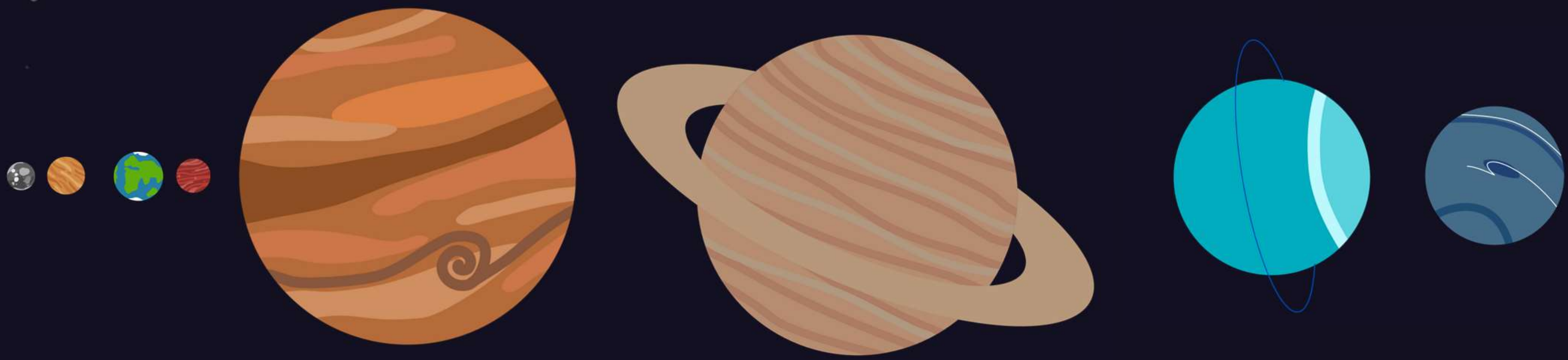
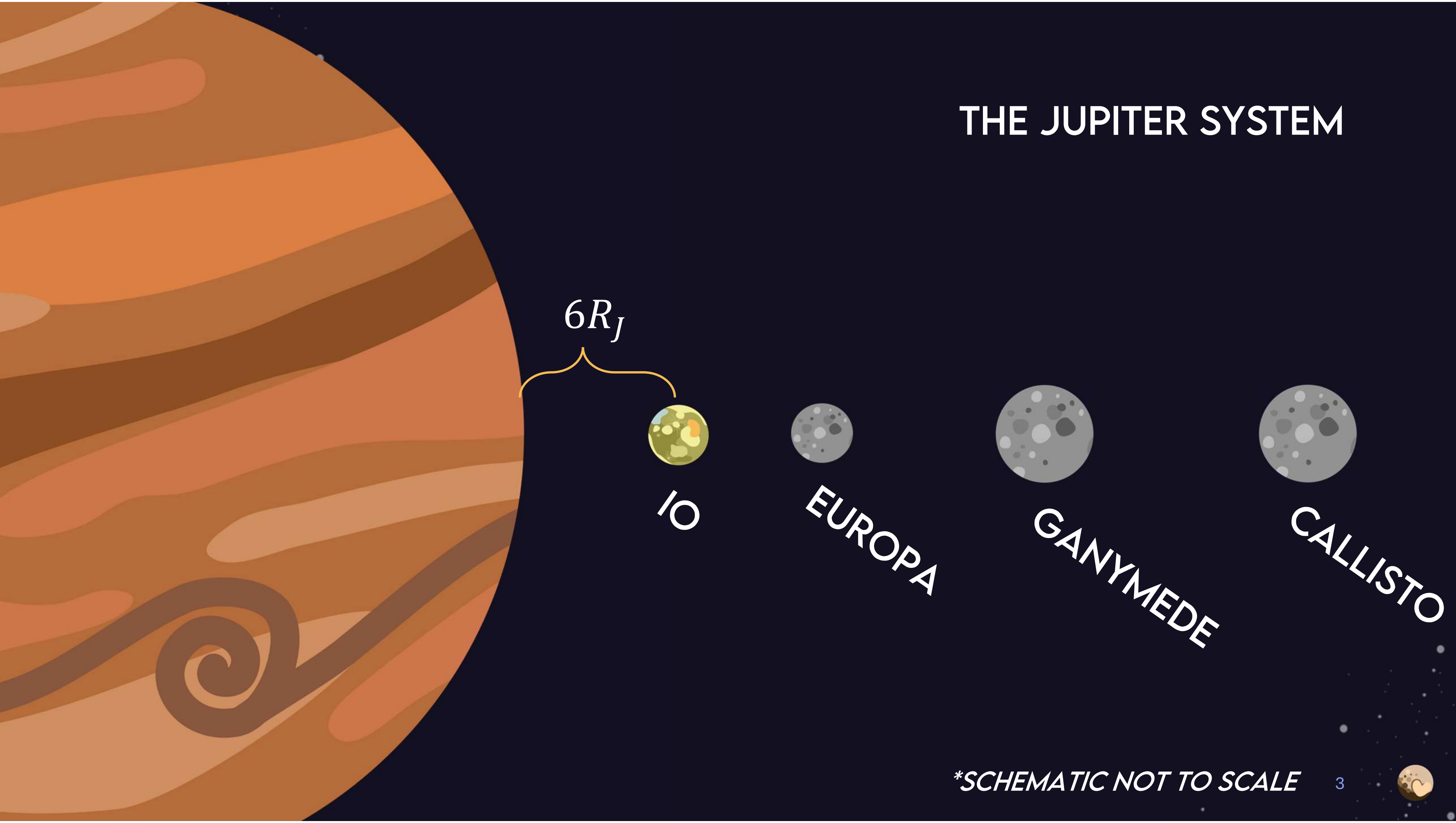
IFESTOS

We are officially going to hell.

OUR SOLAR SYSTEM



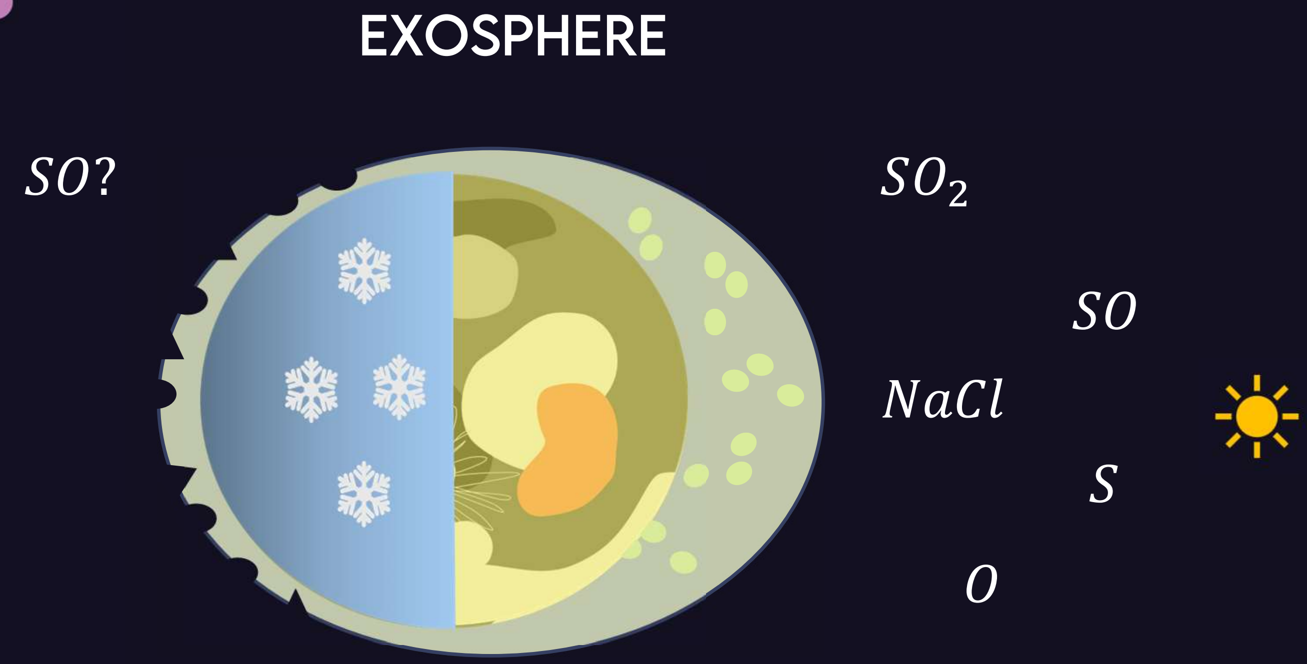
*SCHEMATIC NOT TO SCALE


THE JUPITER SYSTEM
$6R_J$
IO
EUROPA
GANYMEDE
CALLISTO
*SCHEMATIC NOT TO SCALE

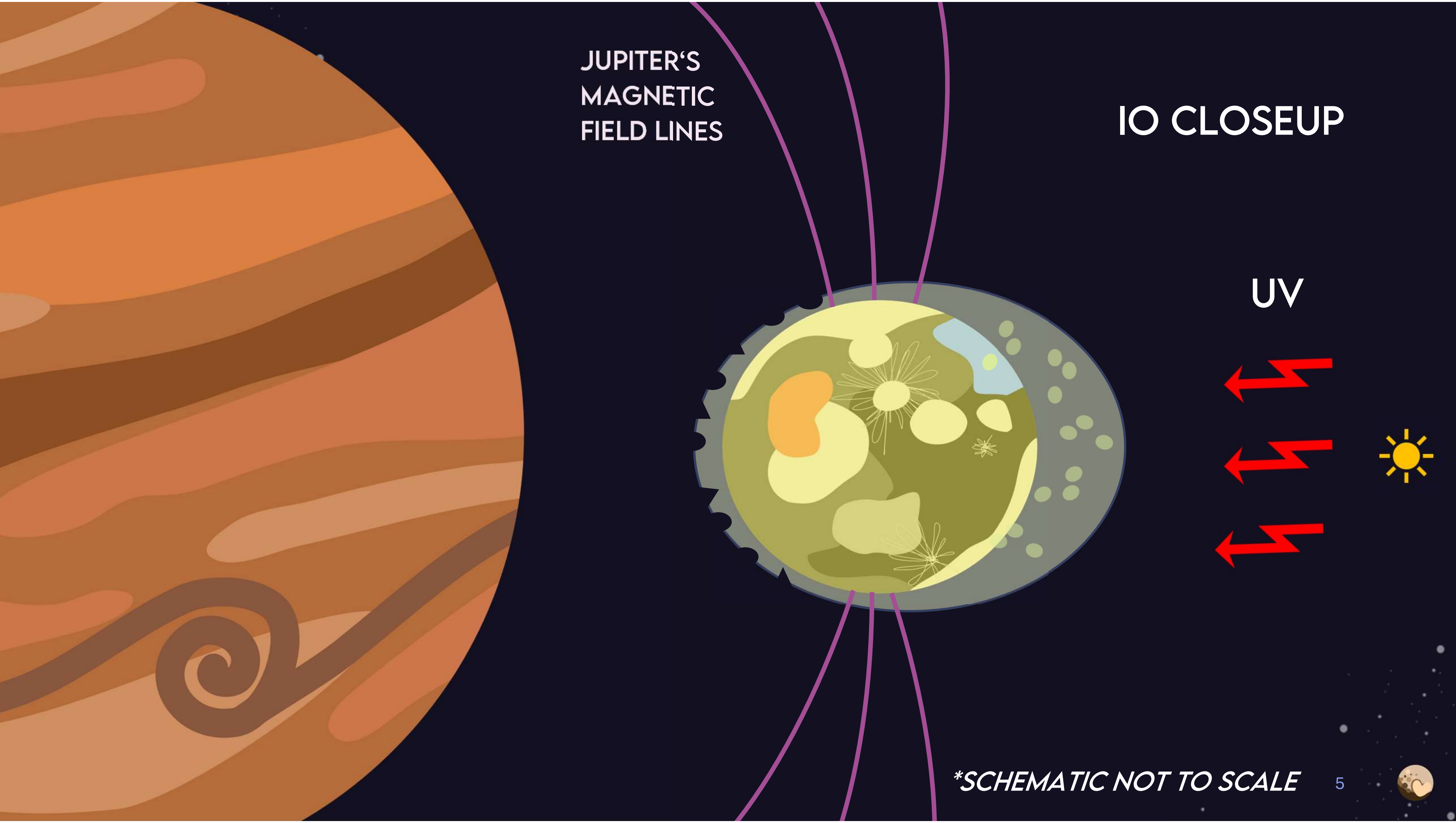
How are molecules transported from the inside to the exosphere?

