lower altitudes, allowing for prolonged observations of the atmosphere during the perigee.



- **Reduced atmospheric drag and longer duration at higher altitudes**: The CubeSat can reach altitudes above the thickest part of Venus' atmosphere during the apogee, reducing atmospheric drag.



- **Targeted data collection and focused sampling**: The elliptical orbit allows the spacecraft to target specific atmospheric layers and phenomena, such as cloud formations and pressure systems. By approaching from different angles and speeds, the CubeSat can gather varied data.

- **Minimal thermal stress**: By spending less time in the thick atmosphere where temperatures can exceed 450 °C (842 °F), the CubeSat reduces exposure to extreme heat

- **Efficient solar power generation**: During the higher-altitude sections of the orbit, the CubeSat can maximize solar power generation

MATERIALS AND INSULATION

- PEEK-based Carbon Fiber Composite(1.33 g/cm^3) used for the structural frame, can withstand temperatures up to 260°C,highly suitable for environments that might involve corrosive gases or chemicals ,can be used to encapsulate sensitive electronic components.

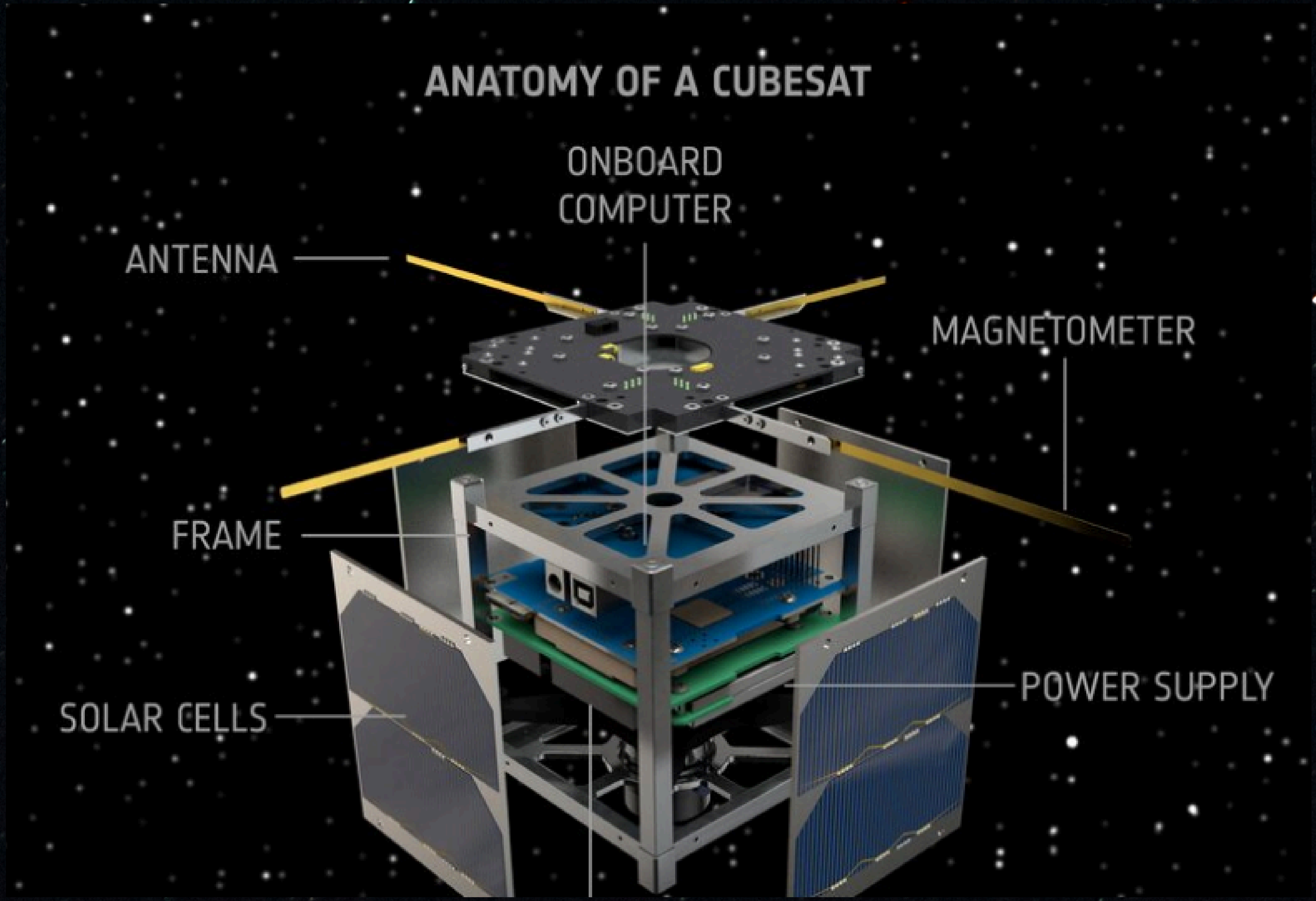
- Gold foil coating on external surfaces .

