Europa Reconnaissance Formation Mission

Presented By:

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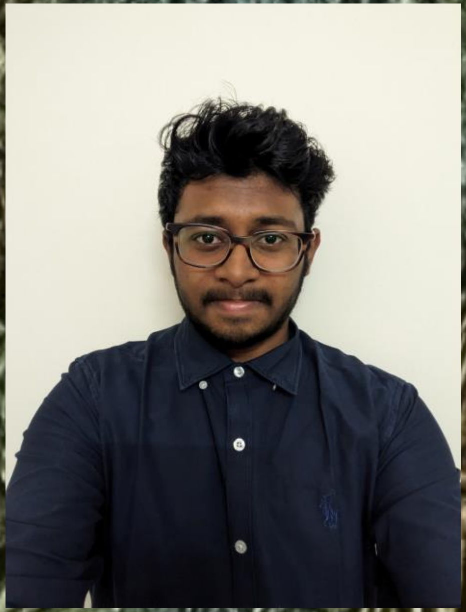

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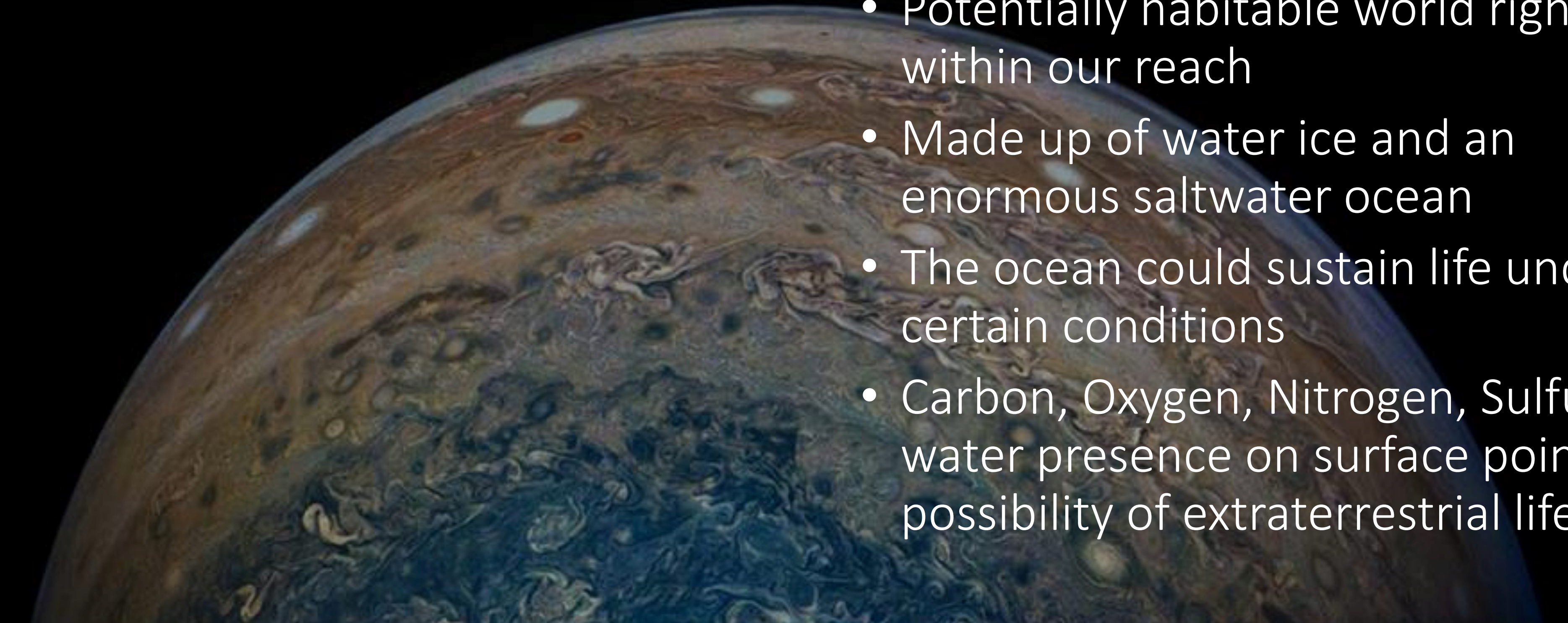
Why Europa?



- Potentially habitable world right within our reach
- Made up of water ice and an enormous saltwater ocean
- The ocean could sustain life under certain conditions
- Carbon, Oxygen, Nitrogen, Sulfur & water presence on surface point to possibility of extraterrestrial life

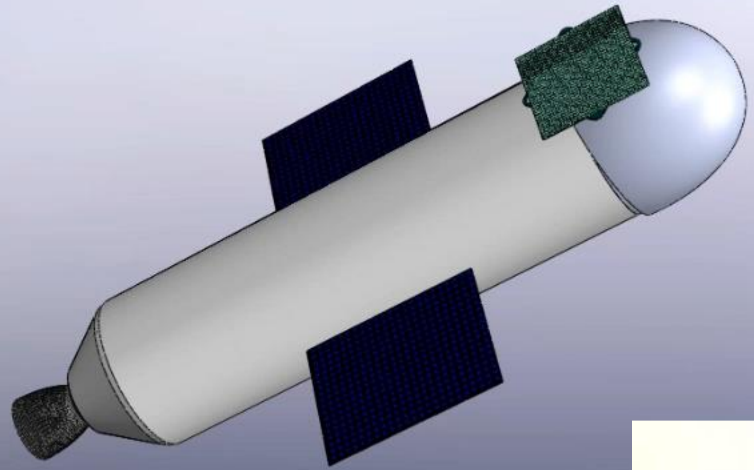
Table of content

Mission Objectives

- Map the underground topology of Europa by Ice Penetrating Radar
- Determine the surface composition of Europa
- Quantify the magnetic field of Europa in a stable orbit
- Capture highest resolution images of Europa's surface
- Generate a high-quality 3D model of Europa by cameras and LIDAR


