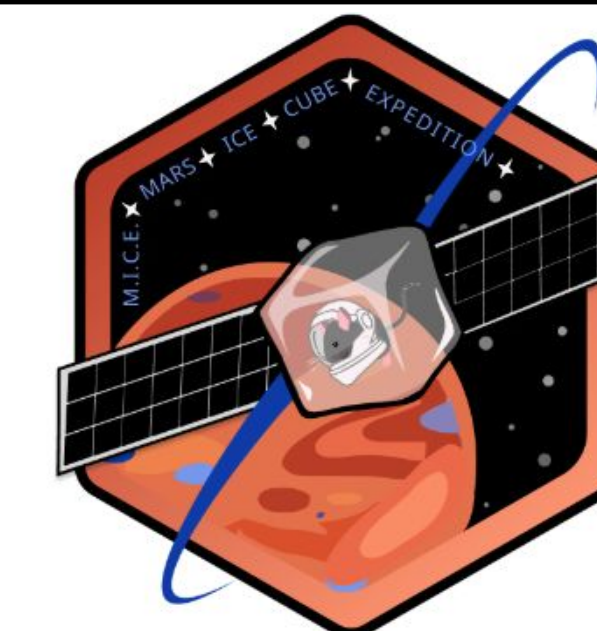


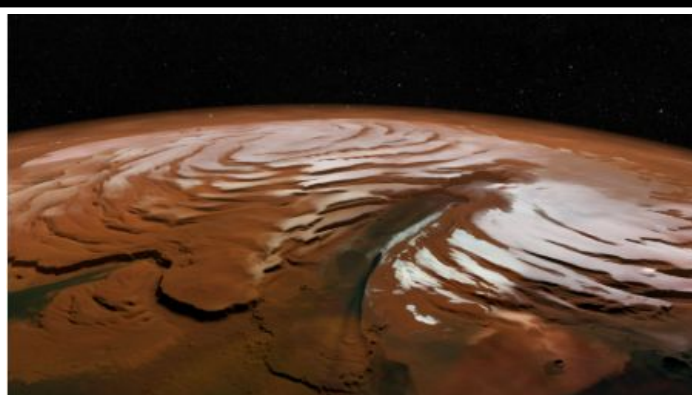
Mars Ice Cubesat Expedition (MICE)

Kiril Yampolsky, Daniel Green, Santiago Ulloa, Devin Patel
Kyle Huynh, Jared Agos, Dylan Spiker, Ryan Henderson



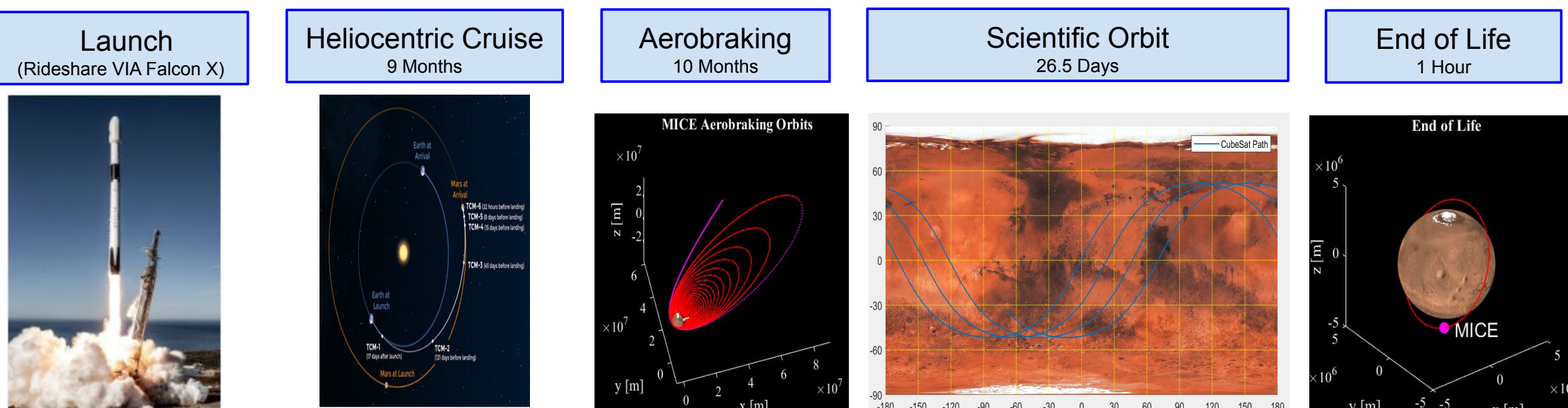
Mission Objectives

Focus on **Ice mapping** near-surface ice deposits in mid-latitude regions of Mars



Develop a scalable approach to planetary mapping using **SmallSat technology** to obtain high-resolution data **without needing large expensive hardware**