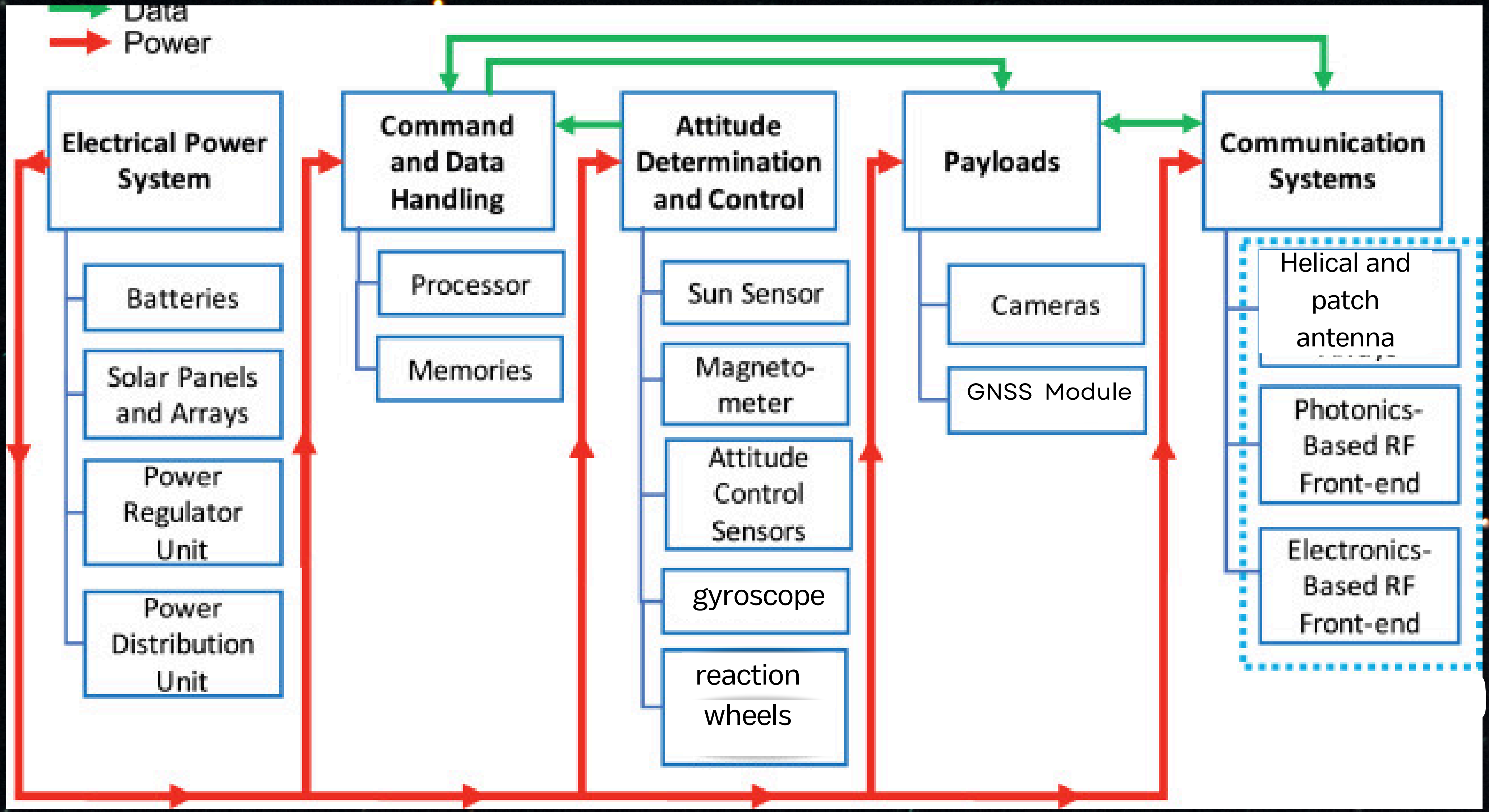
- Using MLI(Multi Layer insulation) for interior components.