Credit: Space X

Carrier Stage



RAAG

Rapid Astrogation Adaptative Generator

RAAG ENGINE

Thrust – 1500N

Mass Flow Rate – 0.5591 Kgs/s

NTO Mass Flow Rate – 0.338 Kgs,

MMH Mass Flow Rate – 0.175 Kg

O/F Ratio – 2.181

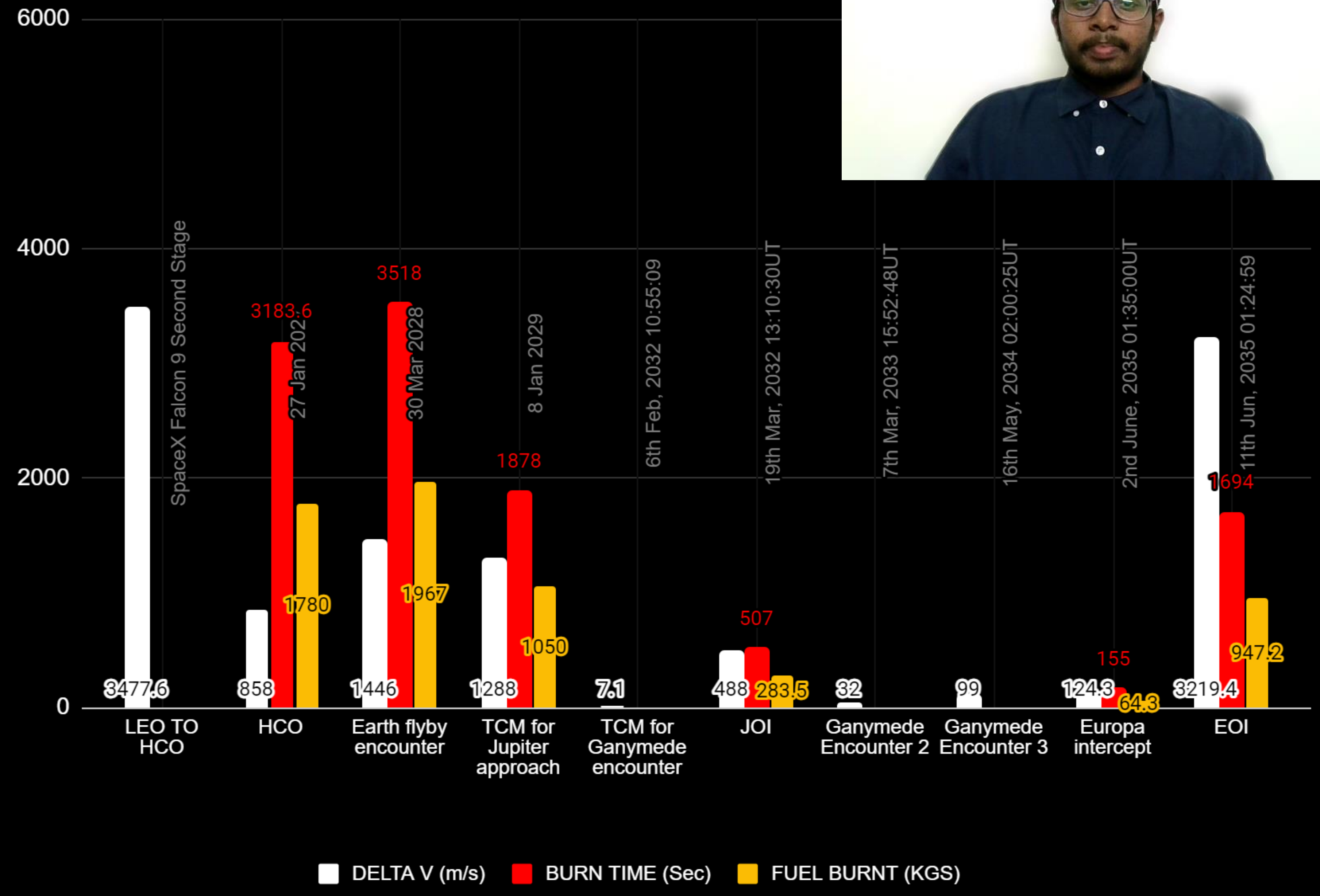
Chamber Pressure – 800 psi

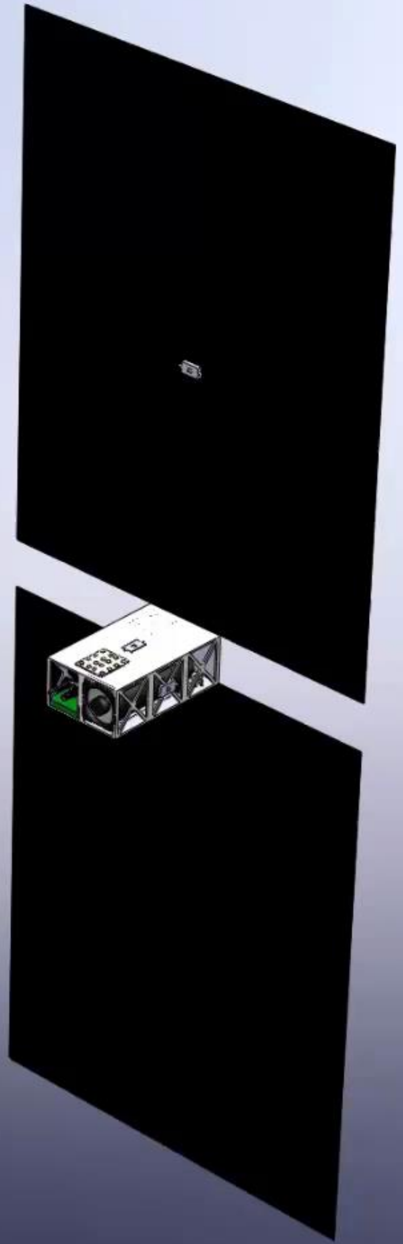
Max Burn Time – 194 mins (1165 sec)

Total Propellant Mass – 6500 kgs

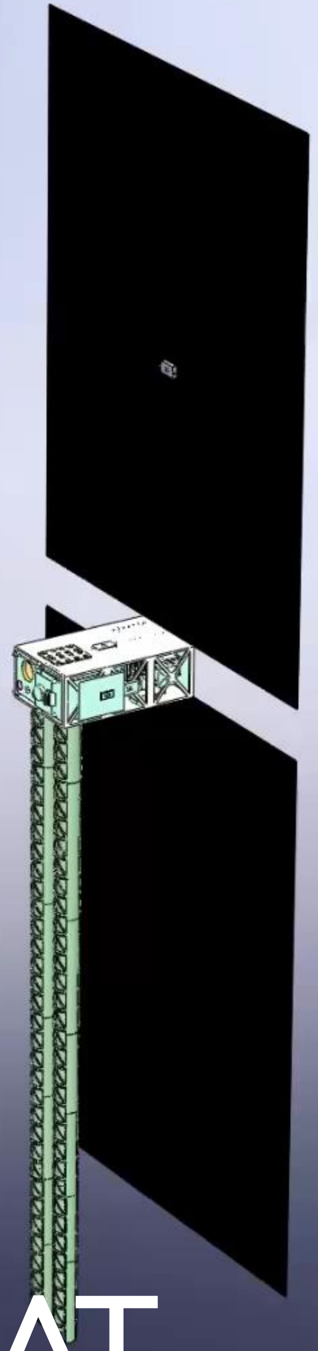
*NTO- Dinitrogen Tetroxide
*MMH- Monomethyl Hydrazine
*O/F- Oxidizer by fuel ratio
*LEO- Low Earth Orbit
*HCO- Heliocentric orbit
*TCM- Trajectory Correction Maneuver
*JOI- Jupiter Orbital Insertion
*EOI- Europa Orbital insertion