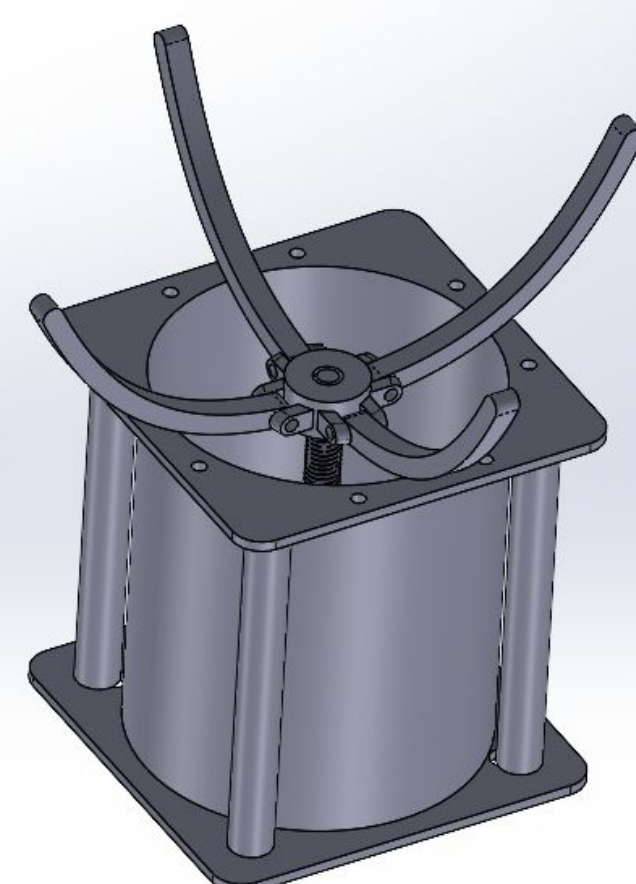
Timeline of Project



Payload

Mission Details

- 6 Cubesats around Mars
- Circular Orbit, 300 km Altitude
- 60 degree Inclination
- Antenna takes up 1.5 U in CubeSat
- Martian Regolith, Water Ice, and Dry Dust
- swath width of 26.18 meters
- Mars will be fully scanned in 26.5 days



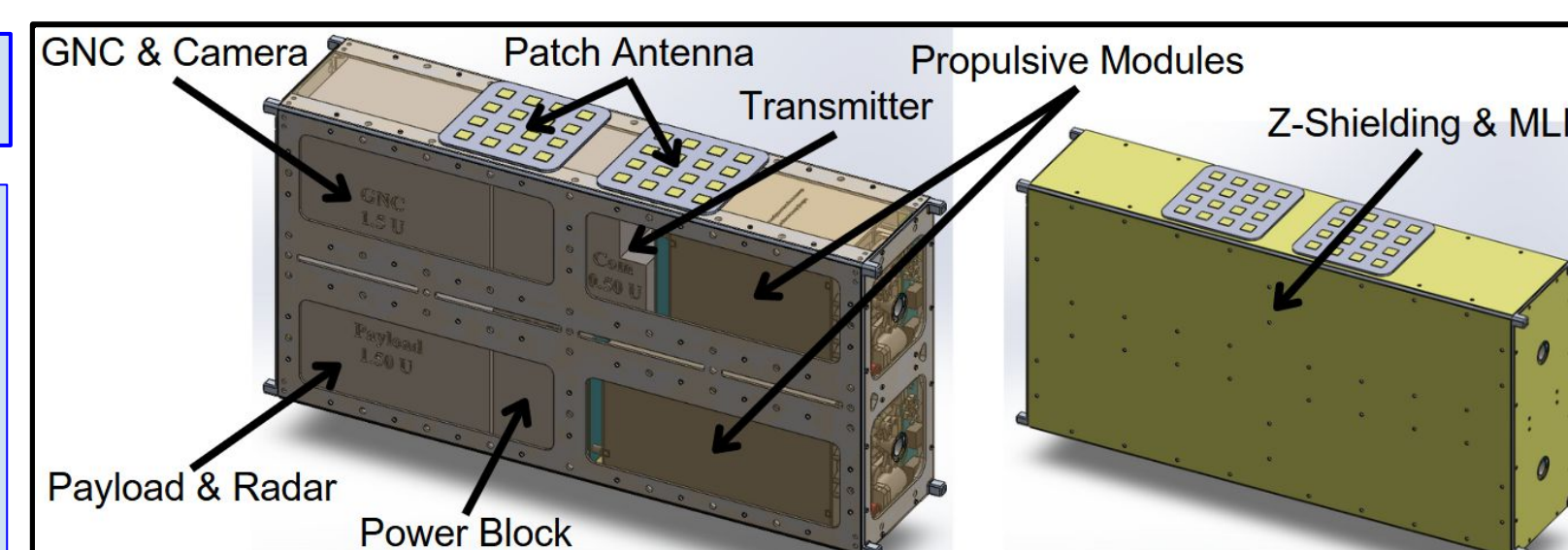
Antenna Details

- L-Band radar, 930 MHz
- Resolution of 10 - 20 m
- Penetration 0 - 10 m
- 7.1 Gigameters Coverage per day
- Total Coverage of 86.6% of Mars
- Data rate of 12.5 kbps for 1.03 Gb per day