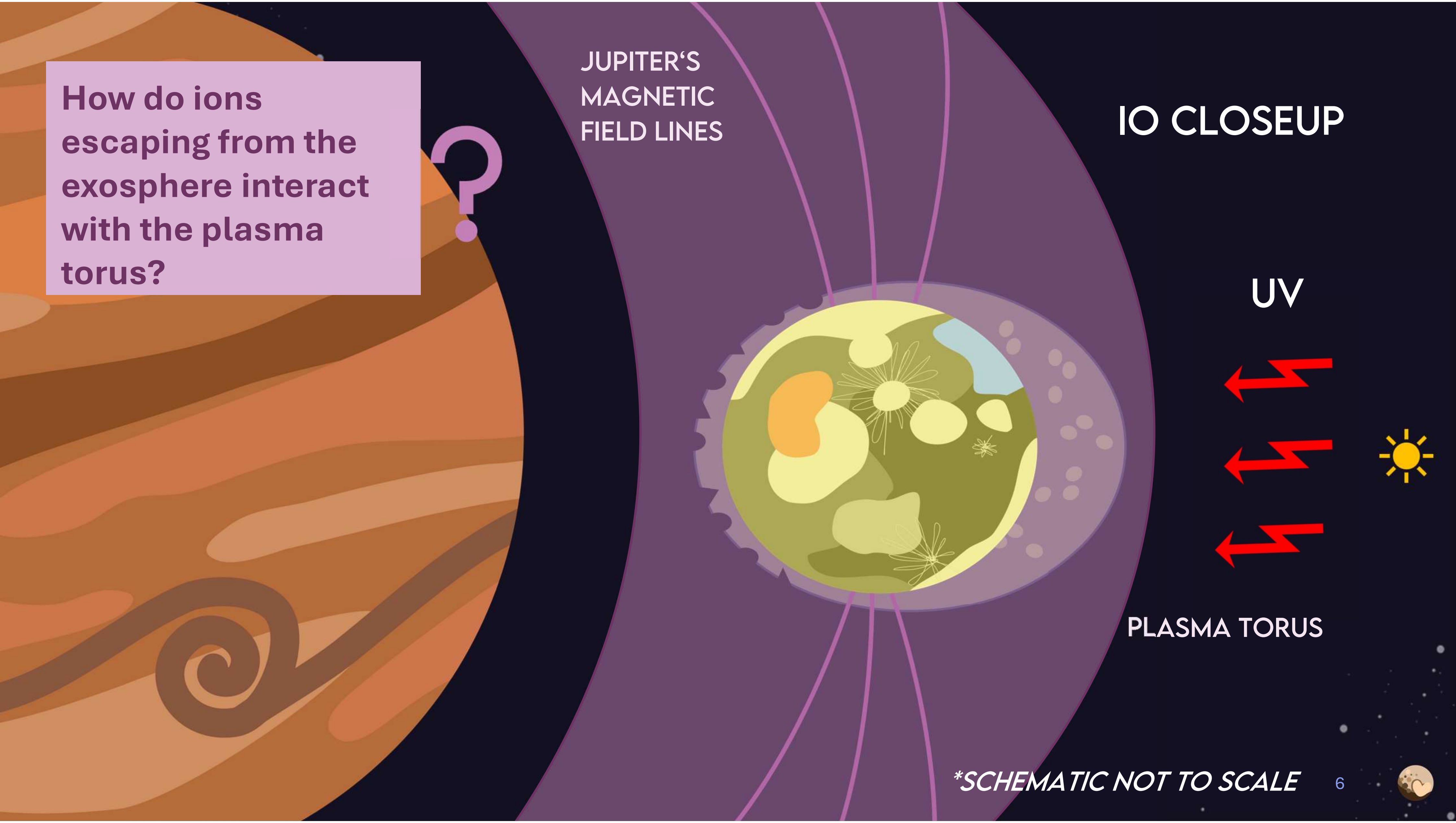
?

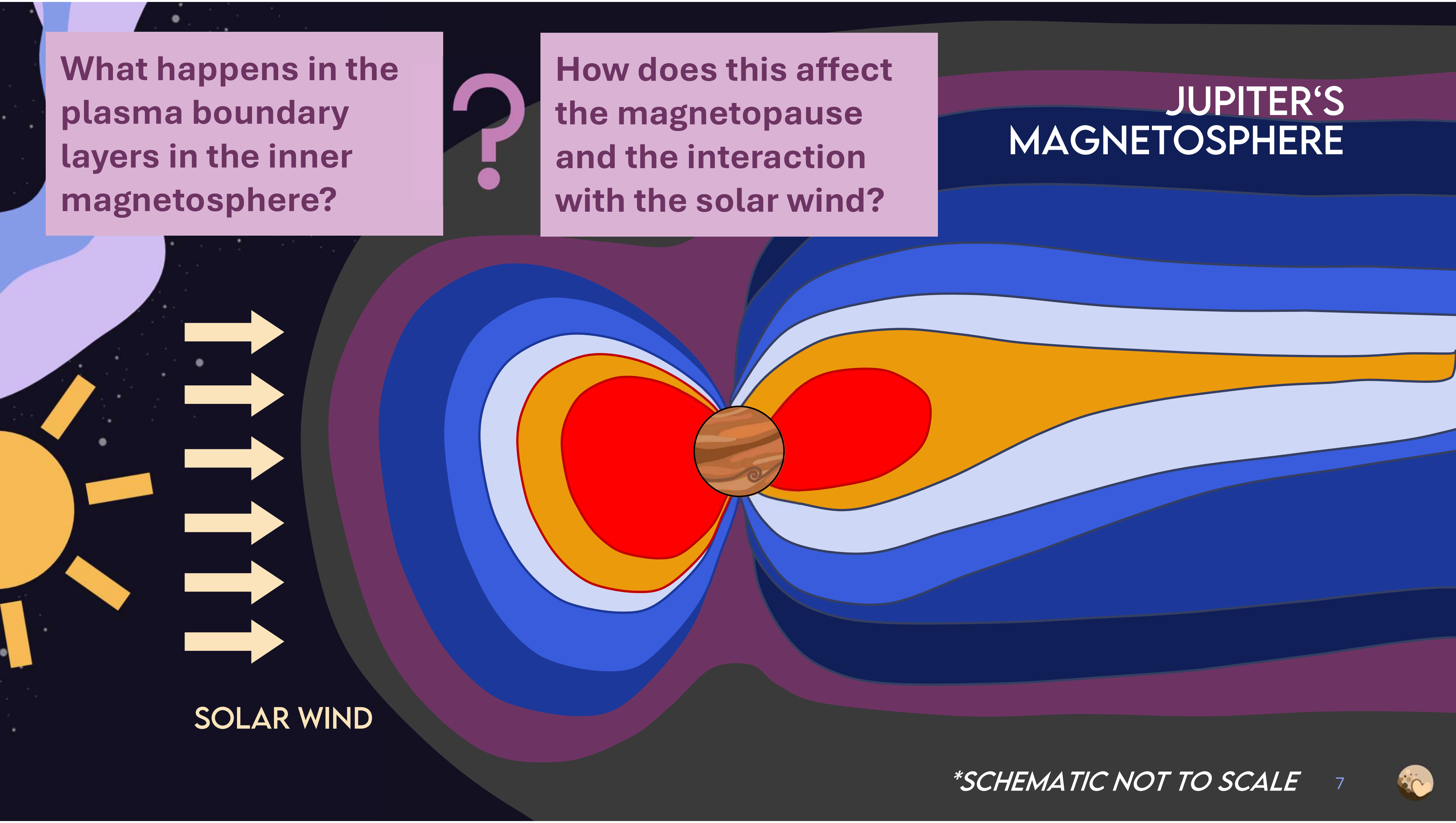
IO CLOSEUP



*SCHEMATIC NOT TO SCALE

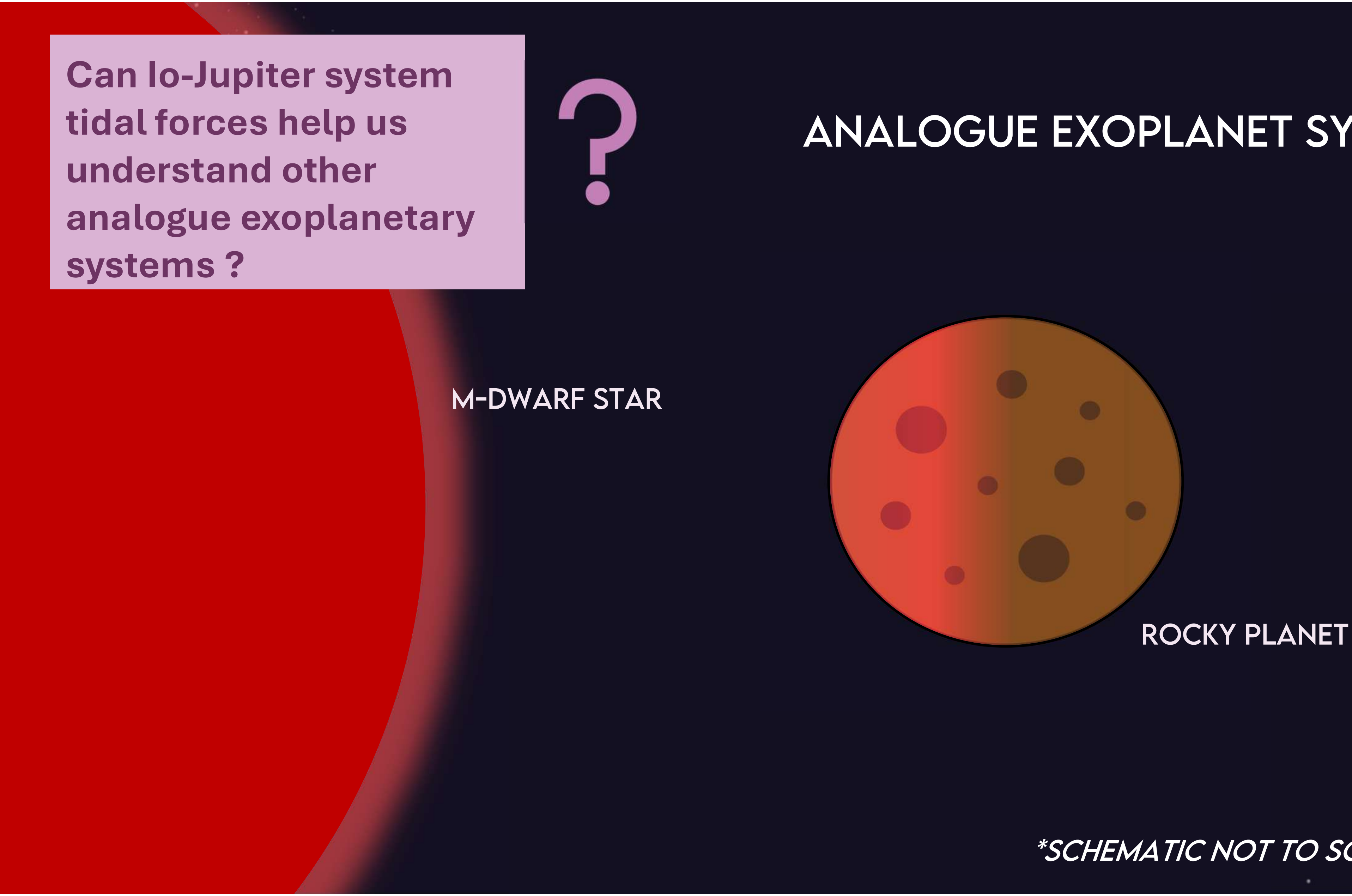

JUPITER'S
MAGNETIC
FIELD LINES
IO CLOSEUP
UV
*SCHEMATIC NOT TO SCALE


How do ions escaping from the exosphere interact with the plasma torus?
JUPITER'S MAGNETIC FIELD LINES
IO CLOSEUP
UV
PLASMA TORUS
*SCHEMATIC NOT TO SCALE

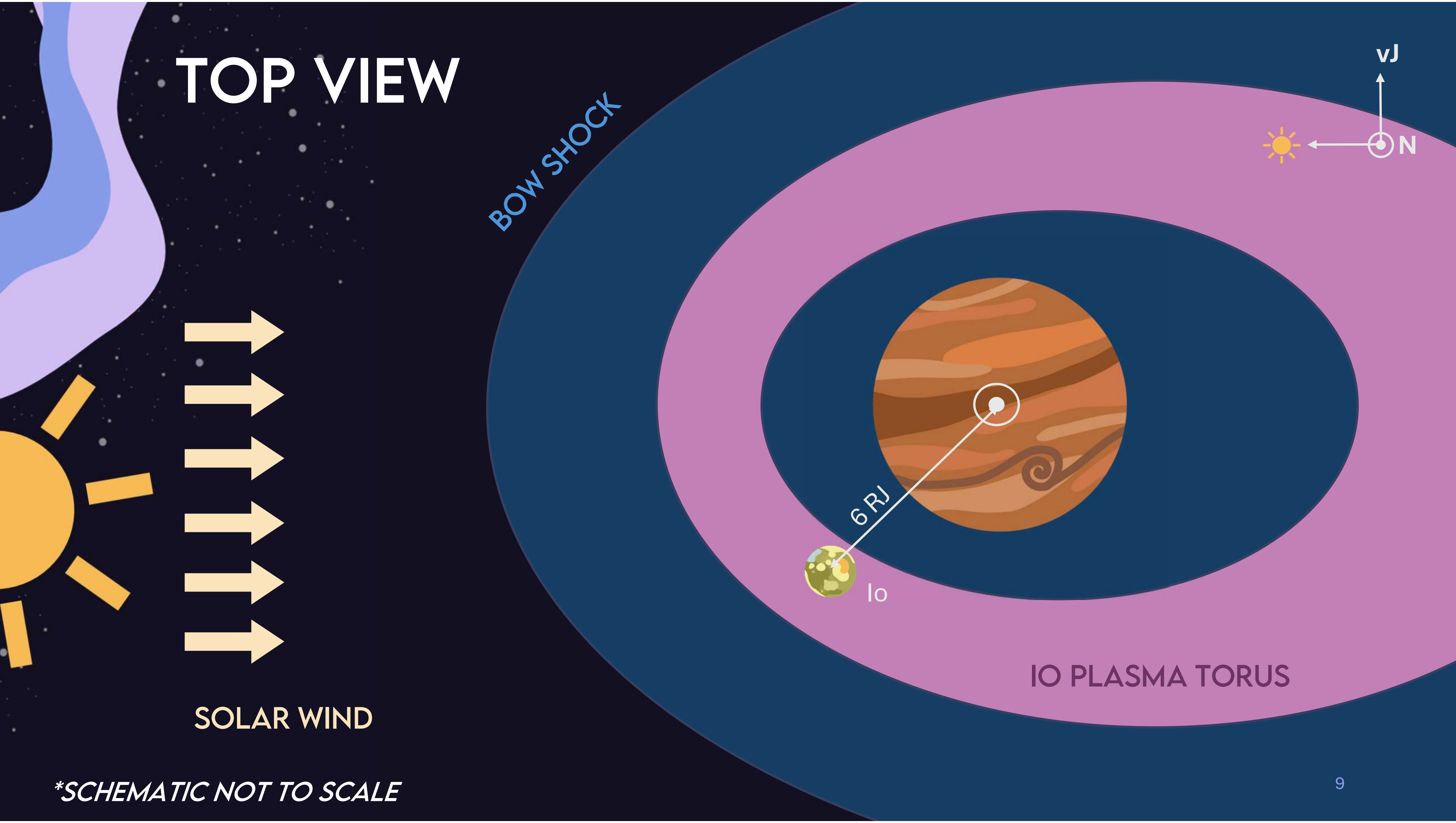

What happens in the plasma boundary layers in the inner magnetosphere?
?
How does this affect the magnetopause and the interaction with the solar wind?
JUPITER'S MAGNETOSPHERE
SOLAR WIND
*SCHEMATIC NOT TO SCALE

Can Io-Jupiter system tidal forces help us understand other analogue exoplanetary systems ?