DELTA V BUDGET





CAMSAT



SCISAT

HPMI PACKAGE

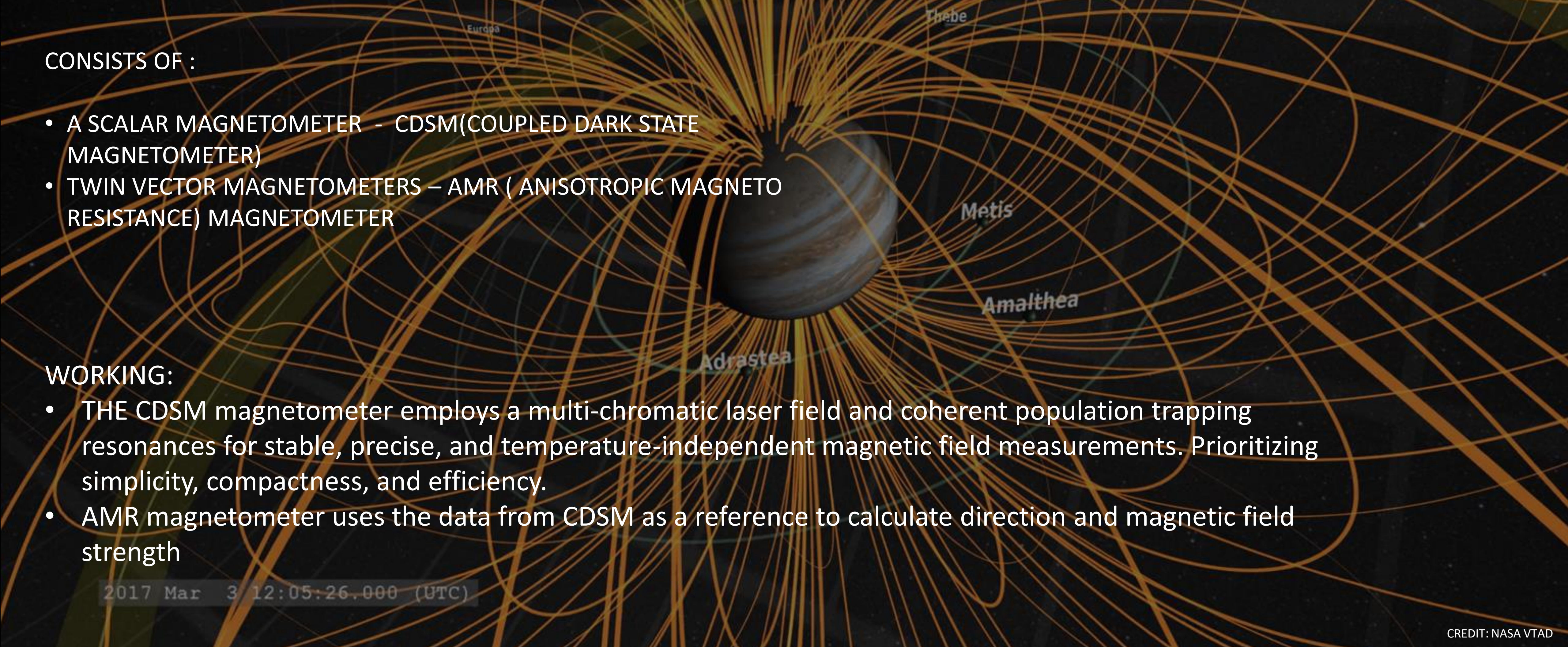
(HIGH PRECISION MAGNETOMETER INSTRUMENT)

CONSISTS OF :

- A SCALAR MAGNETOMETER - CDSM(COUPLED DARK STATE MAGNETOMETER)
- TWIN VECTOR MAGNETOMETERS – AMR (ANISOTROPIC MAGNETO RESISTANCE) MAGNETOMETER

WORKING:

- THE CDSM magnetometer employs a multi-chromatic laser field and coherent population trapping resonances for stable, precise, and temperature-independent magnetic field measurements. Prioritizing simplicity, compactness, and efficiency.
- AMR magnetometer uses the data from CDSM as a reference to calculate direction and magnetic field strength