CAT and MICE

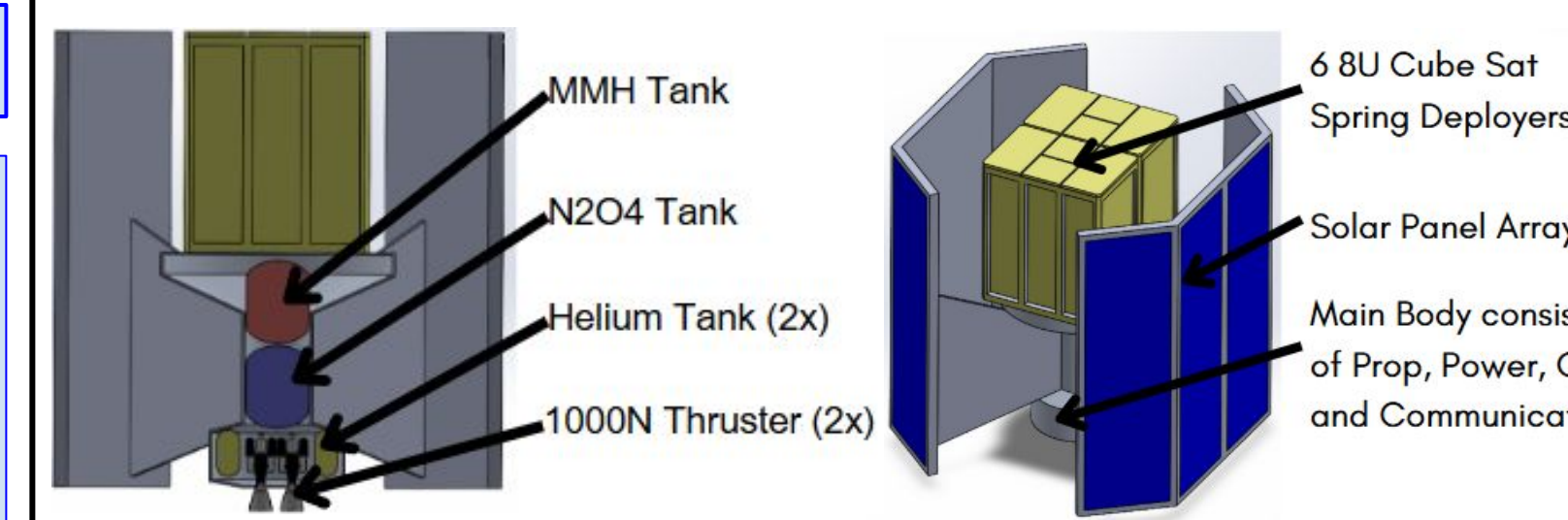
MOUSE: CubeSat

The MOUSE is an 8U CubeSat structure utilizing an anodized T6-6061 Aluminum and Titanium frame. The anodized frame, exterior z-shielding panels, and a layer of MLI protect against radiation and thermal loads. Total weight amounts to **14.135 kg**.



CAT: Carrier Vehicle

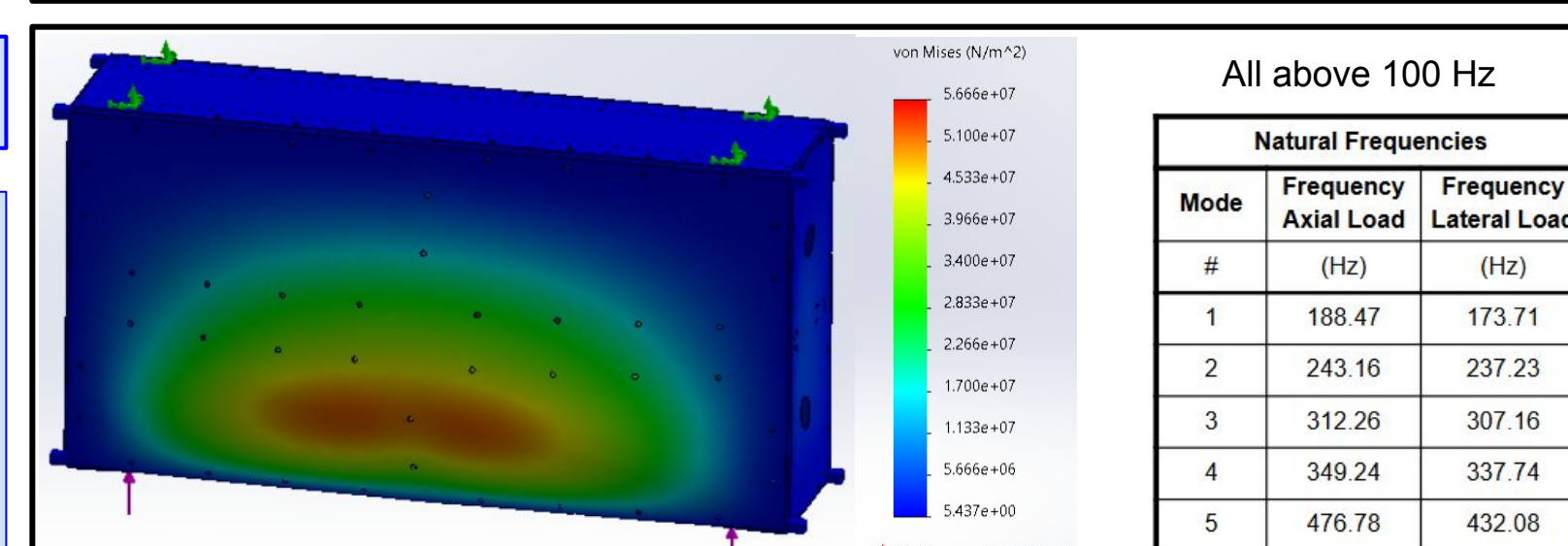
The CAT vehicle is able to hold 6 MOUSE CubeSats on its journey to mars. The CAT's propulsive capabilities take the form of two 20N thrusters fueled by MMH and N2O4. The CAT also features 2 large solar panels to power the vessel on its journey.