ANALOGUE EXOPLANET SYSTEM



**SCHEMATIC NOT TO SCALE*


TOP VIEW
BOW SHOCK
vJ
N
6 RJ
Io
IO PLASMA TORUS
SOLAR WIND
*SCHEMATIC NOT TO SCALE

JUPITER: PREVIOUS AND ONGOING MISSIONS

- Pioneer's
- Voyager's
- Galileo
- Cassini
- Juno
- JUICE *
- Europa Clipper *

BUT WHAT DO WE WANT TO STUDY EXACTLY?

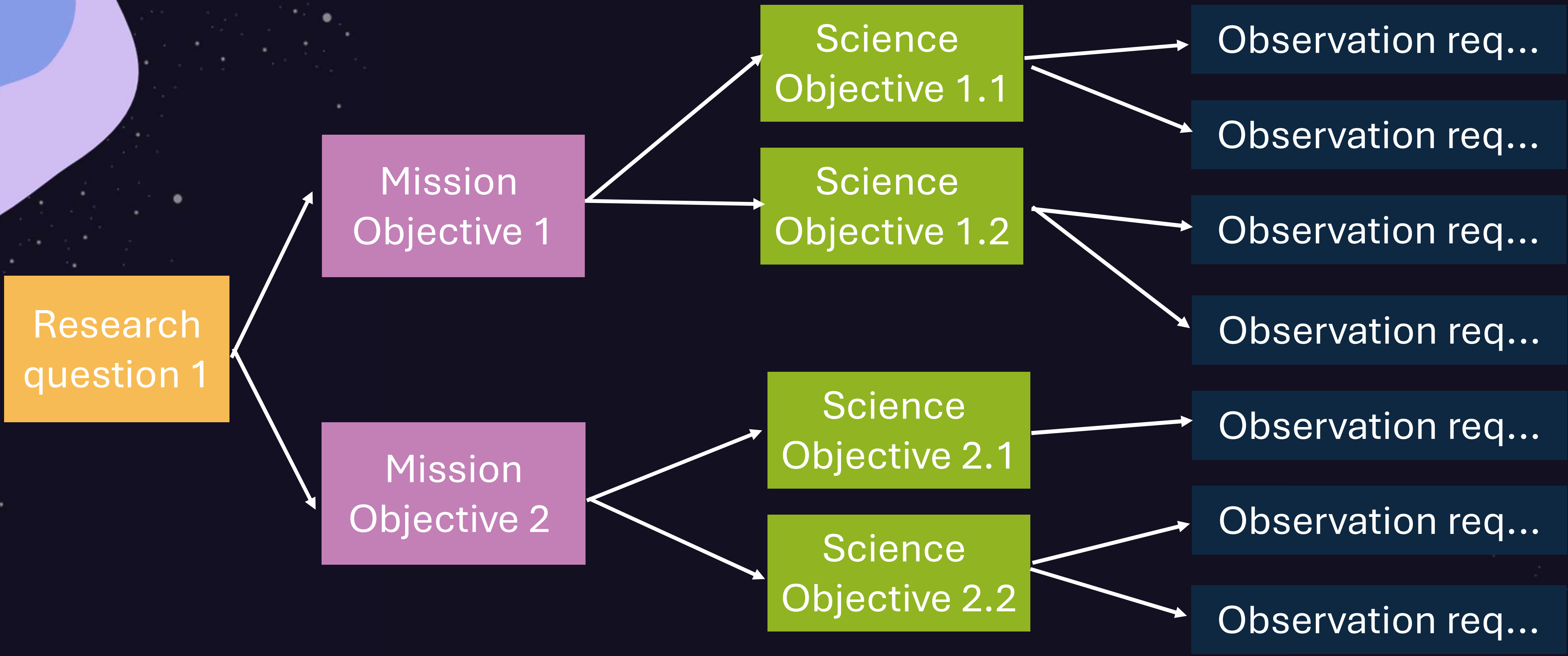
RQ1 What are the fundamental acceleration and loss mechanisms in the Jovian magnetosphere near Io's orbit?

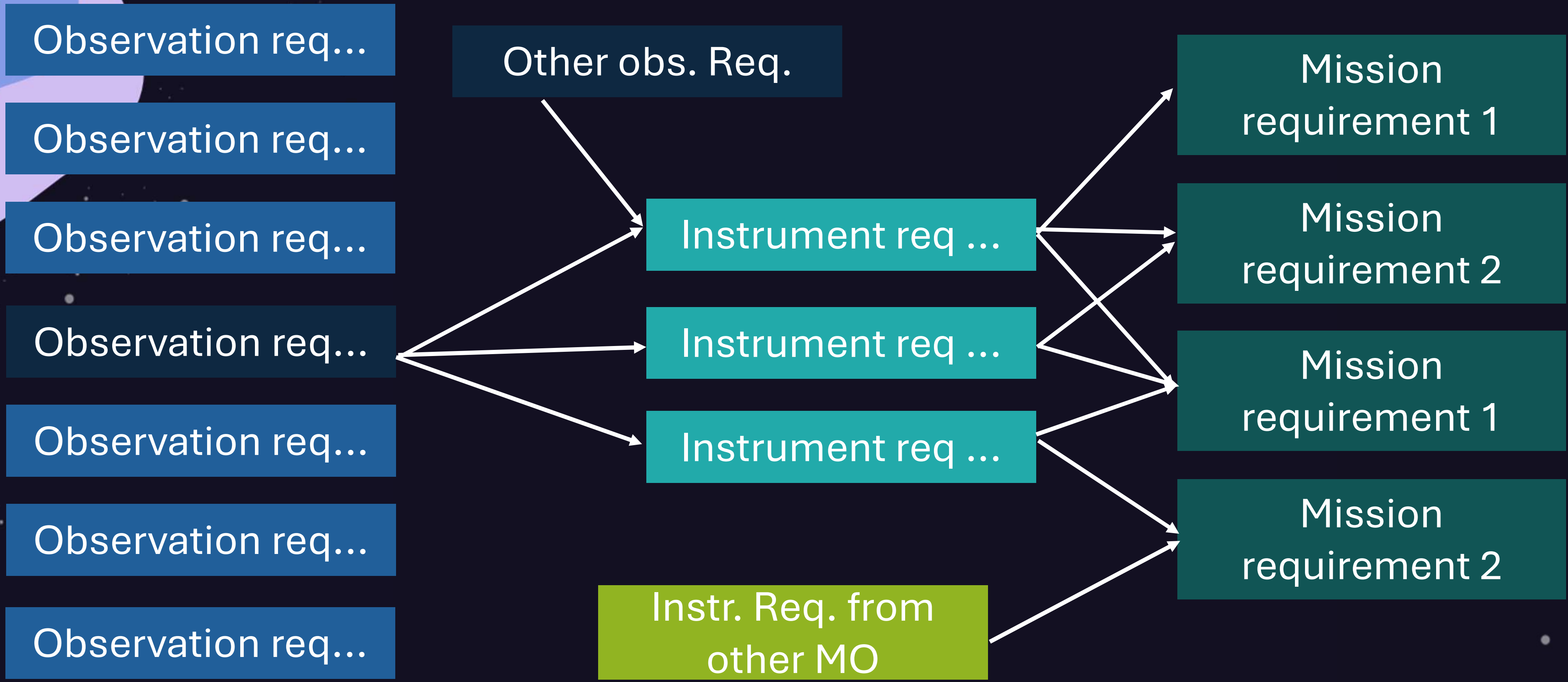
RQ2 What mechanisms/dynamics govern the physical interactions at Jupiter's magnetosphere?

RQ3 What are the internal processes and structures of Io?

RQ4 What does Io's tidal heating, exosphere, and torus reveal about the interior state, volcanism, and mass loss in close-in exoplanet systems?

SCIENCE TRACEABILITY MATRIX (STM) PHILOSOPHY





Observation req...
Observation req...
Observation req...
Observation req...
Observation req...
Observation req...
Observation req...
Other obs. Req.
Instrument req ...
Instrument req ...
Instrument req ...
Instr. Req. from other MO
Mission requirement 1
Mission requirement 2
Mission requirement 1
Mission requirement 2

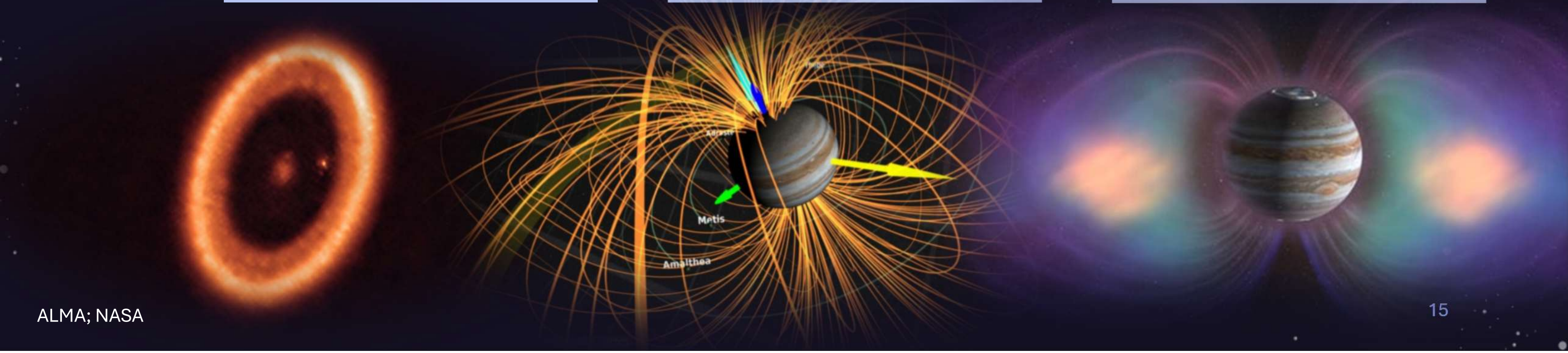
MO1

Determine how Io supplies plasma to Jupiter’s inner magnetosphere and how the resulting plasma torus is structured, transported, heated, accelerated and lost.

SO1.1:
Determine 3**D structure** and **temporal evolution** of the **Io plasma torus.**

SO1.2:
Identify kinetic processes that **heat**, **accelerate**, **transport** and **remove** Io-sourced plasma in Jupiter’s inner magnetosphere.

SO1.3:
Quantify **ionisation**, **pickup** and **transfer of mass** and **energy** from Io’s environment into the plasma torus.



ALMA; NASA

MO1

OR1.1.1: Characterize the evolution of plasma torus over various timescales

OR1.1.2:Characterize the radial, vertical, and azimuthal variations of Io's plasma torus at different longitudes and local times

OR1.1.3: Resolve the structure and dynamics of the Io plasma torus from local kinetic scales, through the Io kinetic region, to the global torus

OR1.2.1: Study mechanisms of inner magnetosphere and radiation belt generation in Jovian system

OR1.2.2: Investigate the influence of sputtering and thermal desorption processes on the plasma loss on Io.

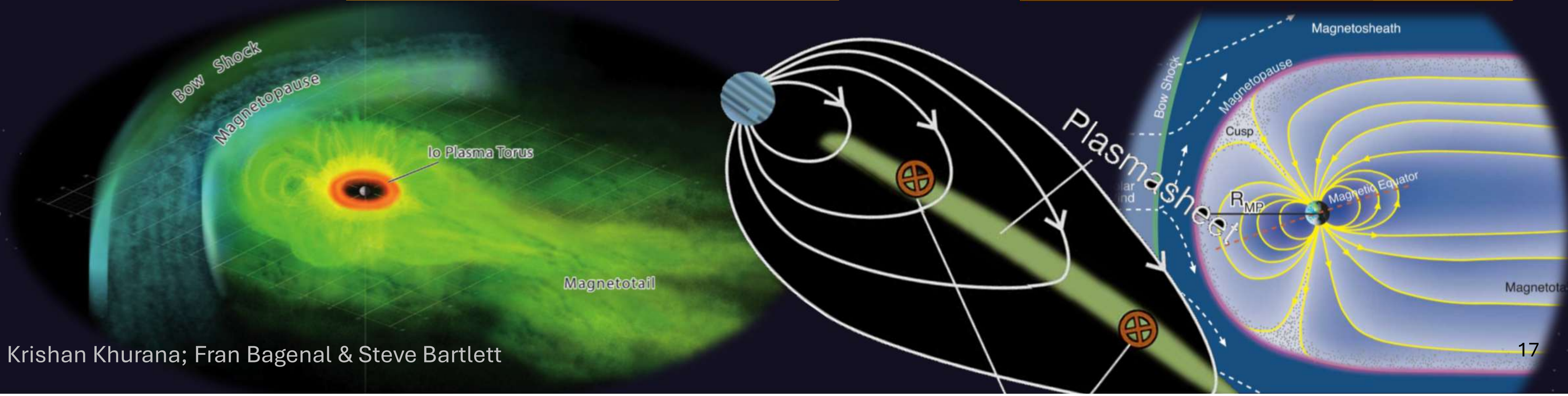
OR1.2.3: Study Io as the source of the plasma torus

OR1.3.1: Characterize how Io-sourced plasma and neutral material propagate through the Jovian system.