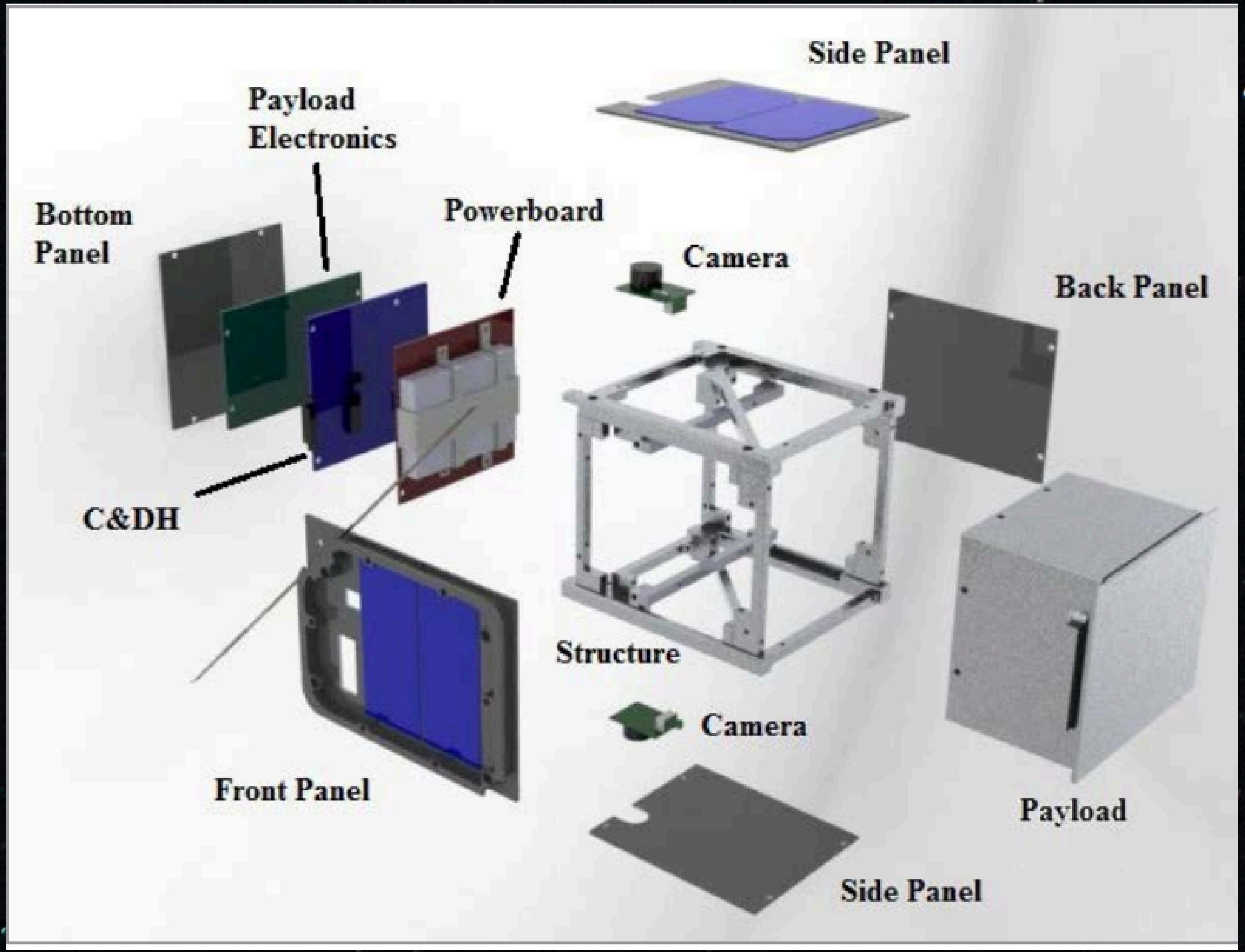
- Mylar a lightweight polyester film that metallized with aluminium to achieve high reflectivity is used as a heat shield.