Structural Simulations

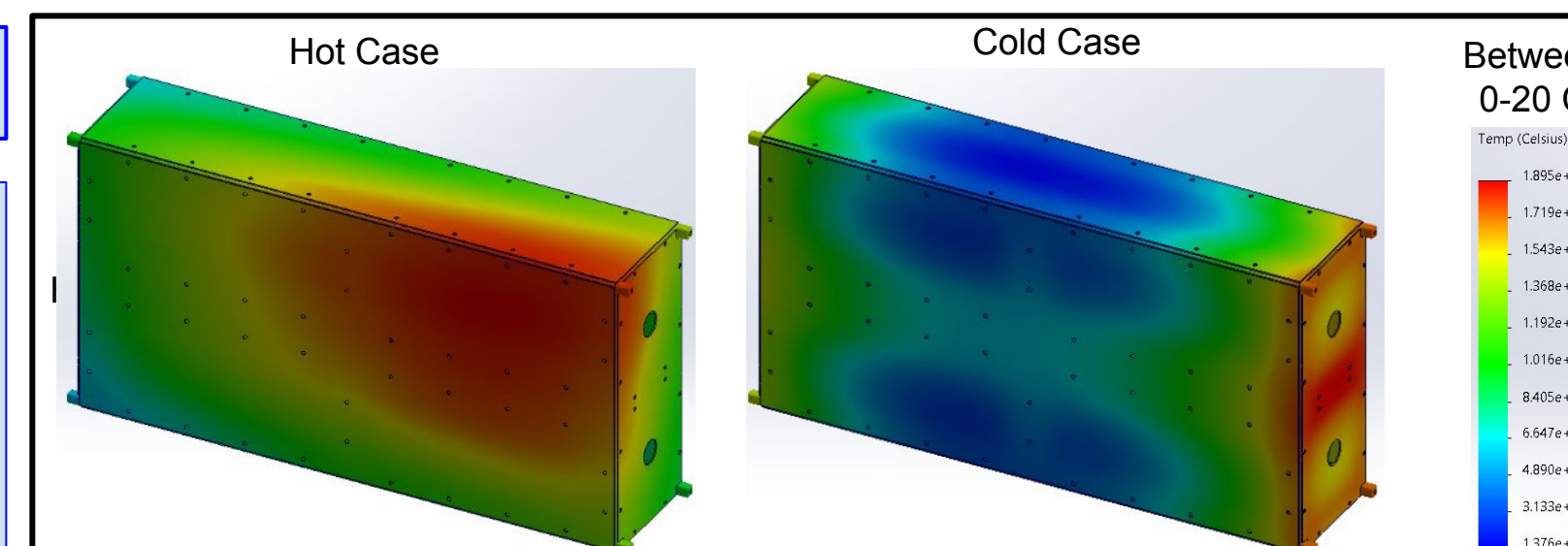
Overall Factor of Safety: **1.5**

- Statically Simulated to mimic launch loads
- Axially Loaded: **832 N**
 - Laterally Loaded: **278 N**
 - Avoid natural frequency range **25-100 Hz** to avoid resonance with carrier