MO2 Characterise the spatial and temporal dynamics of Jupiter’s plasma boundaries and current sheets in the planet's inner magnetosphere.

SO2.1:
Determine **structure** and **variability** of plasma boundaries in Io interaction region with the inner magnetosphere.

SO2.2:
Characterise signatures of **energy conversion processes** in the inner Jovian current sheet (e.g. magnetic reconnection).



Krishan Khurana; Fran Bagenal & Steve Bartlett

MO2

OR2.1.1: Characterize the temporal and spatial movements of the fluids.

OR2.1.2: Characterize the temporal and spatial movements of the ions.

OR2.1.3: Characterize the temporal and spatial movements of the electrons.

OR2.3.1: Characterize the temporal and spatial change of the overall magnetic field

OR2.3.2: Characterize the UV spectra of the magnetic field layers

OR2.3.3: Study the bow shocks at the boundary layer

OR2.2.1: Detect the change in magnetic field topology and study magnetic reconnection

OR2.2.2: Resolve electron behaviour in the diffusion region to confirm active reconnection

OR2.2.3: Quantify energy conversion at the reconnection

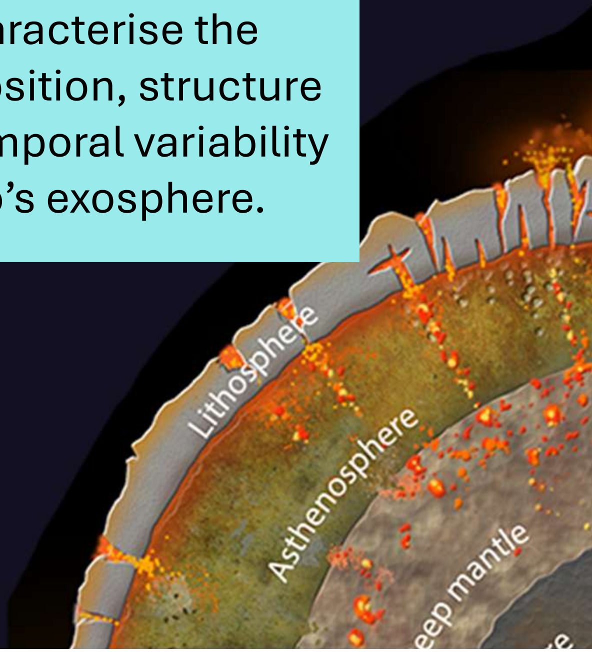
MO3

Determine how Io's volcanic activity contributes to Io's exosphere and study Io's interior subsurface magma reservoirs.

SO3.1:
Constrain Io’s interior structure, tidal deformation and spatial distribution of tidal heat dissipation.

SO 3.2:
Characterise the spatial distribution and temporal variability of Io’s volcanic activity.

SO3.3:
Characterise the composition, structure and temporal variability of Io’s exosphere.



NASA/JPL

MO3

OR3.1.1: Map spatial distribution of sub-surface magma sources

OR3.1.3: Constrain the thermal properties of subsurface magma reservoirs

OR4.1.1: Correlate sub-surface magma sources with volcanic centers

OR4.2.1: Map the spatial distribution of volcanoes

OR4.2.2: Characterize the activity state of Io's volcanoes

OR5.1.1: Map the spatial distribution of volcanic gas emissions

OR5.1.2: Characterise the composition and abundance of volcanic gases

OR5.2.1: Correlate volcanic gas emissions to exospheric gas distributions

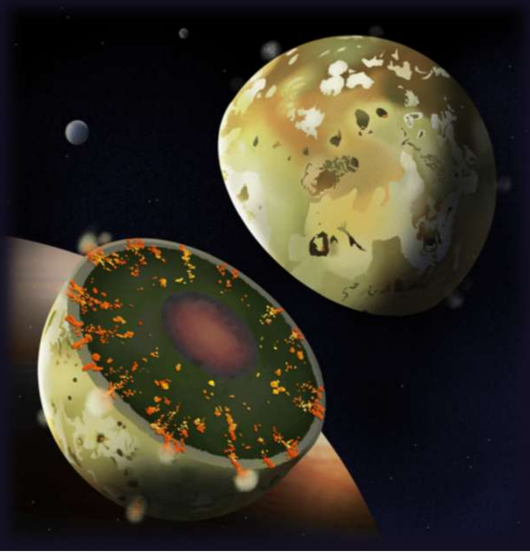
MO4

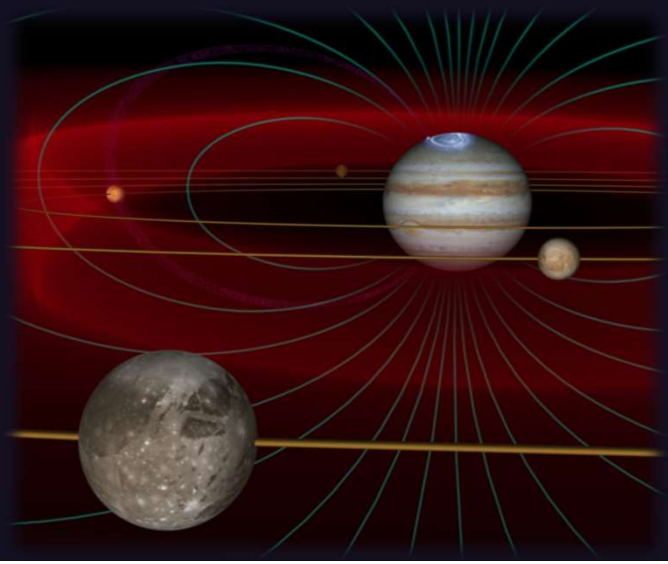
Study what Io's tidal heating, exosphere, and torus can reveal on the interior state, volcanism, and mass loss in close-in exoplanetary systems.

SO4.1:
Quantify the relationship between Io's tidal response, surface heat-flow distribution and volcanic thermal output.

SO4.2:
Determine which unresolved ultraviolet and radio signatures trace mass loading, transport and loss inrotation-dominated plasma tori

SO4.3:
Determine which exospheric signatures trace volcanic outgassing and escape from tidally heated rocky bodies.





[Park+2025; SwRI]

MO4

OR6.1.1: Measure the periodic motion and orbital-period vibration ("wobble") of Io's surface

OR6.1.2: Measure spacecraft trajectory perturbations to determine Io's gravity field

OR6.2.1: Characterize the density and composition of the torus material over space and time.

OR6.2.2: Determine the input and loss fluxes of torus material and its transport within the torus.

OR6.3.1: Characterize the composition, density, temperature, spatial structure and variability of Io's exosphere

OR6.3.2: Determine volatile supply/escape rates linking the exosphere to the torus

SUMMARY – WHAT WILL IFESTOS DELIVER?

1. Ifestos will trace the origin, evolution and fate of Io-sourced plasma.

2. Ifestos will reveal how magnetic fields, plasma boundaries and energy-conversion processes shape Jupiter's inner magnetosphere.

3. Ifestos will connect Io's interior, volcanism and atmospheric mass supply.

4. Ifestos will establish Io as a benchmark for interpreting tidally heated planetary systems.

MISSION REQUIREMENTS

MSN-CON-01	The S/C shall be compatible with Ariane 64 launch vehicle
MSN-CON-02	The science orbit shall be in the constant view of the Sun
MSN-ENV-01	The S/C shall be operational in Jupiter and Io radiation environment for the mission lifetime
MSN-ENV-02	The S/C shall be operational in temperatures for hot and cold case for the mission lifetime.

MISSION REQUIREMENTS

MSN-OPR-01	The UV measurements shall be made at a distance not closer than 3*RJ away from plasma torus for at least 10 hours per measurement
MSN-OPR-02	The gravity measurements shall be conducted during at least 4 Io flybys at an altitude of 500 km or less
MSN-OPR-03	The LOS from S/C to Earth shall cross Io for radio occultation experiments
MSN-OPR-04	The remote sensing measurements shall cover a total of 10 % of Io's surface with resolution of 100 m on the span of mission lifetime
MSN-OPR-05	The plasma measurements shall cover 80% of plasma torus from the top view within 10*RJ during the span of mission lifetime

MISSION REQUIREMENTS

MSN-OPR-06	The S/C shall be in an orbit that is in resonance with Io's orbit
MSN-OPR-07	The S/C shall cross the torus every orbit for at least 6 months
MSN-OPR-08	The S/C shall cross the torus every orbit for at least 30 orbits
MSN-OPR-09	All the data shall be downlinked before end of primary mission lifetime

WHAT DOES IFESTOS NEED FOR THIS?

- Ifestos will map the torus from above and below → polar orbit
- Ifestos will cross the torus at least 30 times, over 6 months, and preferably longer, to study spatial and temporal variations of the torus
- Ifestos will flyby Io closer than 500 km at least 4 times to measure/map >= 10% of its surface, interior, and exosphere

HOW DO WE MEASURE THIS?

Introduction into the Instrument Suite

IFESTOS SENSOR SUITE

IOS
Io Sensing

MAG
Magnetometer

VIRIS
Visual and Near Infra Red Imaging Spectrometer

TIRM
Thermal Infra Red Imager

RSE
Radio Science Experiments

WAC
Wide Angle Camera

ISP
In-Situ Plasma

MAG
Magnetometer

RPW
Radio and Plasma Wave Instrument

ENAI
Energetic neutral atom and ion imager

ED
Electron Detector

RMP
Remote Plasma

MAG
Magnetometer

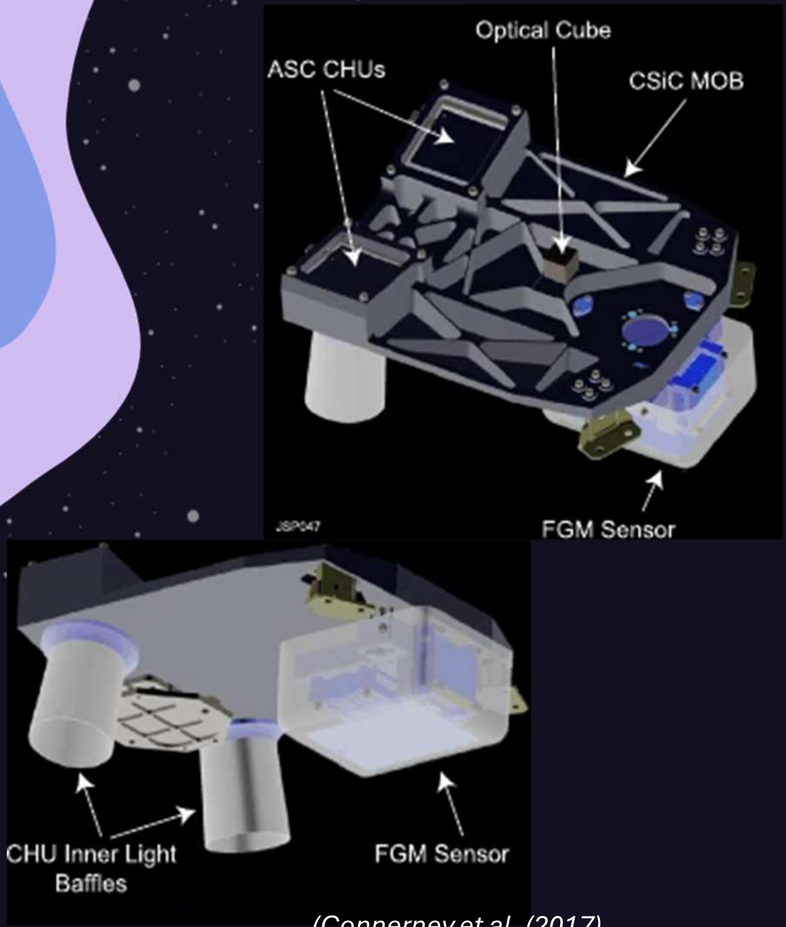
UVS
Ultra Violet Spectrometer

ENAI
Energetic neutral atom and ion imager

RSE
Radio Science Experiments

RADMON
Radiation Monitor

MAGNETOMETERS (MAG)



(Connerney et al. (2017))

- 2 tri-axial fluxgate magnetometers + 1 scalar magnetometer
- Mounted on a 10.6 m magnetically clean boom
- Measures: B_x ,B_y ,B_z and |B|
- Range: ±8400 (nominal), ±150.000 nT extended,
- Survey mode: 32 vectors/s
- Burst mode: 128 vectors/s

→ **Map the magnetic field structure and variability of Jupiter-Io system**

TRL	TEMPERATURE	HERITAGE
5	-150 - +60 °C (FGM) -150 - +50 °C (scalar)	JUNO-MAG

ENERGETIC NEUTRAL ATOM AND ION IMAGER (ENAI)

(https://www.jhuapl.edu/destinations/instruments/joeejeni (Johns Hopkins University – APL))