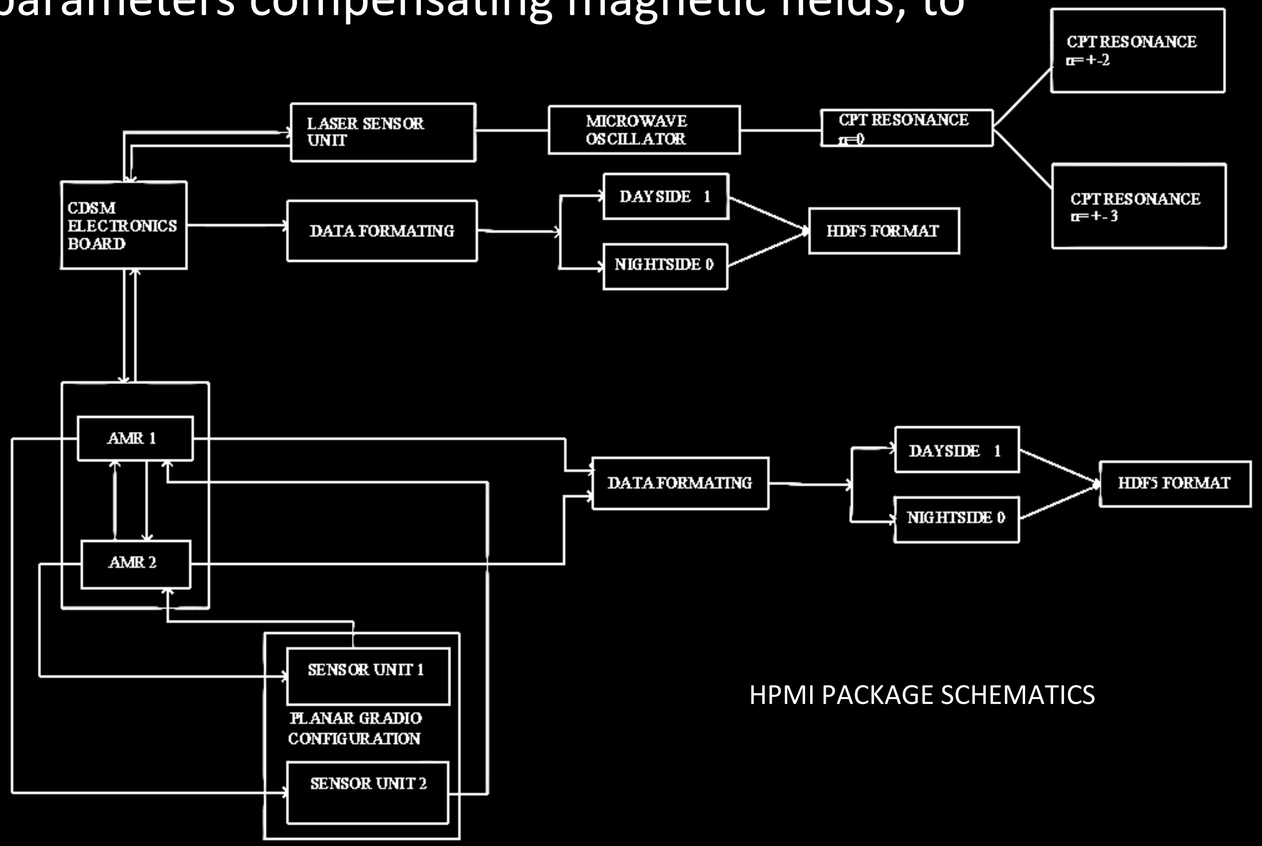
CREDIT: NASA VTAD

TECHNICAL MODIFICATIONS

To Make AMR Magnetometer a Zero-field detection device

We used

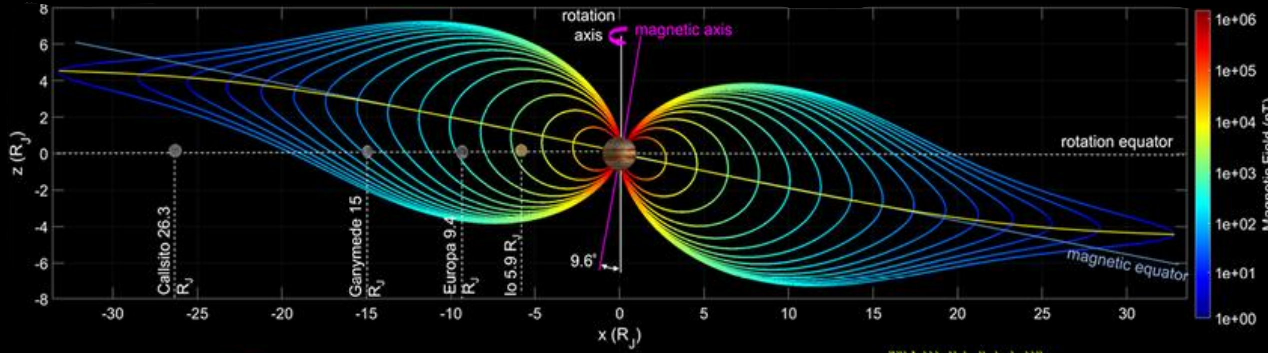
- Full Wheatstone bridge Configuration (full Wheatstone bridge configuration provides a balanced state at zero magnetic field)
- Feedback Control System (actively adjusting parameters compensating magnetic fields, to maintain the bridge in a balanced state)
- Differential Measurements (Multiple sensors oriented in different directions)

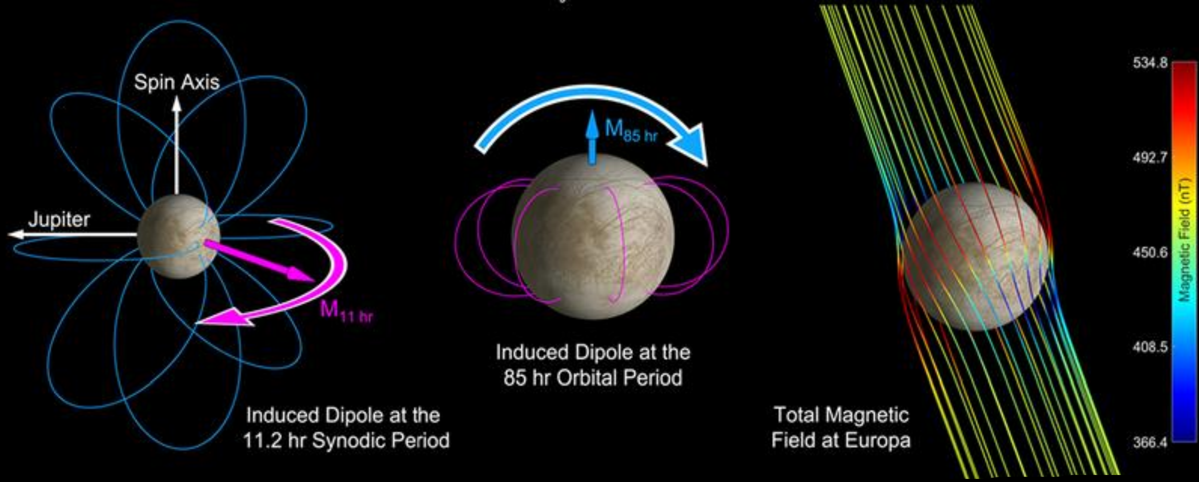


HPMI PACKAGE SCHEMATICS

APPLICATIONS OF HPMI PACKAGE

- CHARACTERIZING EUROPA'S MAGNETIC FIELDS IN OVERALL, STRENGTH AND DIRECTION TO CREATE DETAILED MAP OF MAGNETIC FIELDS ACROSS EUROPA
- DETECTION OF ANOMALIES IN MAGENTIC FIELDS
- INDICATES IN SUBSURFACE OCEAN BENEATH EUROPA
- STUDYING ICE-MAGMA INTERACTION
- UNDERSTANDING THE MOON'S INTERIOR DYNAMICS





BENEFITS OF HPMI PACKAGE

- UNDERSTANDING OF EUROPA'S EVOLUTION
- MISSION PLANNING AND NAVIGATION FOR FUTURE MISSIONS
- TESTING DIFFERENT HYPOTHESIS

The LIDAR’s Mission

- Long-range CubeSat LIDAR: Range of up to 1,000 km
- Purpose: Mapping Europa's surface features, altimetry, and surface property analysis

How it Works:

- Laser pulses from satellite to surface
- Return signal captured by onboard telescope
- Measures distance by analyzing time taken by laser pulse

Technical Specifications

Parameter	Value
Range Capability	Up to 1,000 km
Range Resolution	15 cm at long range, 60-degree cone at short range
Power Consumption	14.3 W during operation
CO2 LIDAR Wavelength	2051 nm
Operation Range	1.9 nm to 2.1 nm