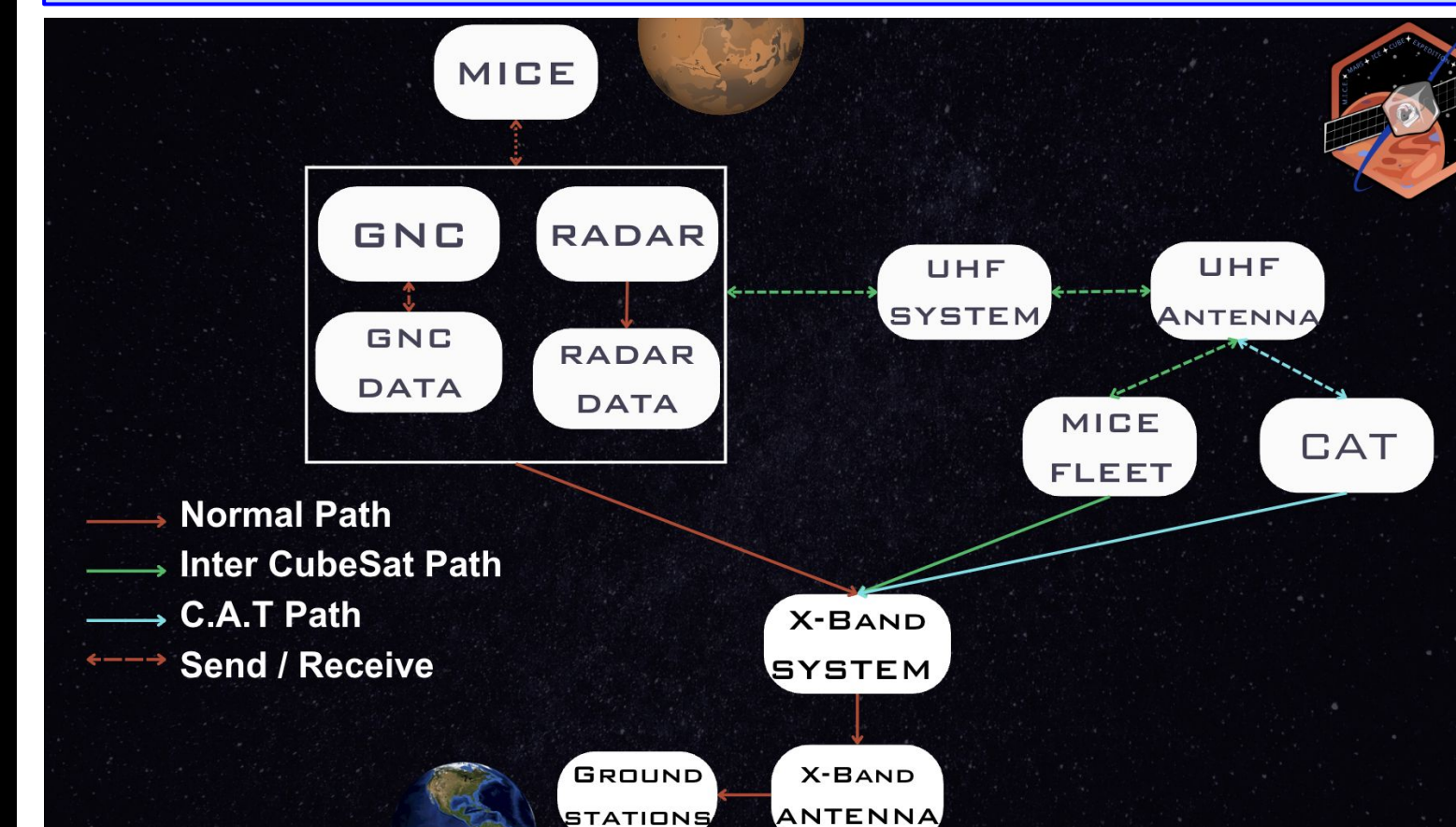
Thermal Simulations

Hot Case: Exposed directly to the Sun within Mars' Atmosphere
Cold Case: Eclipsed from the Sun in Mars' Atmosphere
Must be within **0-20 C** to ensure good operating conditions



Communications

Mission Dataflow



Requirements

- Minimum data rate speed of 1500 kbps to send .4 GB (8hrs)
- Linked for at least 8 hours a day.
- The required signal strength also has to be over 20 dB for a mars orbiter.

Antenna

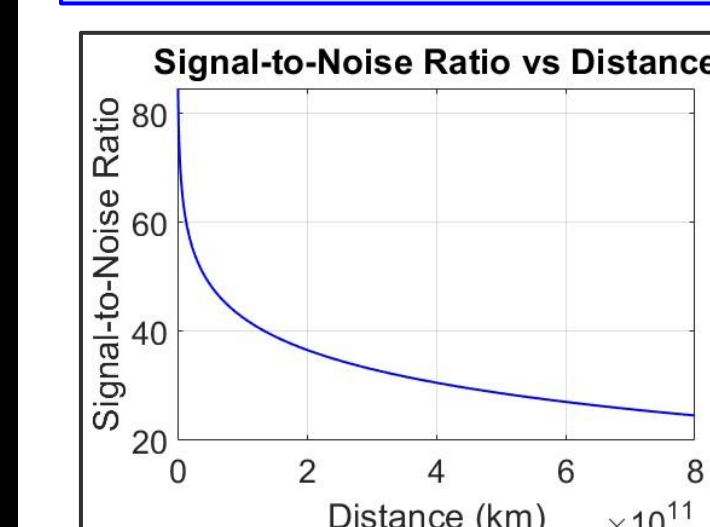
Ground Station Communications:

- 2 X-Band Patch Array Antennas
- X-Band Transmitter

MICE & CAT Communications

- 2 UHF Patch Array Antennas
- UHF Transmitter

Link Budget



Minimum SNR: 24.1 dB
Maximum SNR: 82.3 dB

Ground Stations

- Nasa Deep Space Network 70m Antennas:
- Goldstone, CA
 - Madrid, Spain
 - Canberra, AU

PCMS

Power: 5-7 W
Cost: \$25 million
Mass: 442 grams
Size: .5U

Power

Requirements

- Produce an average of at least 46 watts of solar power per orbit to have energy stored for eclipses
- Store enough energy to survive multiple eclipses
- 40Wh backup battery for communications

Solution

- 0.8 m² double-sided panels (160 W peak) to capture
- 160Wh total battery capacity
- Power consumption: 46 W (attitude control, first 2000 seconds), then 31 W thereafter

Guidance, Navigation, and Control

MOUSE Requirements

- Achieve pointing accuracy of sub 25 arcsecs during SAR imaging
- Perform semi autonomous orbit and attitude corrections
- Maintain precise relative positions and orientations between other MOUSE units with sub-meter accuracy

CAT Requirements

- Execute precise and controlled aerobraking maneuvers
- Deploy MOUSE units with precise velocities and orientations
- Maintain attitude and orbit post MOUSE deployment to serve as communications relay

MOUSE GNC

- Compact system based on XACT-50 unit (1.23 kg)
- Pointing accuracy of ± 10.8 arcsec and ± 25.2 arcsec
- Thrusters for large corrections

CAT GNC

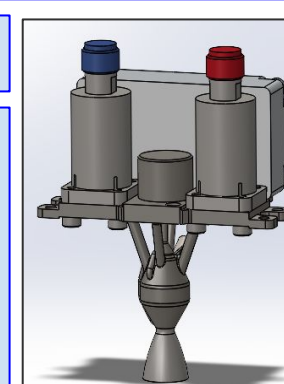
- State of the art sensor and control suite: Honeywell MIMU, 3x RWs, star and sun trackers, 8x control thrusters
- Optical navigation and deployment verification cameras

Attitude Simulations

- Simulation visualizes hybrid attitude control system in Mars orbit
- Visualizes cubesat trajectory around mars with fixed-body axis, control system performance, and efficient control actuator usage
- Reaction wheels provide continuous pointing within ± 6 mNm
- Thrusters only remain active throughout initial stabilization achieving precise attitude maintenance with minimum propellant usage
- Initial conditions - roll:45°, pitch:45°, yaw:180°, 0.01 rad/s rotation along X and Y axis