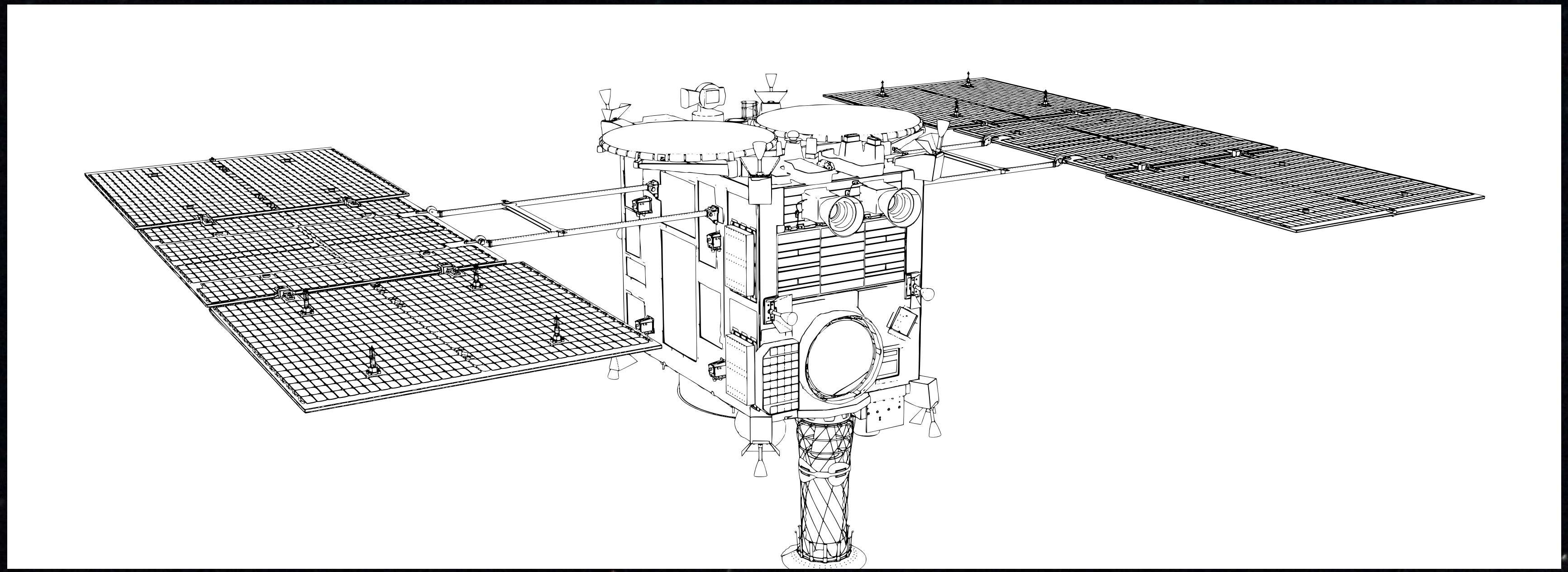
DESIGN AND STRUCTURE

- The CubeSat features dimensions of 15 cm by 15 cm by 15 cm.
- Structural frame of the cubesat is made out of PEEK-based carbon fibre
- The heat shield is crafted from lightweight Mylar polyester film ($15 \times 15 \times 0.1 cm^3$) coated with a thin layer of aluminum ($15 \times 15 \times 0.01 cm^3$)
- Pair of side mounted deployable solar panels($12 \times 12 \times 1 cm^3$) with high emissivity coating
- Small sensor apertures and windows with specialized coating present to allow the sensors interact with the atmosphere
- Deployable helical antenna
- Surface mounted patch antenna
- equipped with a multispectral camera




Data
Power
Electrical Power System
Batteries
Solar Panels and Arrays
Power Regulator Unit
Power Distribution Unit
Command and Data Handling
Processor
Memories
Attitude Determination and Control
Sun Sensor
Magneto-meter
Attitude Control Sensors
gyroscope
reaction wheels
Payloads
Cameras
GNSS Module
Communication Systems
Helical and patch antenna
Photonics-Based RF Front-end
Electronics-Based RF Front-end


Side Panel
Payload Electronics
Bottom Panel
Powerboard
Camera
Back Panel
C&DH
Structure
Camera
Front Panel
Payload
Side Panel



SATELLITE BUS

- Multi-Axis MEMS Gyroscopes: Measuring 4 x 4 x 1 mm and weighing 1.5 grams.