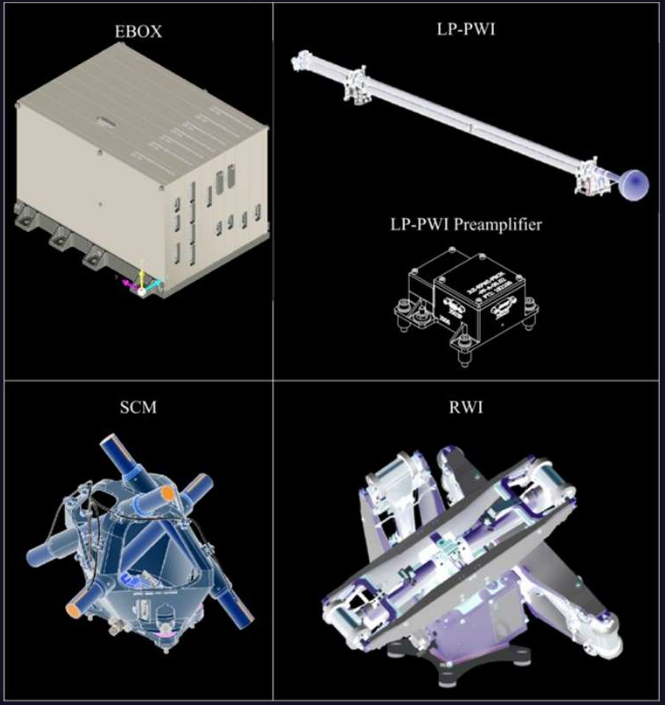
TRL	TEMPERATURE	HERITAGE
5	-20 - +50 °C	JUICE PEP-JENI heritage

- 3x ENAI
- 2 operating modes: ENA imaging and ion imaging
  - ENA imaging
  - In-situ energetic ion measurement
- Range: 0.5 keV – 300 keV for ENAs
  0.5 keV – 5 MeV for ions
- Resolution: ΔE/E ≤ 30 %
- 3 sensor heads for wide simultaneous angular coverage

→ Energy-, direction-, and mass-resolved ENA and ion flux

→ Global maps of charge exchange emissions

RADIO AND PLASMA WAVE INSTRUMENT (RPW)



(Wahlund et al., 2024)

TRL	TEMPERATURE	HERITAGE
5	-50 - +70 °C (SCM) -160 - +100 °C (HF, LP) -20 - +55 °C (EBOX)	JUICE RPWI, JUNO HFR heritage

SCM-RPW: triaxial search coil magnetometer

→ magnetic field vector

LP-RPW: 4 Langmuir probes in tetrahedral configuration

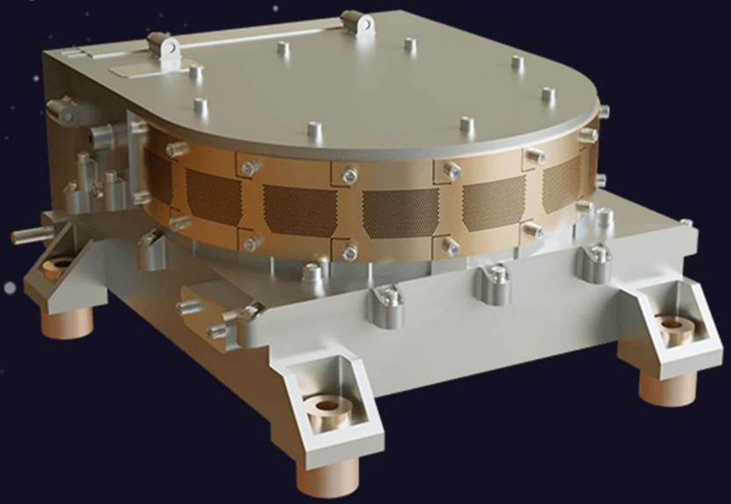
→ plasma density and electric wave components

HF-RPW: High-Frequency Radio Antennas

→ density, temperature and high frequency variations of ionized fluid

EBOX-RPW: RPW Central Electronic Body

ELECTRON DETECTOR (ED)



(https://www.jhuapl.edu/destinations/instruments/joeejeni (Johns Hopkins University – APL))

- 3x ED
- range: 28 keV – 2 MeV
- Energy resolution: ΔE/E 20 %
- 3 detectors for 3D picture

→ **Reconstruct full phase space distribution (PSD)**

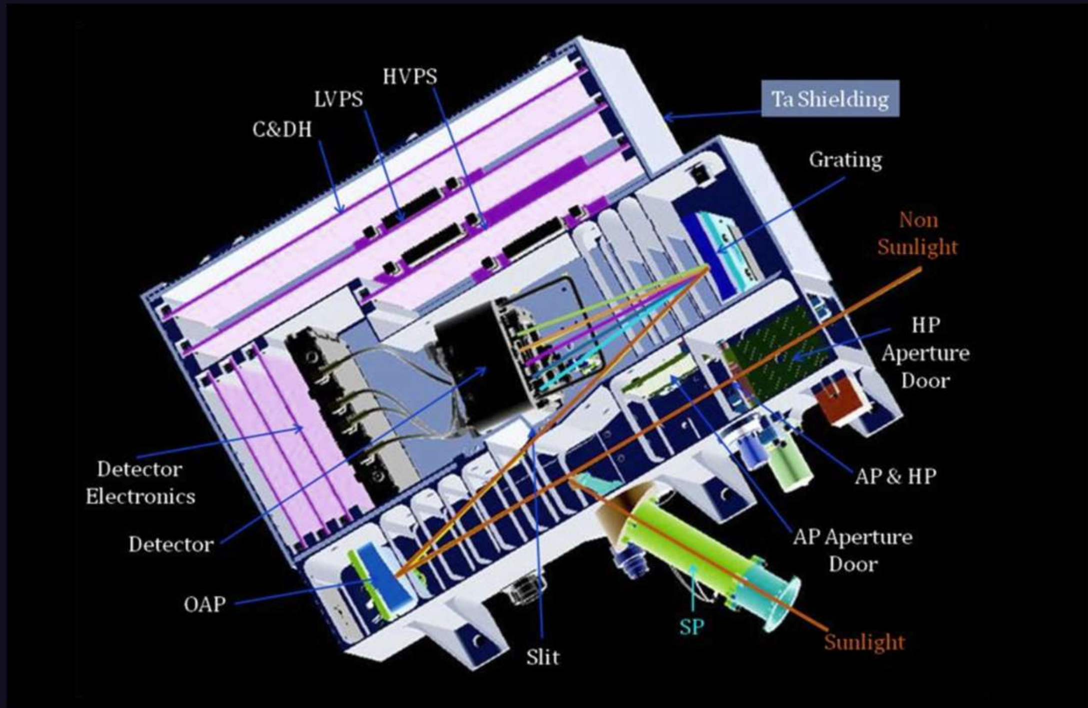
→ **Derive from PSD:** Pitch-angle distributions, Velocity and energy distributions, Bulk velocity Number density, Temperature, Pressure tensor

TRL	TEMPERATURE	HERITAGE
6	-20 - +50 °C	JUICE PEP-JoEE heritage

ULTRAVIOLET SPECTROGRAPH (UV)

- Coverage: 60 – 140 nm
- Spectral resolution: 0.5 nm
- SNR >= 10 per 0.16º spatial sample per 20 min. map (band-integrated)

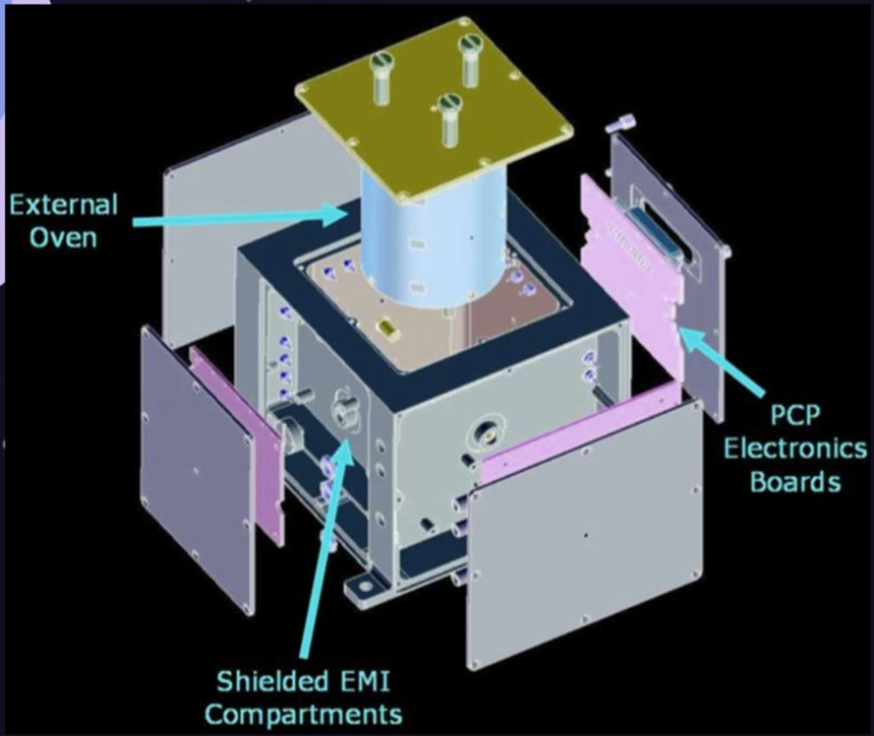
→ **Produce spectral map of plasma torus over space and time**



(Juice Red Book (ESA/SRE, 2014))

TRL	TEMPERATURE	HERITAGE
6	+19 - +21 °C	JUICE UVS heritage

RADIO SCIENCE EXPERIMENT (RSE)



(Shapira et al. 2016)

Dedicated use: KaT + USO

KaT: Coherent Ka/Ka Doppler and ranging → gravity field, tidal response and interior structure.

Ultra Stable Oscillator (USO): quartz crystal resonator + highly stable double oven → TEC and ionospheric electron density.

TRL	TEMPERATURE	HERITAGE
6	-20 - +65 °C (KaT) -30 - +60 °C (USO)	JUICE 3GM heritage

VIS NIR IMAGING SPECTROMETER (VIRIS)

Instrument Main Specs:

- Spectral range : 0.5 - 5.5 μm
- Spatial resolution: 75 m/pixel at 500 km distance

Function: Surface Composition, Atmosphere Composition

TRL	TEMPERATURE	HERITAGE
6	< -184 °C	JUICE MAJIS heritage

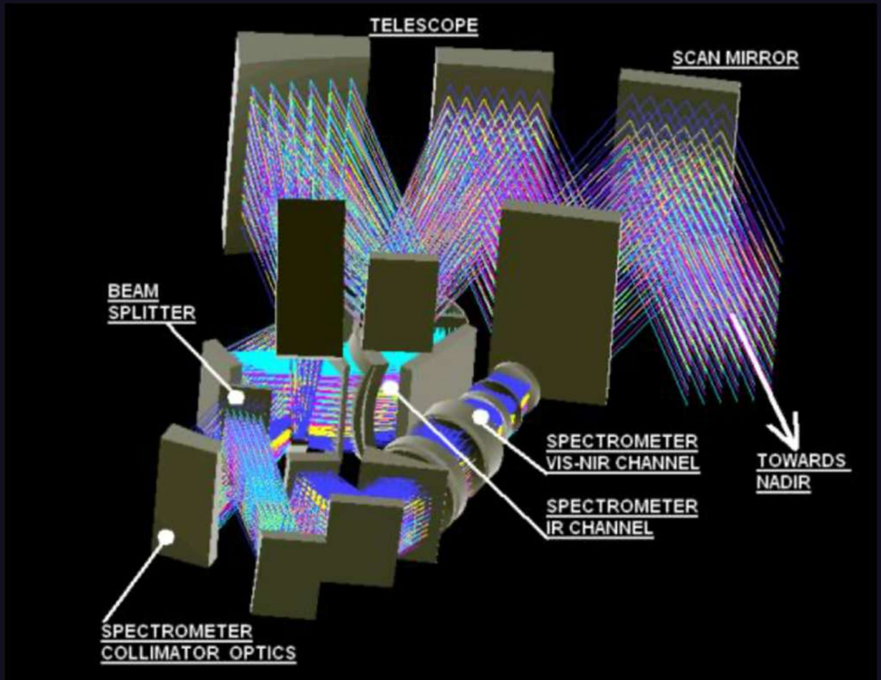


***Figure 4-5.** MAJIS block diagram (top) and optical design (bottom).*

(Juice Red Book (ESA/SRE, 2014))