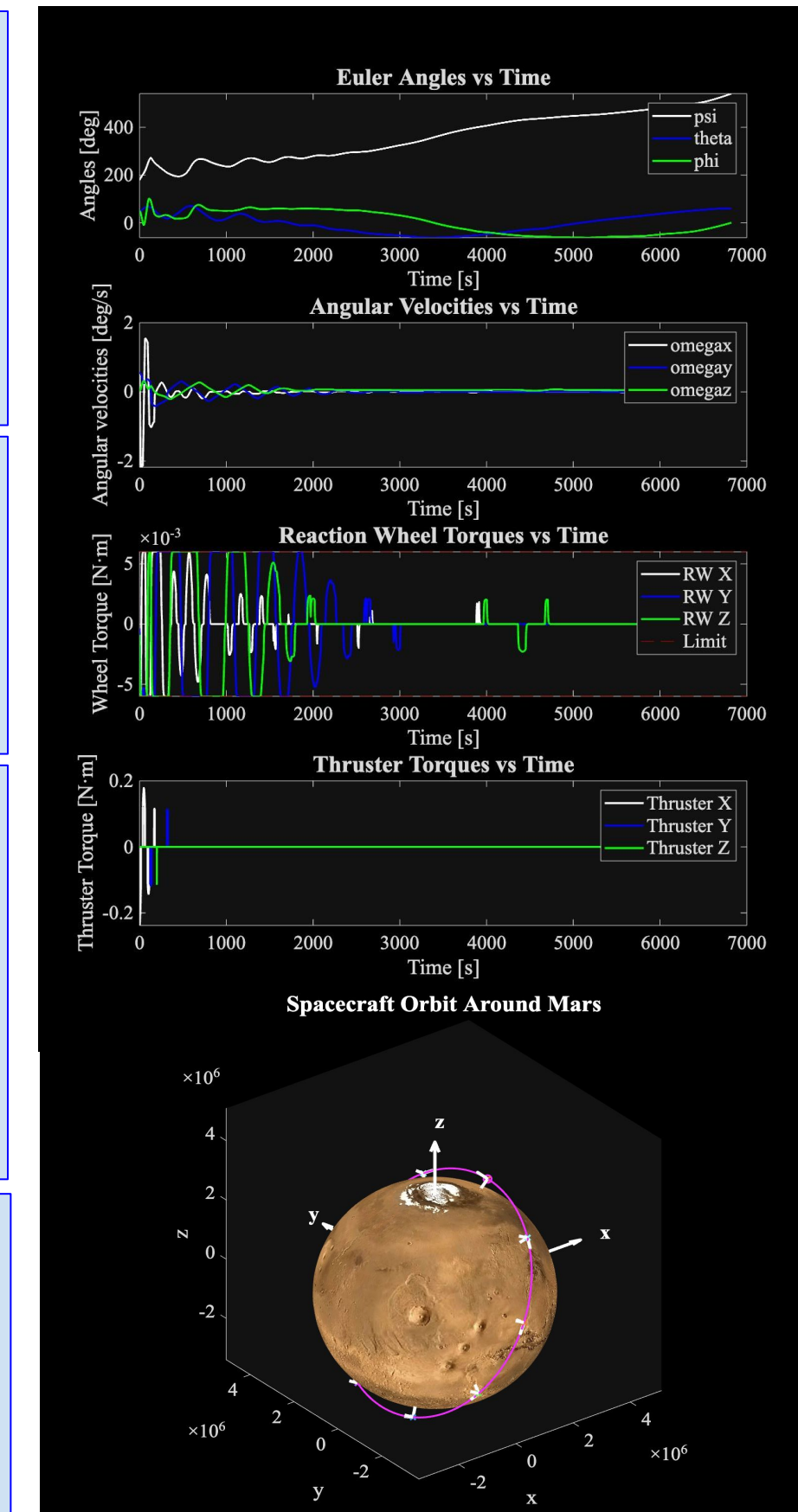
MOUSE Thrusters

- Requirements:
- Volume envelope ≤ 3.5 U
 - $\Delta V \geq 246$ m/s (160 m/s EOL + 40% margin)
 - Total impulse ≥ 3 586 N-s



Solution:

- CubeDrive Modules: 1.5 U + 2 U \rightarrow ~3700 N-s impulse
- Compact Fit: 3.5 U envelope
- Thrusters: Dawn Aerospace CubeDrive bipropellant thrusters



Trajectory

Transfer Requirements

- $\Delta V < 5$ km/s
- Get from GEO to Mars insertion

Solution

- Transfer Date: November 27, 2028
- Change of Velocity: $\Delta V = 3.22$
- Time of Flight: 280 Days

Insertion Requirements

- Minimize ΔV to save fuel and weight
- Insert into a Mars orbit
- Establish the science orbit at an alt. of 300km