- Reaction Wheels :measuring 50mm in diameter and 30mm in height, which weighs 200g
- Sun Sensor: Measuring 30 x 30 mm and weighing 20 grams.
- GNSS Module: Measuring 30 x 30 x 10 mm, 10g
- A 2.4 GHz antenna, with N = 5 turns at λ/4 spacing, the optimal helical antenna yields 11.8dBi gain with 153mm overall length, 39mm diameter, and 30mm spacing between coils,weighs about 50g.

- The CubeSat is equipped with a multispectral camera measuring 50 mm x 50 mm x 60 mm and weighing approximately 200 grams.
- We utilize a cold gas propellant with dimensions of 2 cm in length and 1 cm in diameter, weighing 20 grams.

PAYLOAD

- Microcontroller: Arduino Board-MKR series (67.64 mm x 25 mm), weighing 32g mounted on PCBs (40 mm x 40 mm).
- On-Board Computer (OBC): 90 mm x 90 mm x 10 mm, approximately 50g.
- Battery: Lithium Iron Fluoride (LiCFx) pack, 50g, with a power management system (90 mm x 90 mm x 10 mm, 50g).
- Battery Management System (BMS): 5 cm x 5 cm, 20g.
- Power Distribution Unit: 150g, dimensions 10 cm x 10 cm x 5 cm.
- Power Conditioning and Conversion Module: 50g, dimensions 10 cm x 10 cm x 3 cm.
- Sensors:
  - MEMS Magnetometers: 3 mm x 3 mm x 1 mm, 0.2g.
  - Barometer (BME280): 3.6 mm x 3.6 mm x 1 mm, 200g.
  - Microbolometer: 1 cm x 1 cm, 10g.
  - Miniature Mass Spectrometer (QMS): 6 mm diameter, 200g.