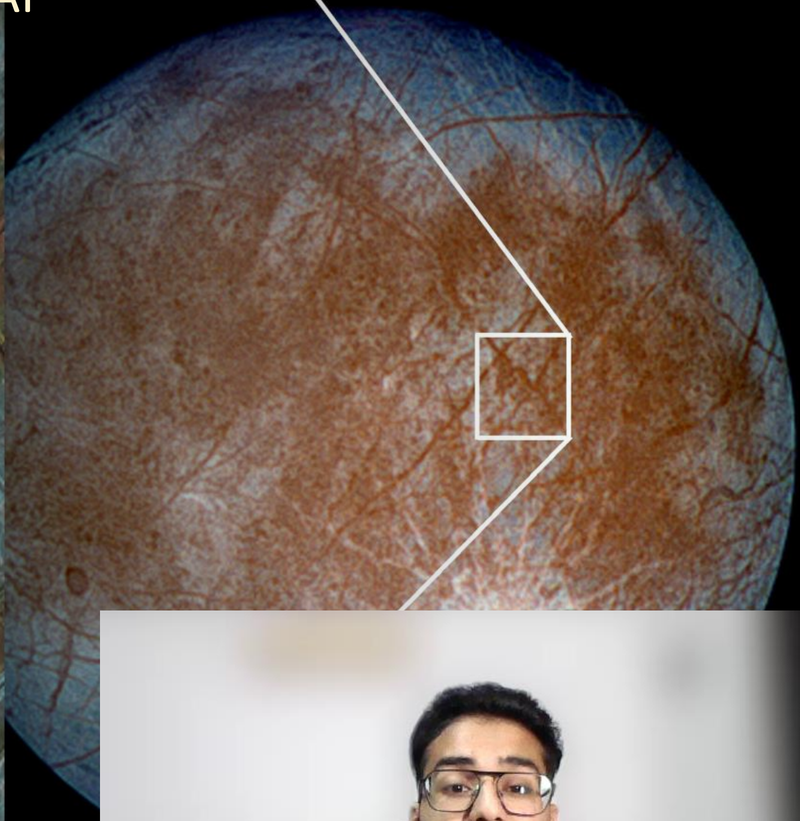
Application and Benefits

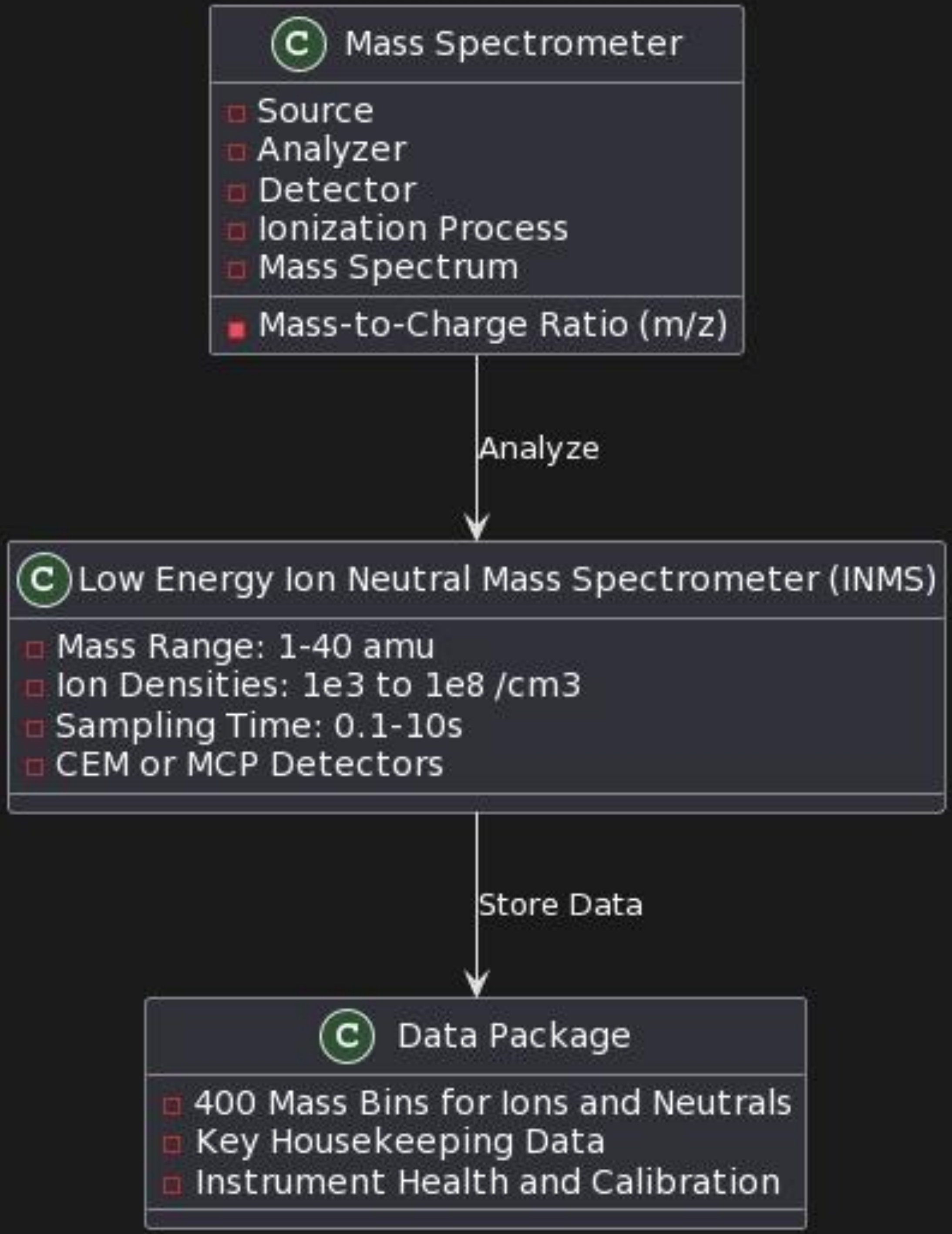
Applications of LIDAR:

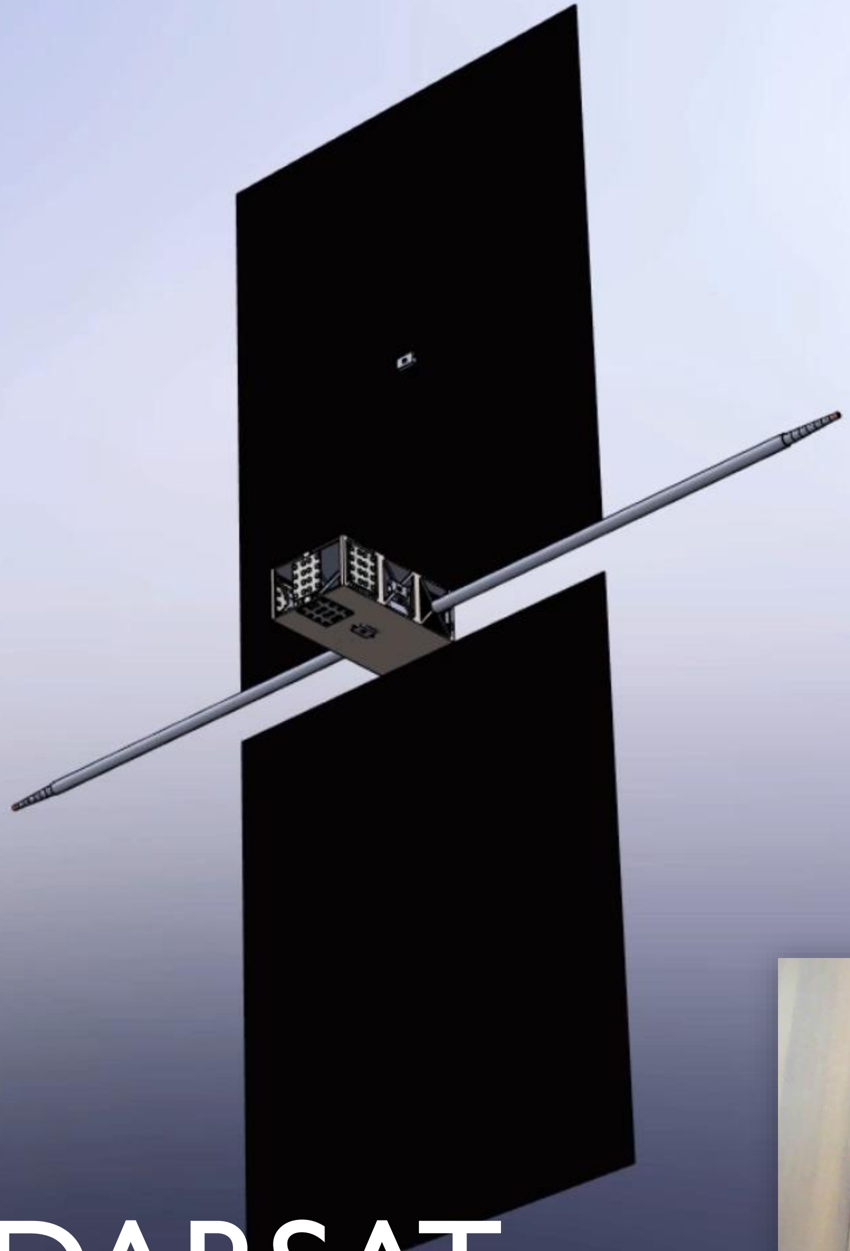
- Detailed Surface Topography & Relief Mapping by combining data of CAMSAT
- Eurapa’s Ice Thickness Estimation
- Atmospheric Studies
- Surface Composition Analysis
- Mapping & Navigation

Benefits:

- Detailed understanding of Europa's surface
- Identifying potential landing sites
- Estimation of subsurface ice thickness
- Precise spacecraft navigation




Mass Spectrometer
Source
Analyzer
Detector
Ionization Process
Mass Spectrum
Mass-to-Charge Ratio (m/z)
Analyze
Low Energy Ion Neutral Mass Spectrometer (INMS)
Mass Range: 1-40 amu
Ion Densities: 1e3 to 1e8 /cm3
Sampling Time: 0.1-10s
CEM or MCP Detectors
Store Data
Data Package
400 Mass Bins for Ions and Neutrals
Key Housekeeping Data
Instrument Health and Calibration



RADARSAT

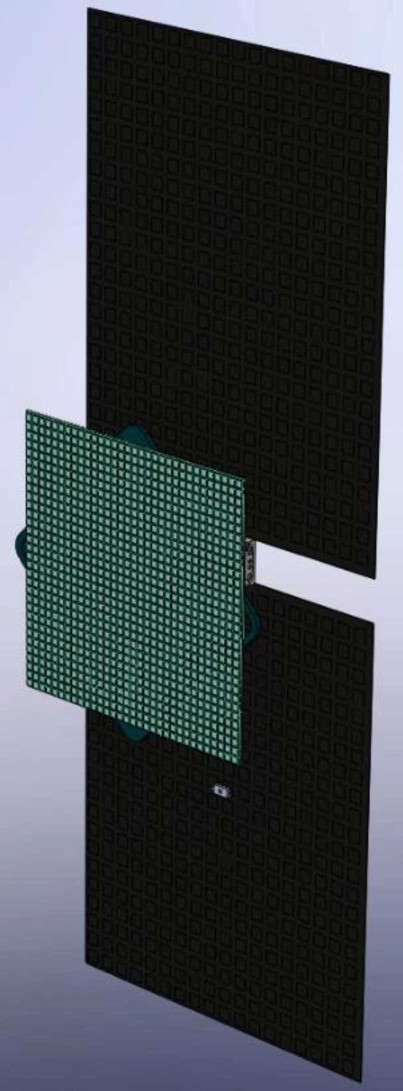
HF Configuration	
Parameter	Value
Operation Frequency	9MHz
Bandwidth	1MHz
Pulse Time	20-100µs
Vertical Resolution	≤300 m
Along Track Resolution	≤5.5 km
Vertical Precision	150 m
Monopole antenna length	8m
Radio Type	Frontier Radio Multi Lingual
Transmission	20W

Alternate VHF Configuration	
Operation Frequency	16MHz
Shallow-depth	≥3 km
Pulse Time	20-100µs
Vertical Resolution	≤30 m
Along Track Resolution	≤2 km
Dipole antenna	3m

Objectives

1) Characterize the ice shell's global structure
2) Investigate material exchange processes among the ocean, ice shell, surface, and atmosphere
3) Determine scientifically compelling sites for future lander missions
4) Determine ice shell's thermal conductivity
5) Confirm presence of water and global subsurface ocean