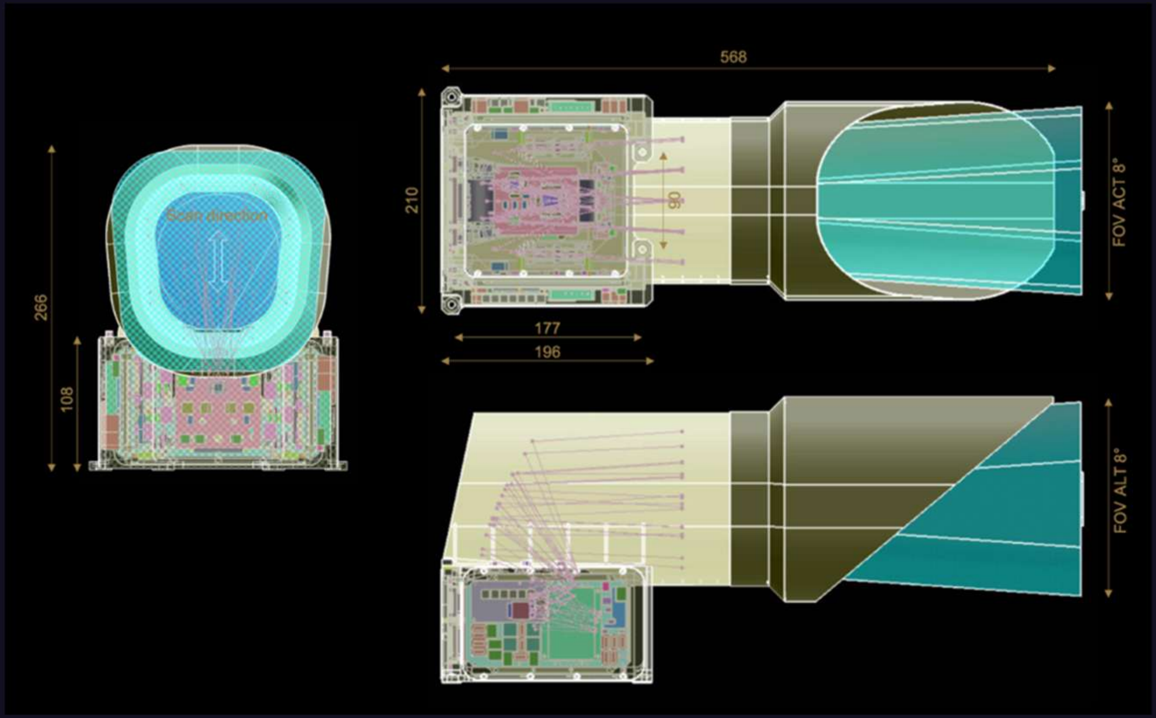
THERMAL INFRARED IMAGER (TIRM)

Instrument Main Specs :

- 625 m/pixel at 500km bolometer (2-16µm)
- 9.4 km/pixel radiometer at 500km (8-40µm)
- Uncooled sensor

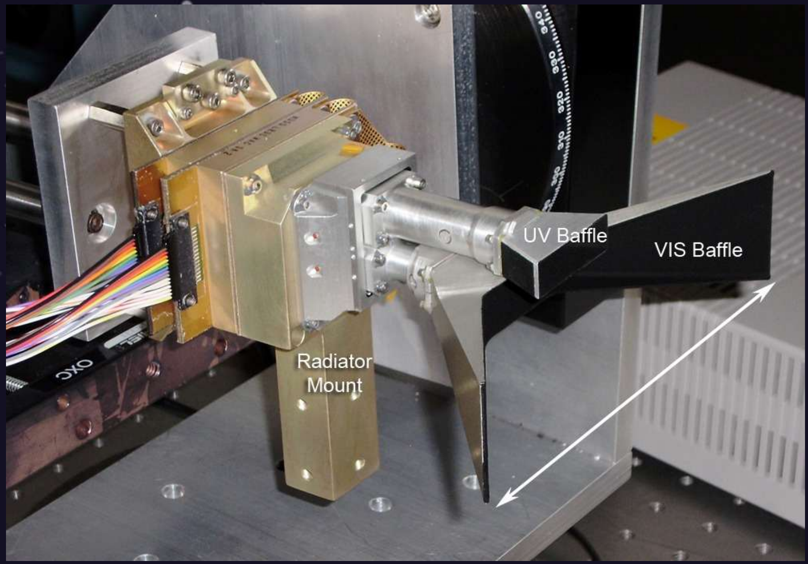
Function : Thermal Mapping of the surface.

TRL	TEMPERATURE	HERITAGE
5	-20 °C	TMAP-IVO MERTIS heritage



(Helbert et al. 2022)

WIDE ANGLE CAMERA (WAC)



(WAC design from university of Arizona)

Instrument Main Specs:

- Spectral range: 400 - 1100 nm visible and near UV
- Spatial resolution: 108 m/pixel at 500 km
- distance
- FOV of 26° x 26°
- Coverage per passage: 4% at 500km
- Pointing: 41 arcsec

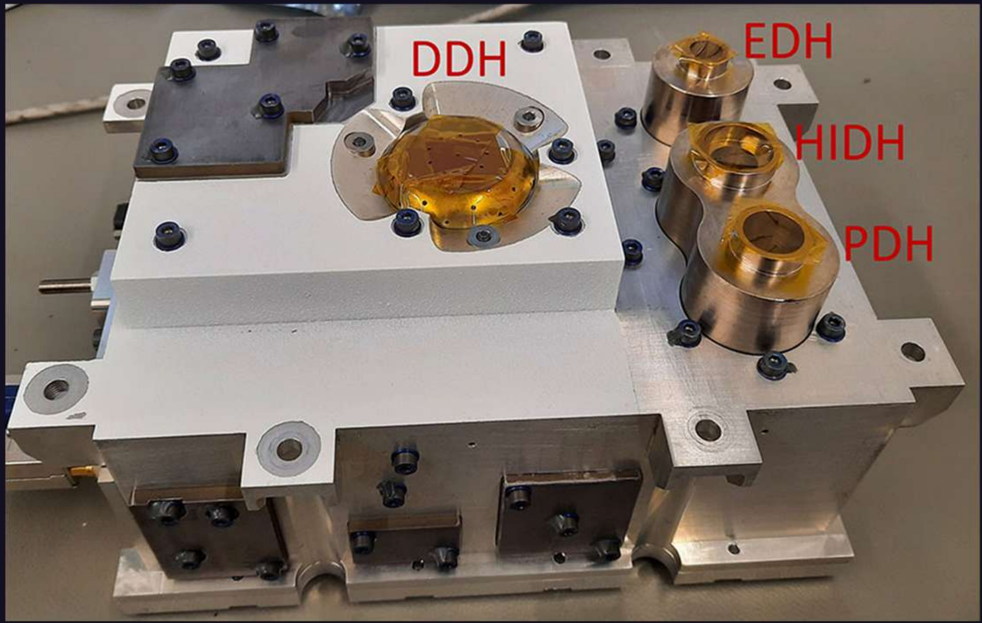
Function: Surface Morphology, Spatial and temporal distribution of volcanoes, global mapping

TRL	TEMPERATURE	HERITAGE
5	-174 °C	IVO-WAC heritage

RADIATION MONITOR (RADEM)

- Electron energy range: 0.3 to 40 MeV
- Proton energy range: 5 to 250 MeV

→ **direction-resolved fluxes and energy spectra of electrons, protons, and heavy ions**



(Hajdas et al., 2025)

TRL	TEMPERATURE	HERITAGE
6	-40 - +50 °C	JUICE-RADEM heritage

INSTRUMENT	PACKAGE	MAIN OBJECTIVE	PRIORITY
MAG	RMP, ISP, IOS	Magnetic mapping of torus and surrounding environment	Threshold
ENAI	RMP, ISP	Neutral atom detection (outside torus) and ion detection (inside torus)	Threshold
UVS	RMP	Torus mapping	Threshold
RPW	ISP	Plasma characterization	Threshold
RSE	RMP, IOS	Io and torus radio occultation, Io gravity mapping	Threshold
TIRM	IOS	Io detailed thermal and volcanic characterisation	Threshold
VIRIS	IOS	Io surface spectral characterisation and thermal mapping	Goal
WAC	IOS	Io imaging	Goal
ED	ISP	Electron density and distribution	Breakthrough

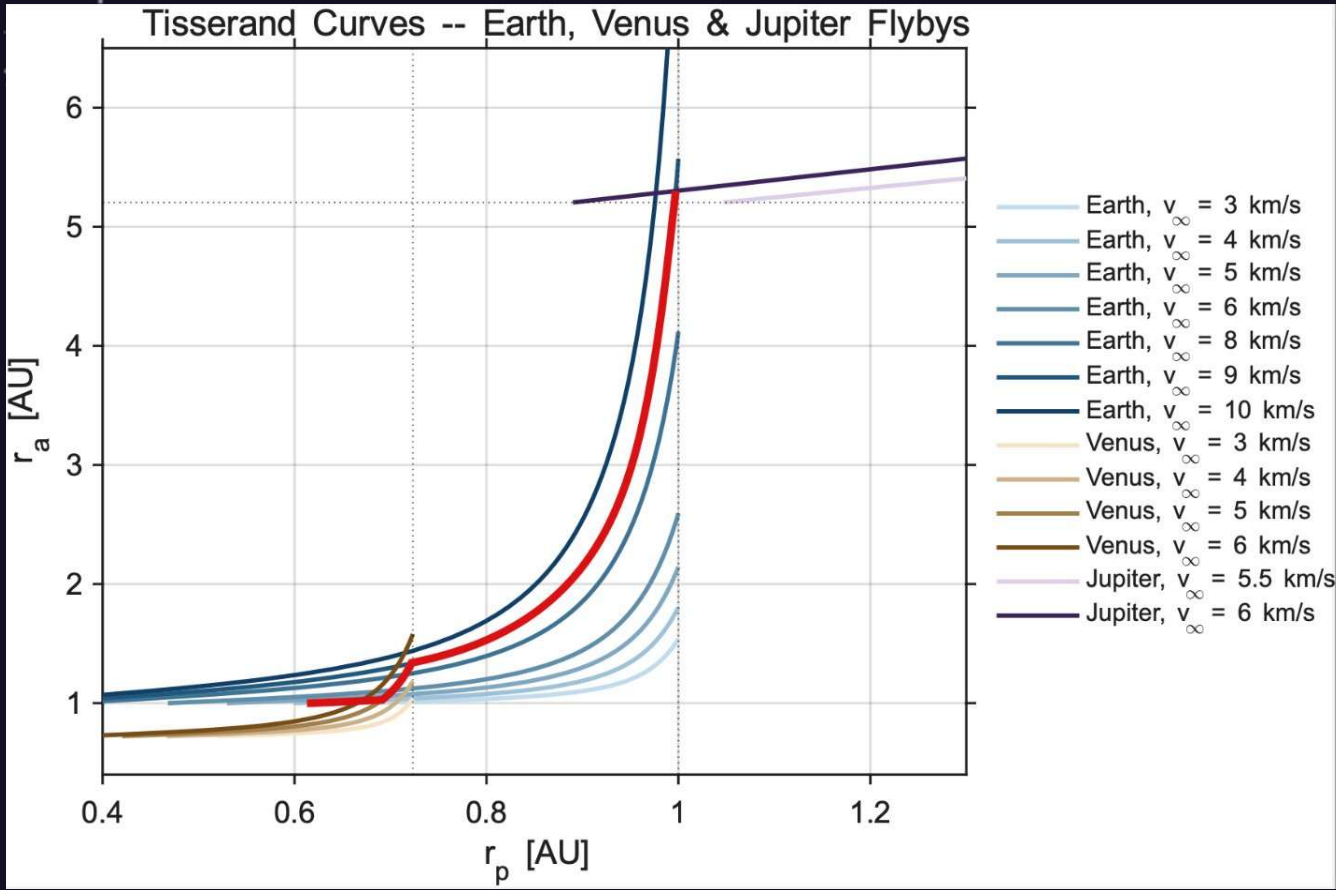
INSTRUMENT SUITE DIFFERENCE TO OTHER MISSIONS

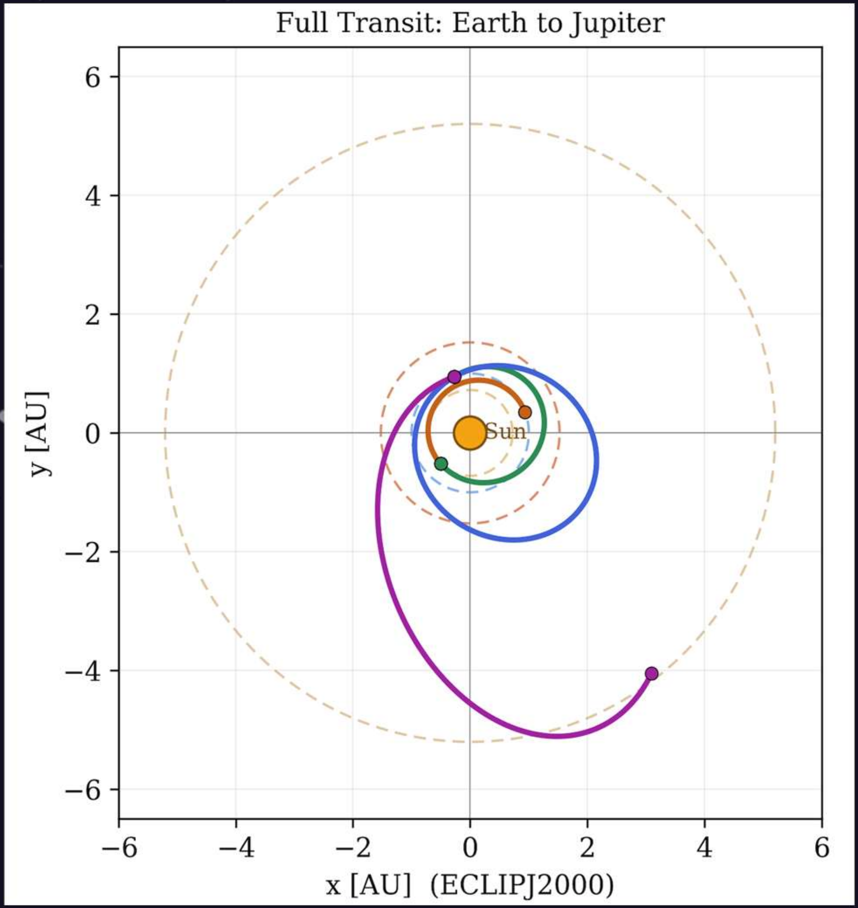
	JUICE	JUNO	IVO (PROPOSED)	IFESTOS
FOCUS	Ganymede, Europa, Callisto	Jupiter	Io	Io-Jupiter system
IO PLASMA TORUS AND MAGNETOSPHERE	Not an objective	Secondary	Secondary	Primary
IO INTERIOR, VOLCANISM, EXOSPHERE	Not an objective	Secondary	Primary	Secondary
EXOPLANET SYSTEM ANALOGUES	Not an objective	Not an objective	Secondary	Secondary
IO ACCESS	No fly-bys	2 fly-bys at ~1500 km	~10 fly-bys at 200-500 km	≥4 fly-bys <500 km

HOW DO WE GET TO THE JOVIAN SYSTEM?