ATTITUDE DETERMINATION AND CONTROL SYSTEM

- CubeSat is equipped with advanced attitude control systems, including

1. MEMS gyroscopes
2. reaction wheels
3. sun sensors

ensuring precise orientation and stability during its mission

- Includes a GNSS module for orbit determination, navigation

- Control algorithm includes PID controllers to maintain and adjust the CubeSat's orientation

- Power Management System, Power Distribution Unit (PDU), and Failure Detection, Isolation, and Recovery (FDIR) System for monitoring and managing the CubeSat's power supply

Why mems gyroscopes?
compact ,lightweight, low power consumption, most importantly can withstand temperature variations and harsh conditions

Why magnetorquers are not suitable?

weak magnetic field of Venus, combined with its dense and corrosive atmosphere, makes magnetorquers impractical for spacecraft operating in this environment

SENSORS

Miniature Mass Spectrometer to analyze, detect and quantify various gases in the atmosphere.

Thermal sensor-Microbolometer enables thermal imaging, remote sensing and surveillance applications

MEMS magnetometer for analyzing magnetic field strength, direction and effects

Pressure, temperature and humidity sensor Barometer(BME280 sensor) can measure humidity in addition to temperature and air pressure

Quadrupole Mass Spectrometers (QMS) can considered as a good option, but due to weight constraints, we cannot use them

Including advanced sensors like an Aerosol Spectrometer and Cloud and Precipitation Sensors would enhance the CubeSat's capabilities for atmospheric studies. However, due to the strict weight and space limitations of CubeSats, adding these instruments isn't feasible

*****All electronics will be radiation-hardened.***

POWER MANAGEMENT

- The CubeSat is equipped with two deployable solar panels mounted on its sides with high emissivity coating to reject heat into the shadow side.
- Lithium Iron Fluoride (LiCFx) Battery pack which offers high energy density is used(*not rechargeable*).
- *While a Radioisotope Thermoelectric Generator (RTG) would provide a reliable power source for extended missions, its weight constraints make it unsuitable for our CubeSat.*
- Power Conditioning and Conversion module includes buck-boost converters used for stepping up or down the voltage from solar panels and battery management system(BMS) monitoring and managing battery health.
- Suitable power distribution unit(PDU).

Communication

Antenna

The antenna is responsible for sending and receiving radio signals

Tranceiver

Combines both transmission and reception in one unit to save space and power

Power Amplifier

Power amplifiers boost the radio signal strength to ensure it can be transmitted over large distances

Modulator and Demodulator

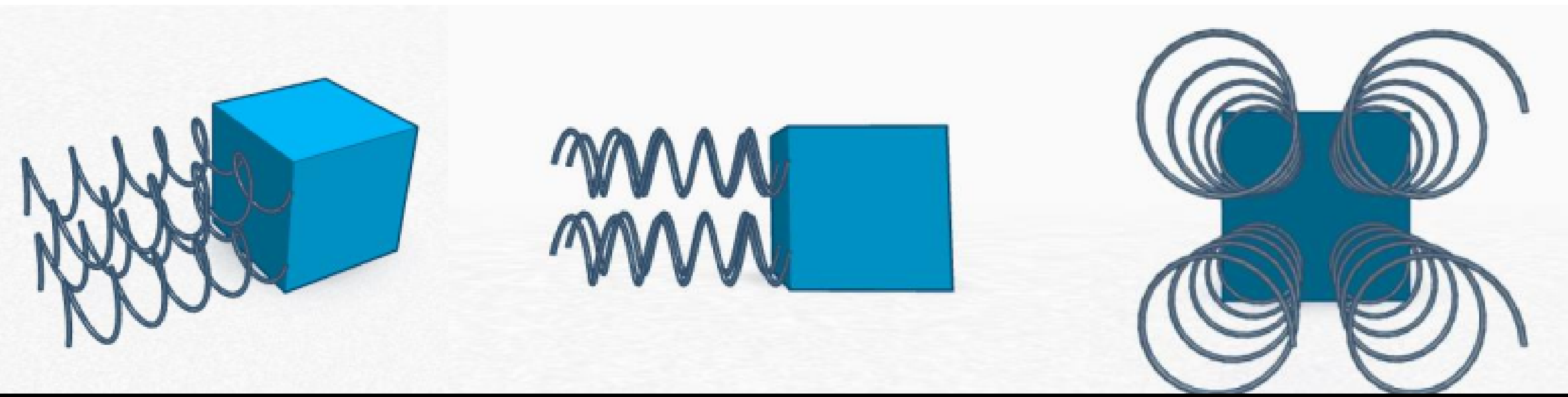
Also known as a modem, these form the two way communication. The modem encodes data and extract from incoming airwaves

For our cubesat, we will be using a combination of helical antenna and patch antenna. The helical antenna will be used for high frequency data transfer while the patch antenna will be used for low frequency commands,etc.