RELAY



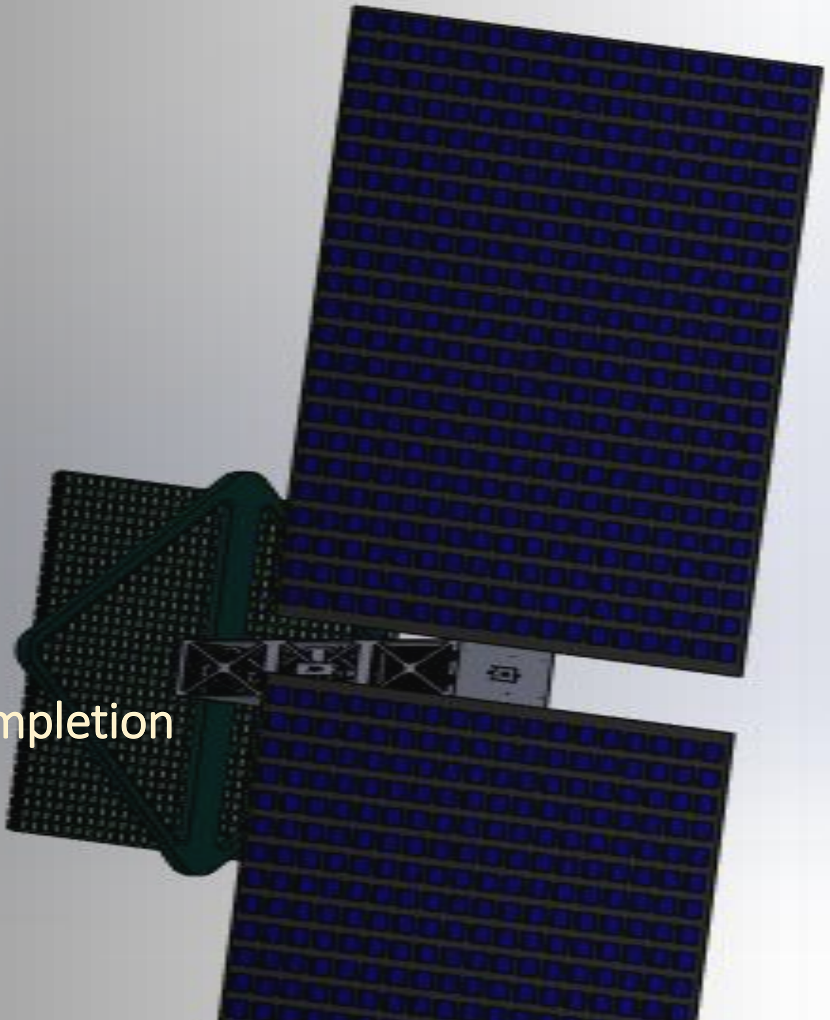
Relay- Data Transmission Scheme

SCISAT:

- Calculate data size to be sent
- Calculate transmission time for all three recon sats
- Transmit data & transfer time to relay at 7184.27 MHz
- Relay sends signal at 8440.80 MHz indicating SCISAT transmission completion

RADARSAT:

- Begins transmission 20 sec after SCISAT's completion
- Transmits data to relay (stored in allocated memory)
- Relay sends signal at 8.3GHz to alert CAMSAT



CAMSAT:

- Initiates transmission after signal from relay at 8.3GHz
- Transmits images following the procedure of previous satellites

Relay:

- After receiving all data, ADCS checks antenna position
- Points antenna towards Earth with high precision
- Begins transmission at 7173.87 MHz
- Returns to charging mode if in sunlit area, sleep mode if eclipsed

Failure (if relay fails):

- Reconsats relay data to Europa clipper
- Transmission: reconsats to Europa clipper at 8424.5MHz
- Europa clipper to Earth at 7170MHz (Channel 21 DSN)

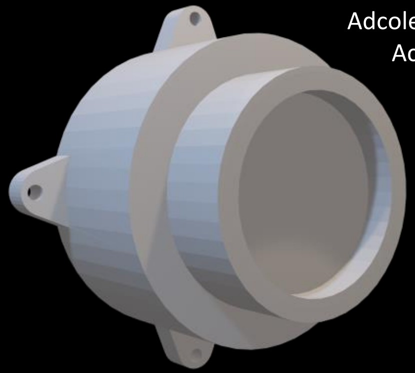
Data - Link Budget

Primary Antenna:	32X32” High Gain Antenna [35dBi, 25 Mbps – 8/16 PSK/QAM, 1.3 Mbps - QPSK]
Peer Antenna:	DSNTrackingStation [X 74.3 dBi 73 dBm [TL:9] QPSK 2.72 Mbps]
Relay Earth Uplink:	7173.87MHz
Relay – Earth Downlink	8428.58 MHz
Distance Max:	967264000000 m
Tx/Rx rate at max distance:	170.0 Kbps/1.36 Mbps
Distance Min:	587721000000 m
Tx/Rx rate at min distance:	340.0 Kbps/1.36 Mbps

ADCS (ATTITUDE DETERMINATION CONTROL SUBSYSTEMS) & POWER SYSTEMS

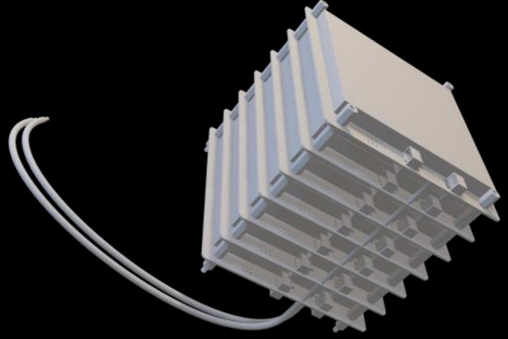
SSOC-D60 SUN SENSOR
Orthogonal Configuration
Accuracy of 0.3°
$\pm 60°$ FOV
0.039 Kgs

All these combines to provide an Accuracy of 365.9 arcseconds or 0.1

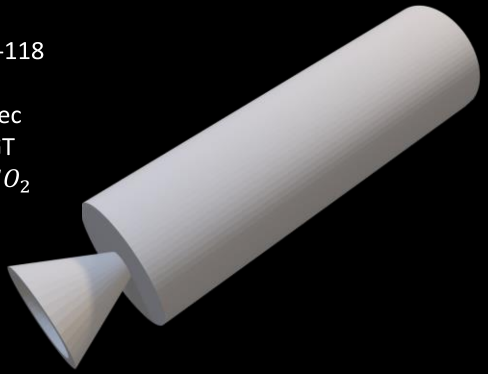


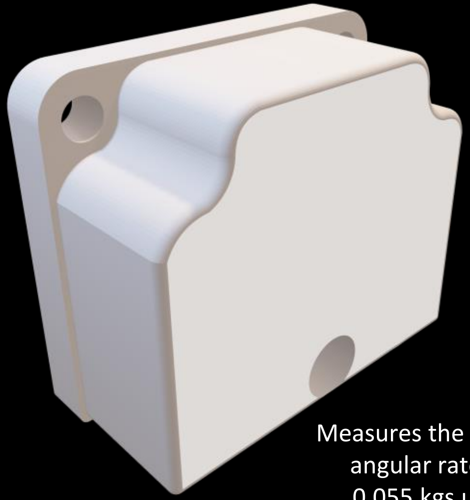
Adcole Coarse Sun Sensor
Accuracy of 0.75°
$\pm 60°$FOV
0.213Kgs

TITAN 350WHR MODULAR POWER ARRAY
350WHR, 84000mAh, 1.050Kgs



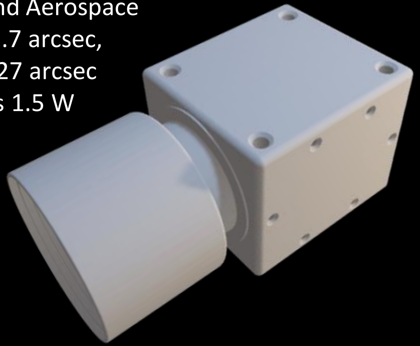
MOOG 058-118
3.6N
Isp – 57 sec
1 of 8 CGT
30Kgs of CO_2