Insight into transfer and insertion orbit strategy

SELECTION OF FLYBY SEQUENCE





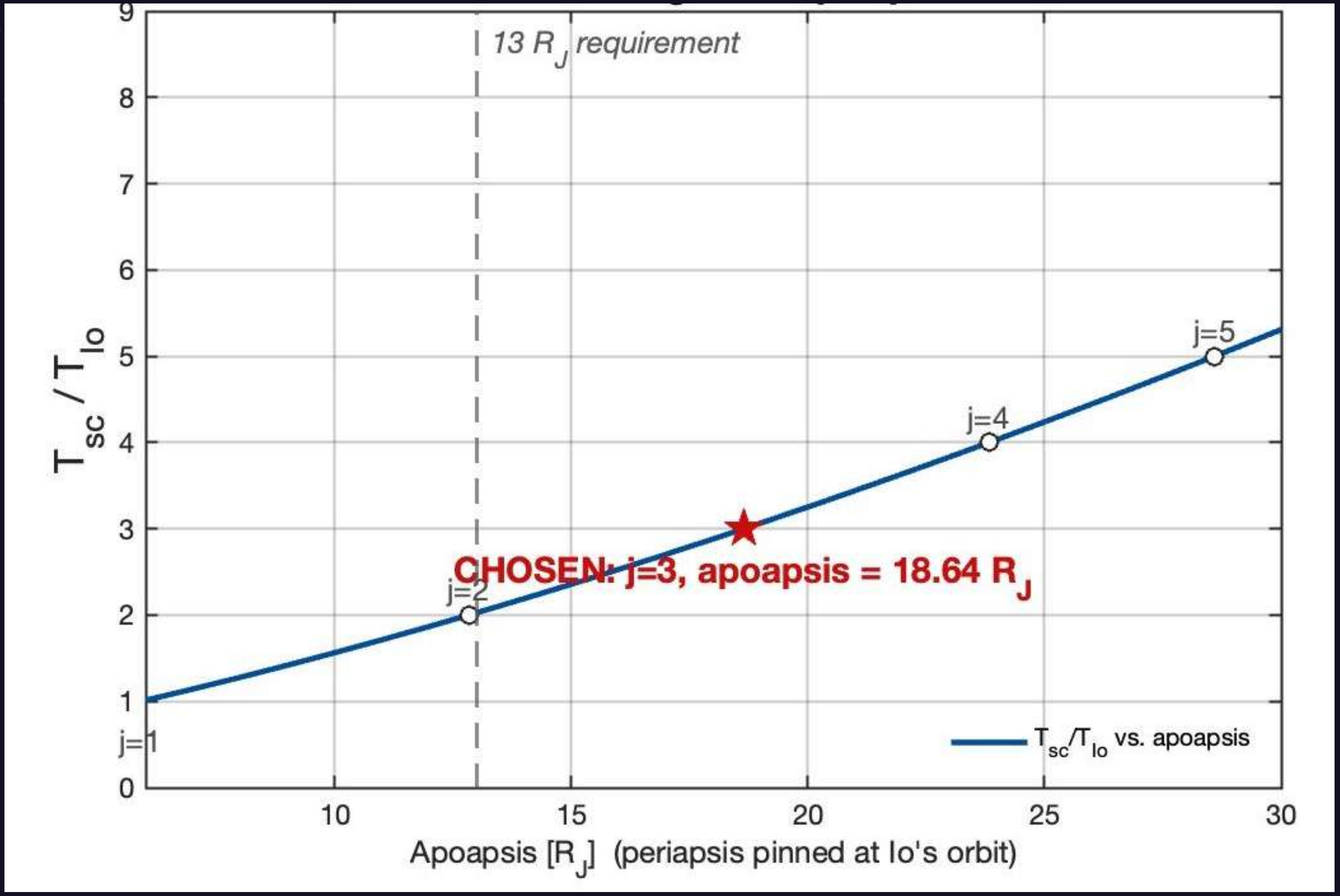
ORBITS TO JUPITER: EVEEJ

Departure Date: **13/10/2037**
Arrival Date: **22/09/2044**
C3 : . **11.28** km^2/s^2
Vinf at arrival: **5986.16** m/s

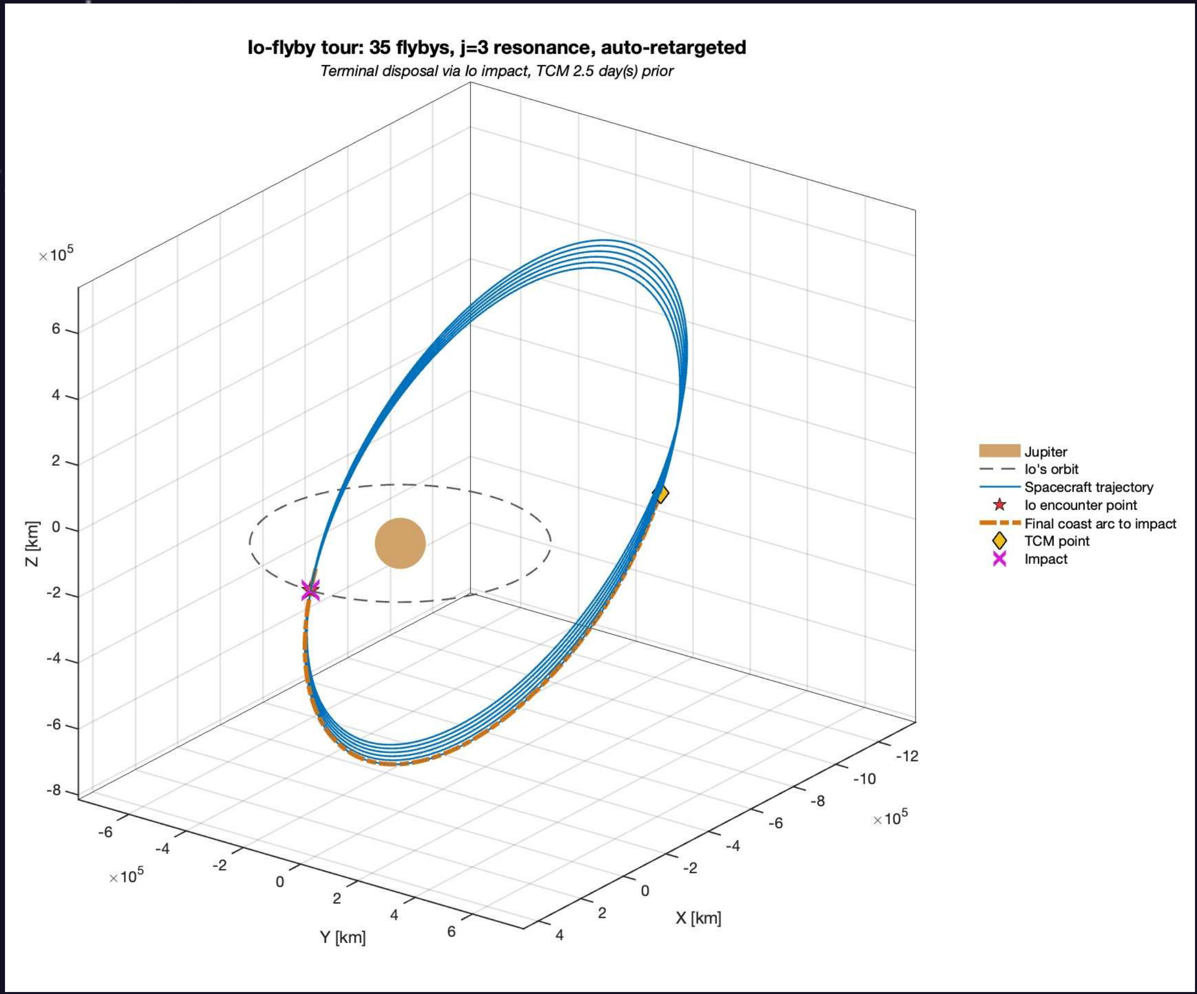
Segment	Delta V [m/s]
Earth Departure	3360.48
DSM	2.11
JOI	693.18
Jov Sys DV	≈ 500 [1]
EOL	0.69

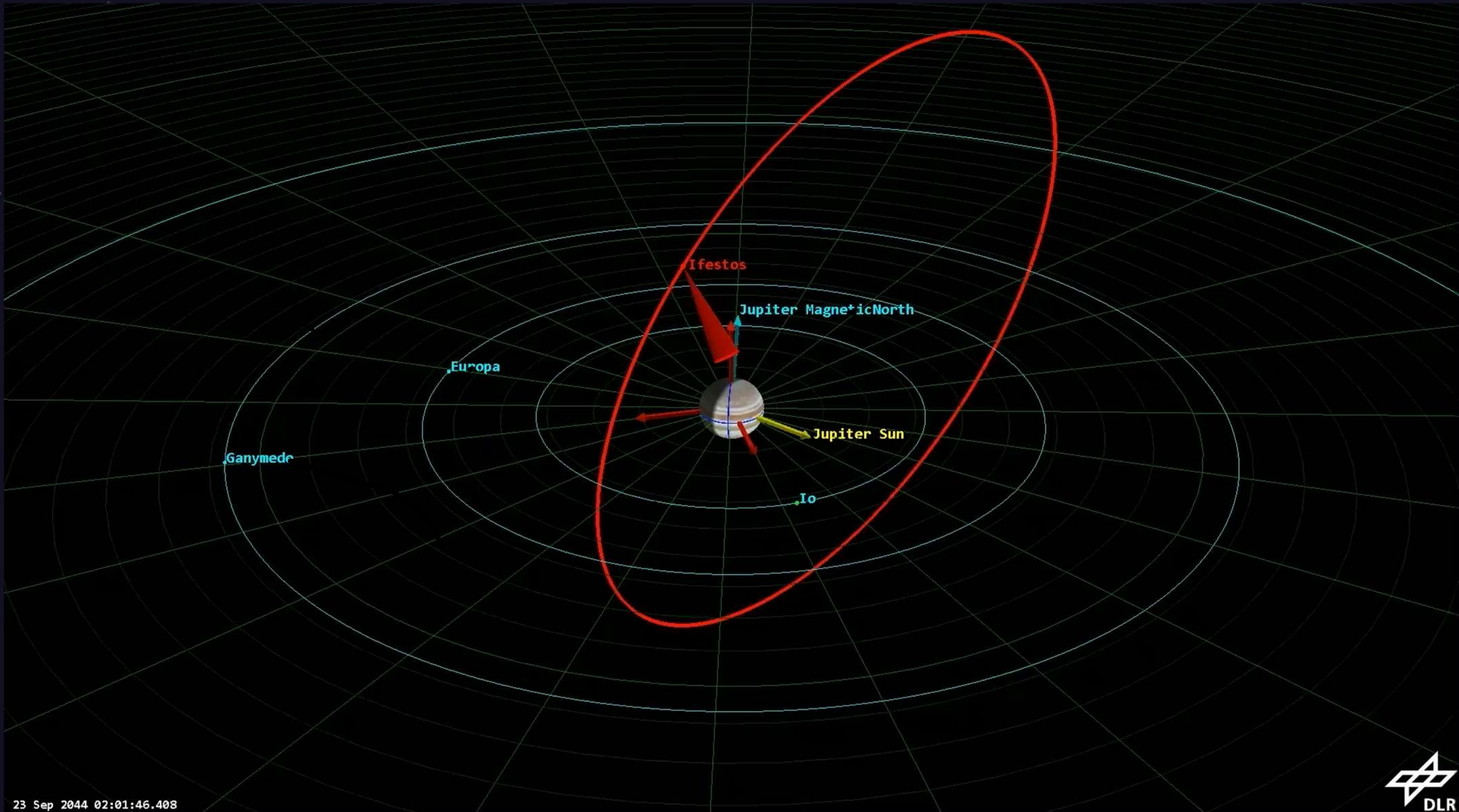
[1] European Space Agency, *Juice: Playing Pinball with Jupiter's Moons*, European Space Operations Centre, https://esoc.esa.int/juice-playing-pinball-jupiters-moons, accessed 20 July 2026.