- A helical antenna (S-band (2-4 GHz)) can handle higher-gain, long-range communication, ideal for primary data transmission and deep-space communication back to Earth.
- Patch Antenna for UHF (300 MHz to 3 GHz): Primarily for low-frequency, close-range, and emergency communication. This antenna can operate with minimal power and may be active during power-constrained scenarios.
- Variable data rate modulation or adaptive data allocation can allow for a dynamic transmission of data.

Why we believe this is a good choice?

- Provides flexibility, redundancy, and versatility for your CubeSat's mission around Venus. It allows for communication under varying conditions, from low-power emergency transmissions to high-bandwidth data transfer
- The use of multiple frequencies can raise multiple design constraints and chances of failure



Physical Layout

Weight and Power output estimation

Sum of all individual component weights= 1333.7 grams

Solar panels-250g

Body-200g

Heat shield- made of Mylar film($15\times15\times0.1cm^3$) with an aluminum coating($15\times15\times0.01cm^3$) would be approximately 37.4 grams.

TOTAL WEIGHT OF THE CUBESAT=1.8Kg(approx)

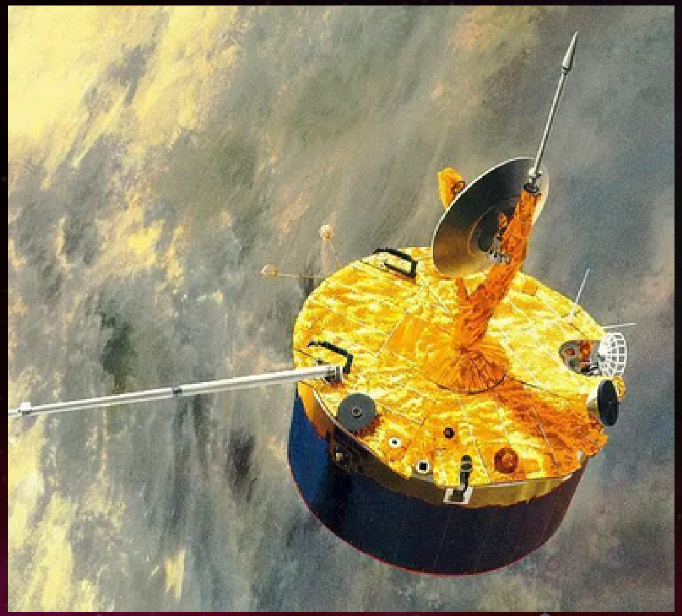
- Area of One Panel: $13\ cm\times13\ cm=169\ cm^2=0.0169\ m^2$
- Area of two panels=$0.0338m^2$

Power Output Estimation:

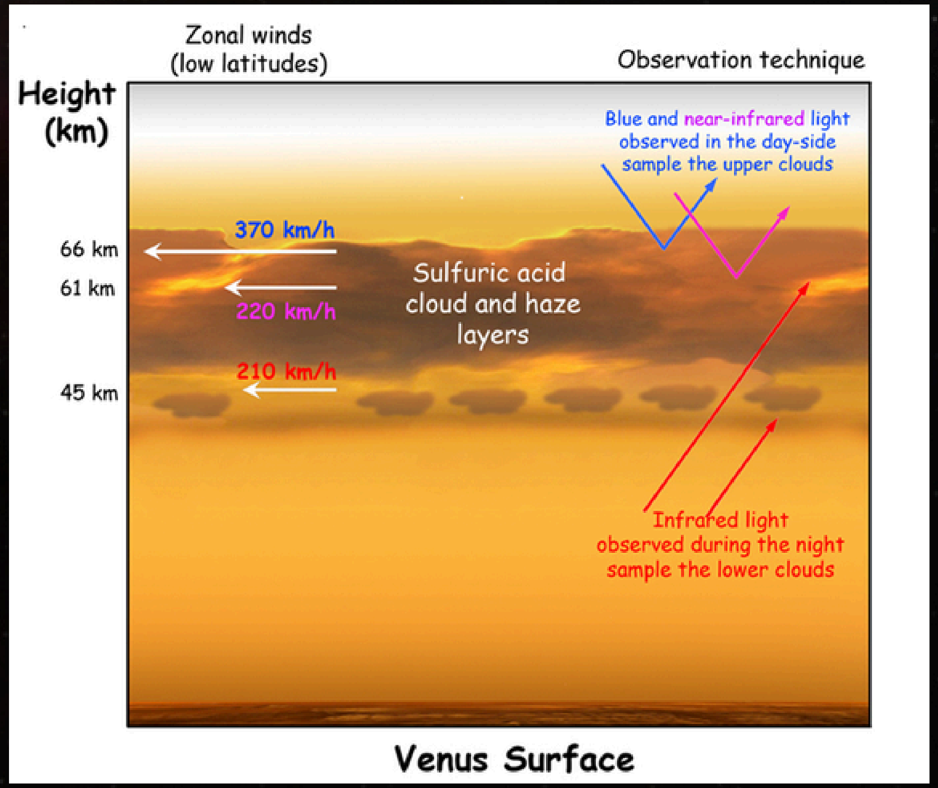
- Irradiance (solar power per area under standard sunlight): $1000\ W/m^2$
- Efficiency of solar cells: assuming 20% efficiency (typical for space-grade solar cells)
- Power Output=$0.0338\ m^2\times1000\ W/m^2\times0.2=6.76W/hr$

WHERE THE CUBESAT MIGHT FAIL

Inadequate Thermal Management: In addition to the usual harsh conditions of space, there is the harsh environments of Venus. Especially as the mission requires entering the atmosphere, complications can arise with the corrosive atmosphere and extreme temperatures.



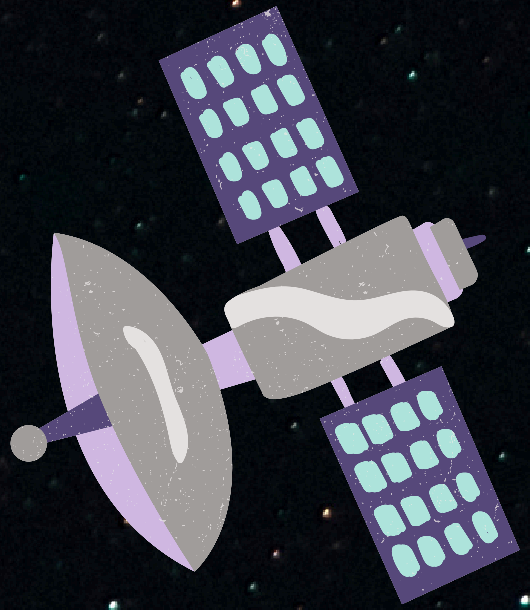
Any spacecraft entering the atmosphere must be designed for short operational lifespans due to the harsh conditions, limiting the amount of data that can be collected.



The dynamics of entering and descending through such a thick atmosphere require careful engineering to ensure safe entry and landing, complicating mission design.

The CubeSat was originally intended to weigh 1 kg, but its weight has increased to 1.8 kg due to the addition of essential components needed to fulfill mission requirements.

There can also be communication and navigation delays resulting from the atmosphere and the highly reflective sulfuric acid clouds of Venus



THANK YOU

(BEYONCE)