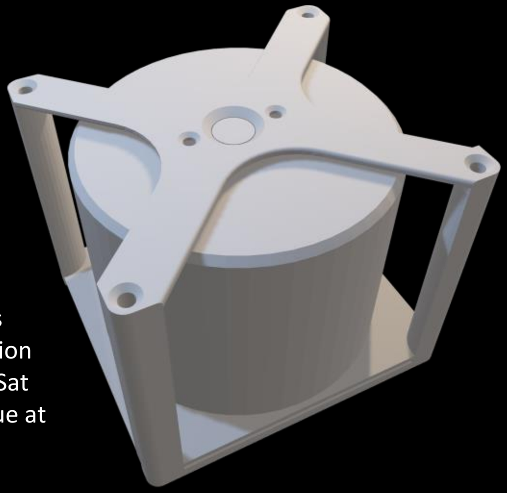




Measures the specific gravity and angular rate of the satellite
0.055 kgs uses 2 W per Sat

MAI-SS STAR TRACKER
Adcole Maryland Aerospace
Cross Axis-5.7 arcsec,
Boresight- 27 arcsec
0.305 Kgs 1.5 W



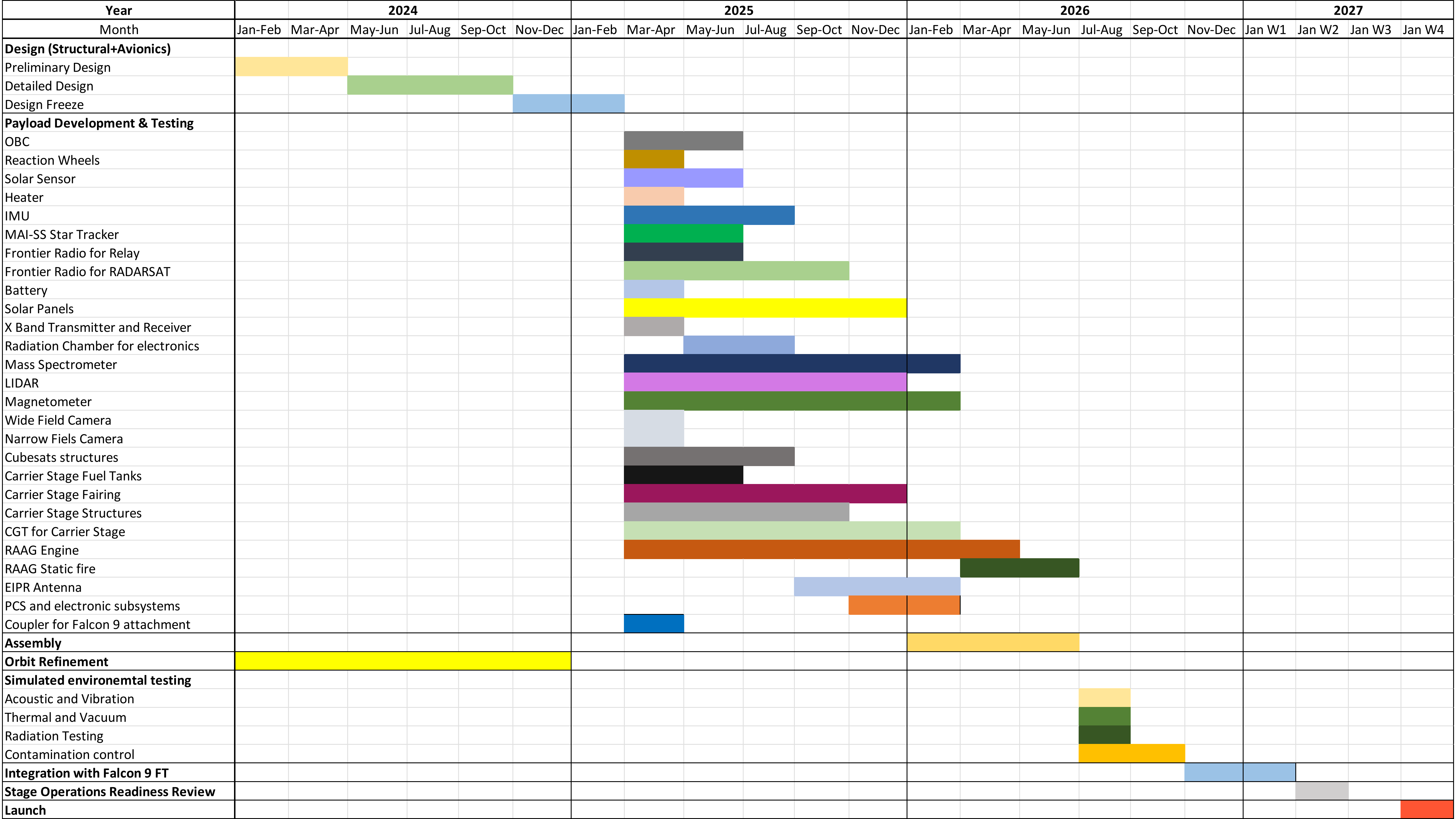


1 of 4 Reaction Wheels
In Tetrahedral Configuration
0.555 kgs and 5.4 W per Sat
Providing ± 0.5 mNm torque at
0.04Nms

Mission Risks

and solutions

- RAAG Engine failure- Multiple ground testing increases performance confidence
- Micrometeorites- Carrier Stage Fairing decreases the probability of damage
- Reaction wheel failure- 4 wheels have been used so that redundancy is increased
- Lethal Jovian Radiation can destroy and make electronics useless- Radiation chamber inside each satellite houses most electronics
- Relay failure- Europa Clipper can be used as relay to send data to Earth


Year
2024
2025
2026
2027
Month
Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec
Jan W1
Jan W2
Jan W3
Jan W4
Design (Structural+Avionics)
Preliminary Design
Detailed Design
Design Freeze
Payload Development & Testing
OBC
Reaction Wheels
Solar Sensor
Heater
IMU
MAI-SS Star Tracker
Frontier Radio for Relay
Frontier Radio for RADARSAT
Battery
Solar Panels
X Band Transmitter and Receiver
Radiation Chamber for electronics
Mass Spectrometer
LIDAR
Magnetometer
Wide Field Camera
Narrow Fiels Camera
Cubesats structures
Carrier Stage Fuel Tanks
Carrier Stage Fairing
Carrier Stage Structures
CGT for Carrier Stage
RAAG Engine
RAAG Static fire
EIPR Antenna
PCS and electronic subsystems
Coupler for Falcon 9 attachment
Assembly
Orbit Refinement
Simulated environemtal testing
Acoustic and Vibration
Thermal and Vacuum
Radiation Testing
Contamination control
Integration with Falcon 9 FT
Stage Operations Readiness Review
Launch

Mission Impact

- Global collaboration
- Advancement in scientific database
- Provides opportunities for new theories regarding Europa’s magnetic field, surface characteristics and subsurface ocean
- Lays foundation for future missions
- First spacecraft to study Europa in a stable orbit
- Helps in landing site determination for lander mission


THANK YOU