Solution

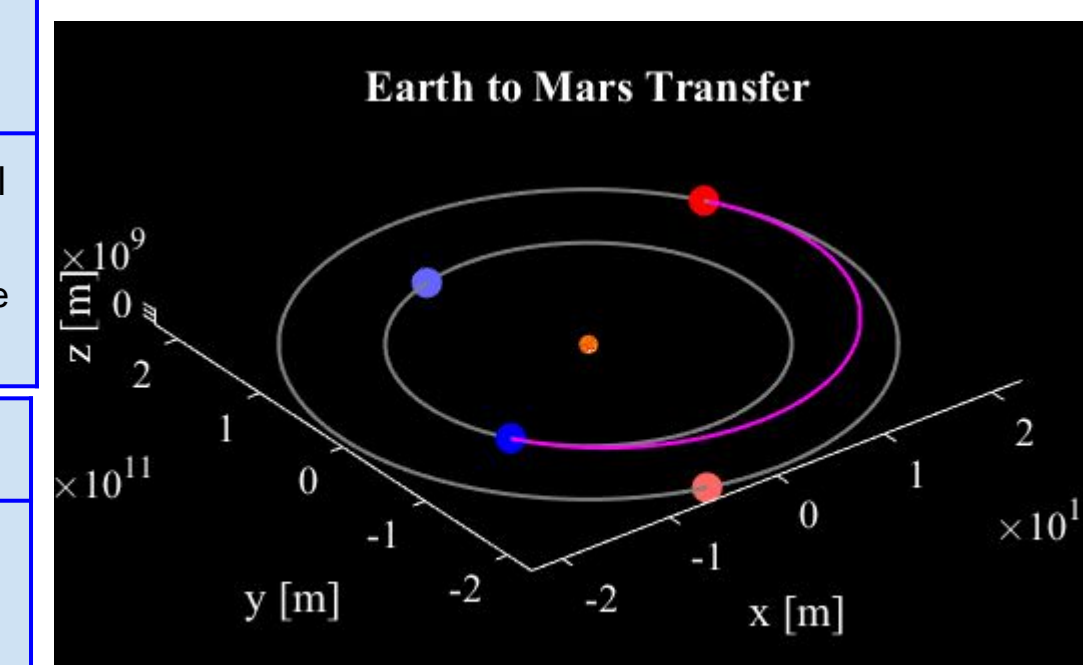
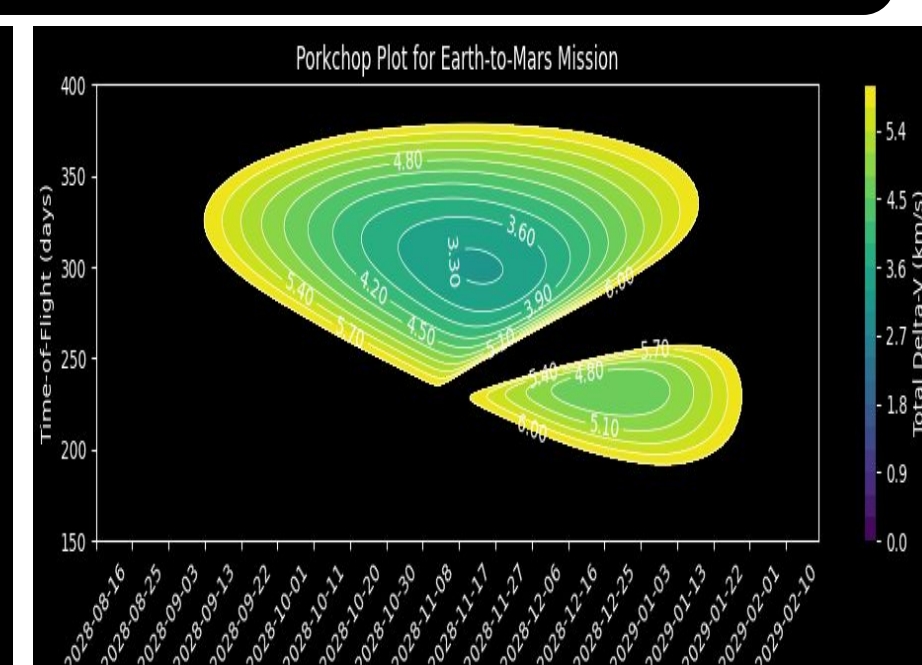
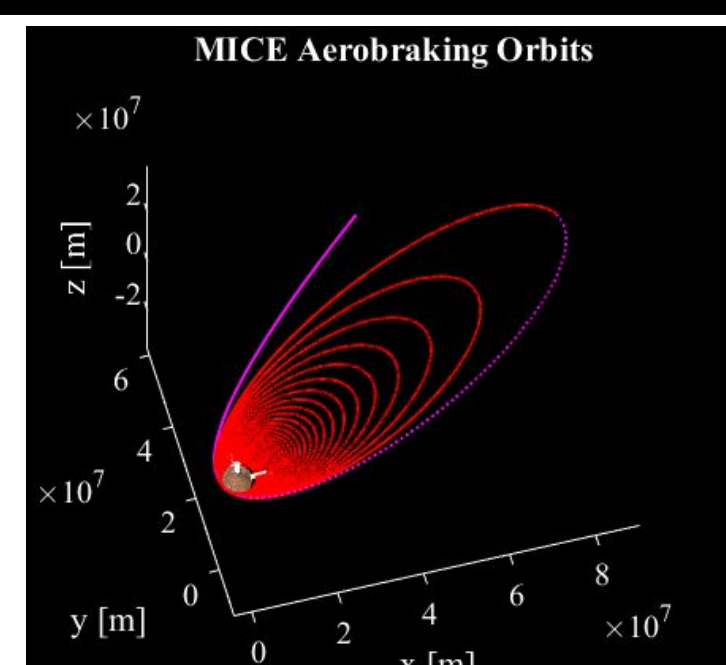
- Insert into a highly elliptical orbit ranging from 98,000 km to 270 km
- Lower periapsis to 200km and aerobreak to slow down
- Reduce apoapsis to 1,050 km then circularize
- Change of Velocity: $\Delta V = 1728$ m/s

End of Life Requirements

- Minimize ΔV to save fuel
- Avoid collision with Mars
- Finish the mission in a safe orbit

Solution

- Orbit at altitude of 660km
- Change of Velocity: $\Delta V = 155$ m/s



Acknowledgements

The MICE mission team would like to thank our amazing professor Pablo Machuca for helping and advising us on this mission for the past year. We would also like to thank the Aerospace Department for funding this project and give a special shoutout to our good friend and former team member, Alvaro Rubio Tejada.

Mission Summary

MOUSE Summary

Power	Cost	Mass	Size
31-46W	\$920k-\$3.4M per cube	14.95kg - 15.5kg	8 U
MARCO	MICE Mission	IMIM Projection	
Cost	Cost	Cost	
\$17M for 2 CubeSat	\$82M-\$190M	\$185M	