CHOICE OF FLYBY RESONANCE



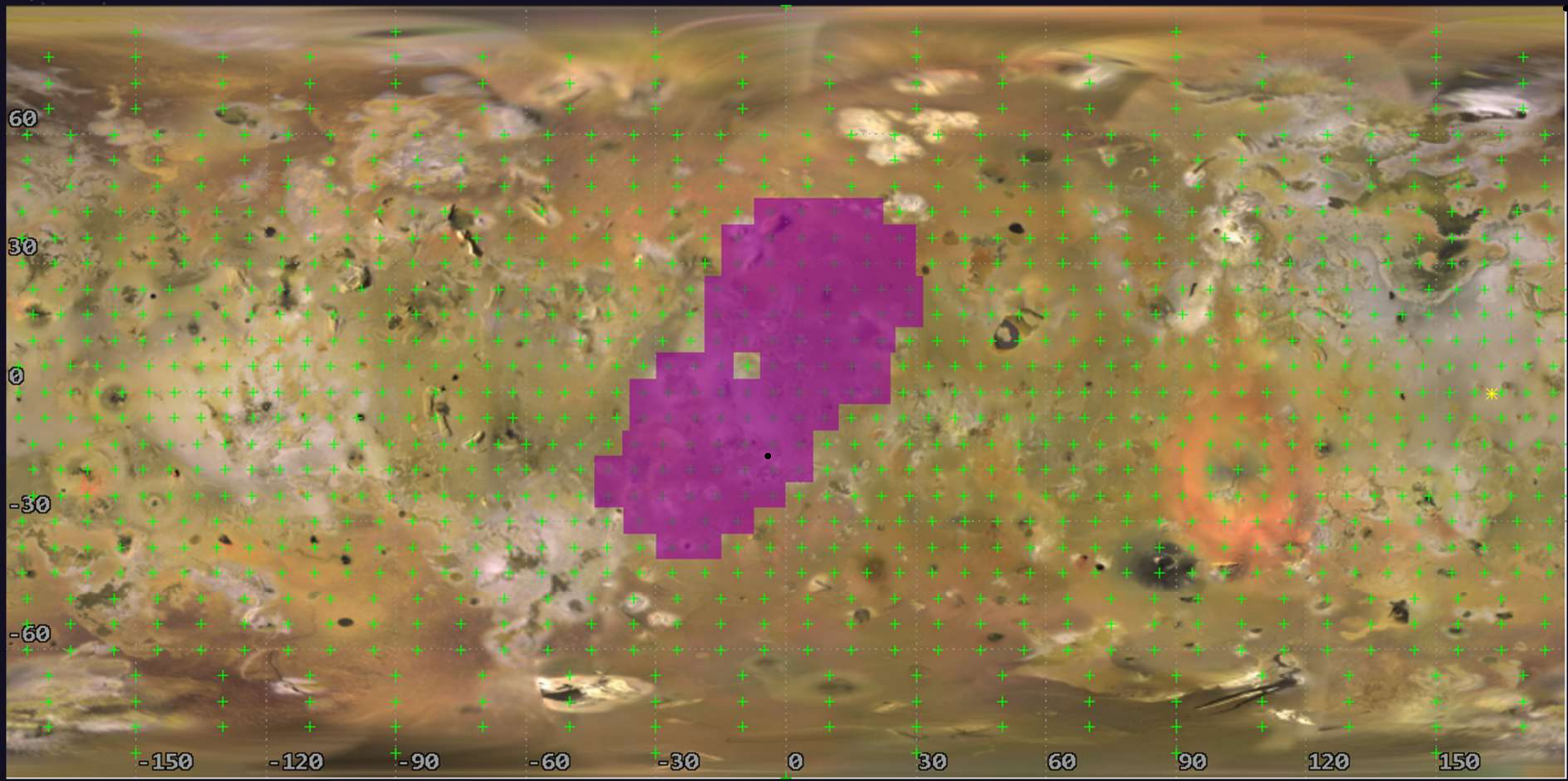
JOVIAN ORBIT



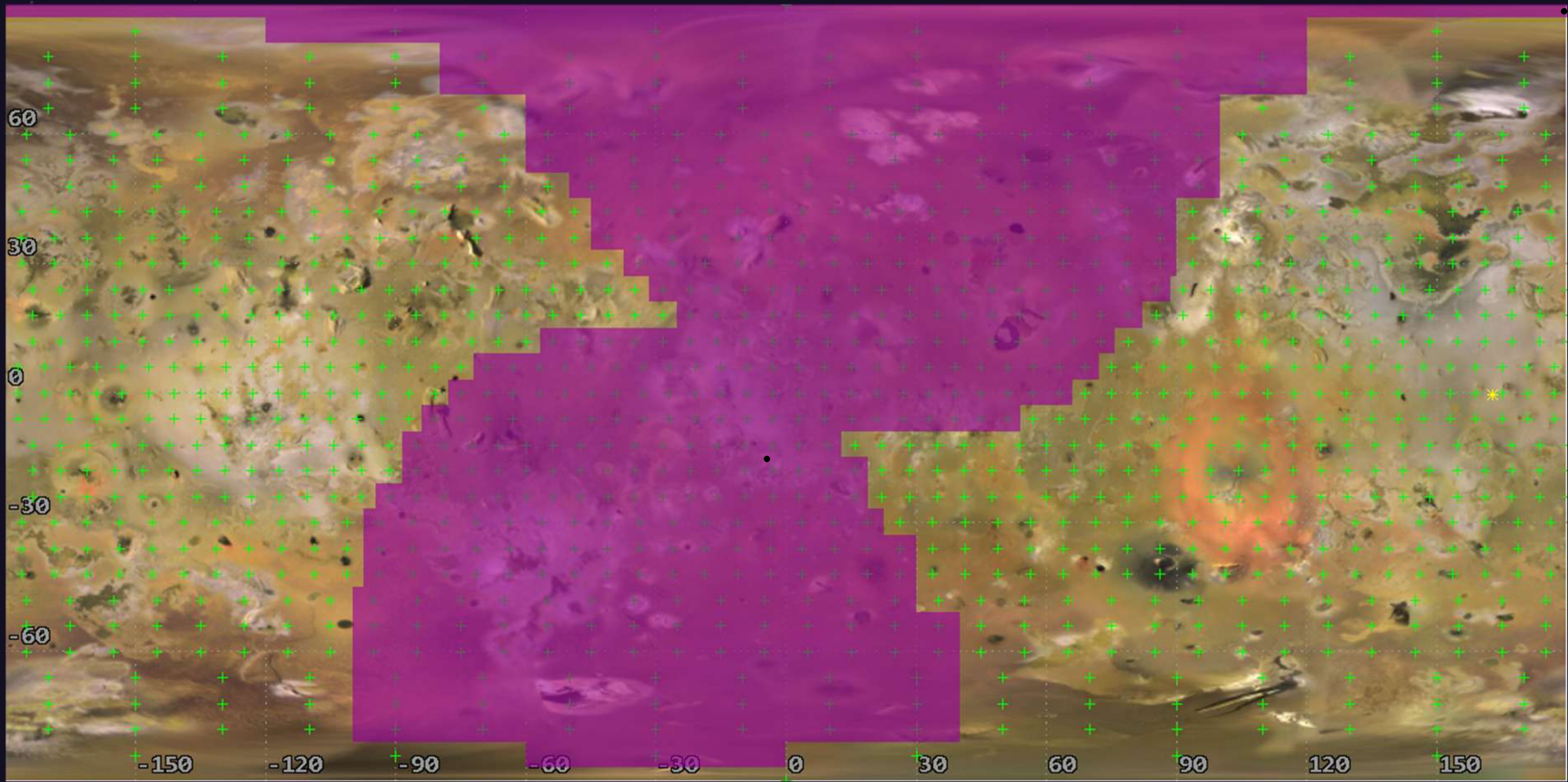


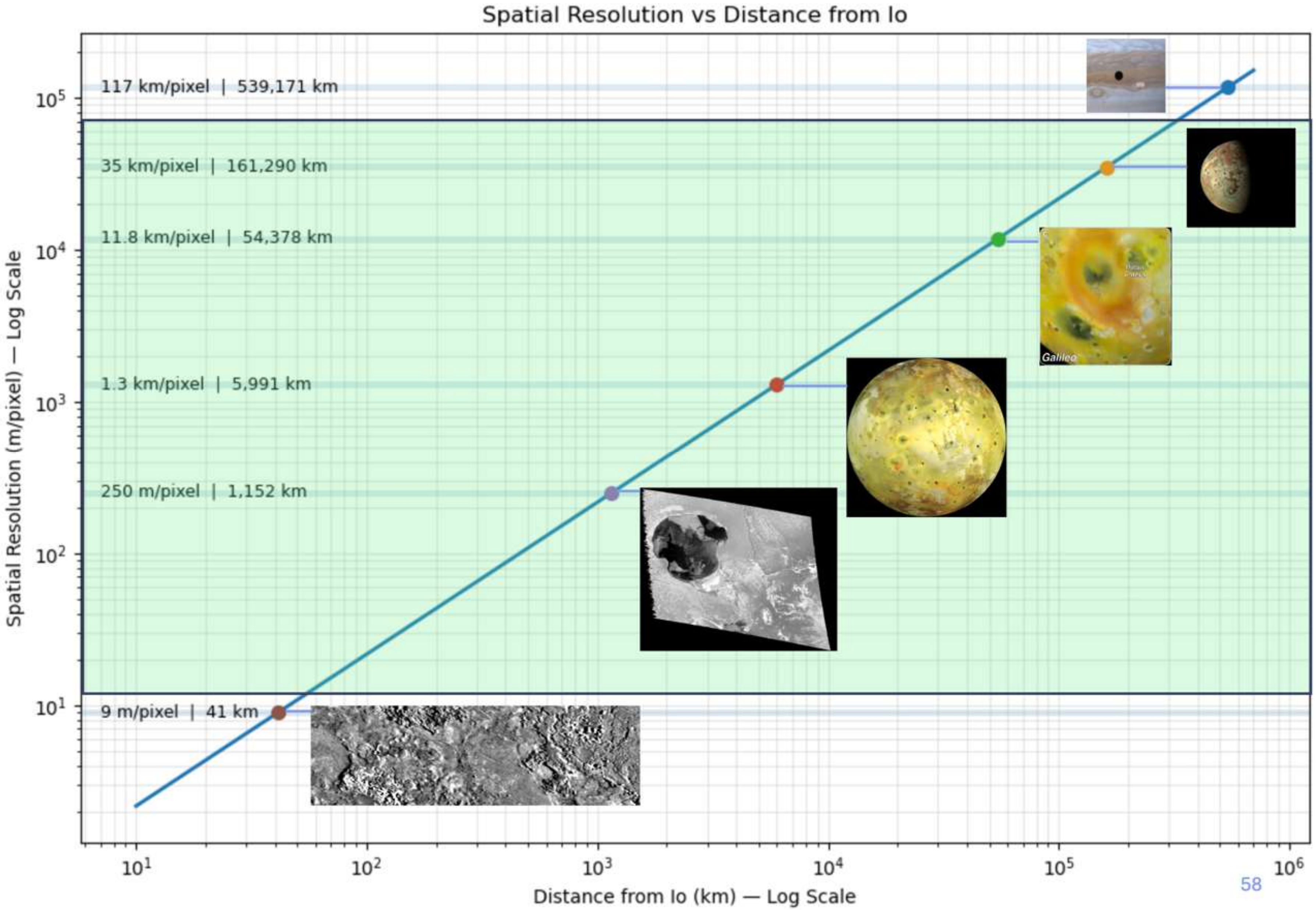
Ifestos
Jupiter MagneticNorth
Europa
Ganymede
Jupiter Sun
Io
23 Sep 2044 02:01:46.408

COVERAGE AT ALTITUDE = 500 KM



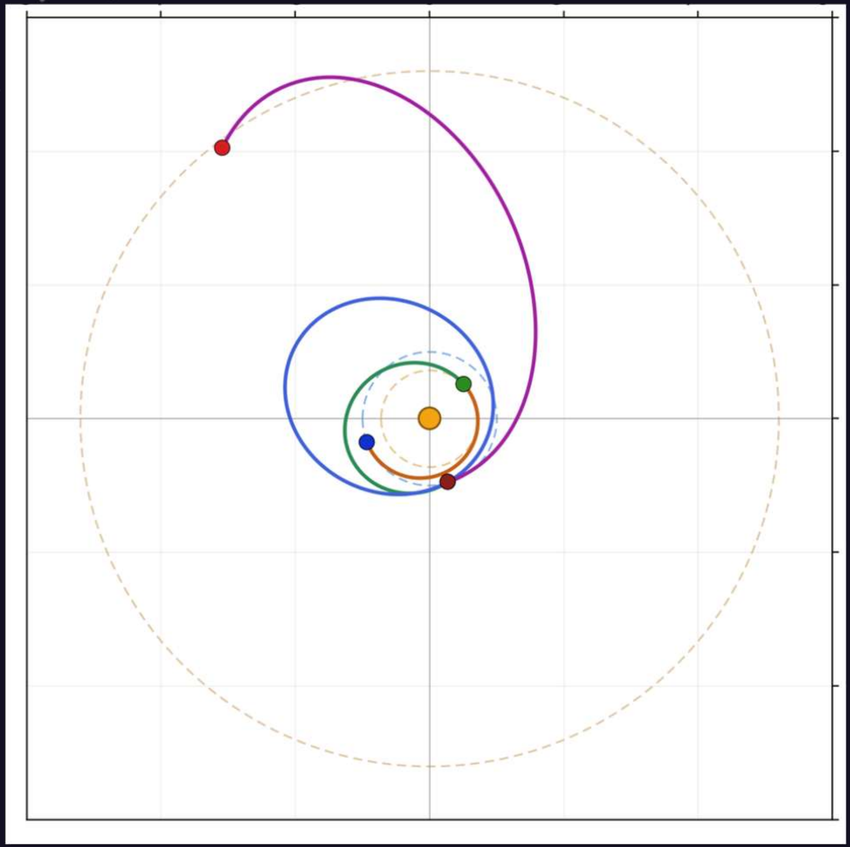
COVERAGE AT ALTITUDE = 2000 KM





Spatial Resolution vs Distance from Io
117 km/pixel | 539,171 km
35 km/pixel | 161,290 km
11.8 km/pixel | 54,378 km
1.3 km/pixel | 5,991 km
250 m/pixel | 1,152 km
9 m/pixel | 41 km
Galileo
Spatial Resolution (m/pixel) — Log Scale
Distance from Io (km) — Log Scale

MITIGATION STRATEGY: 2ND LAUNCH WINDOW

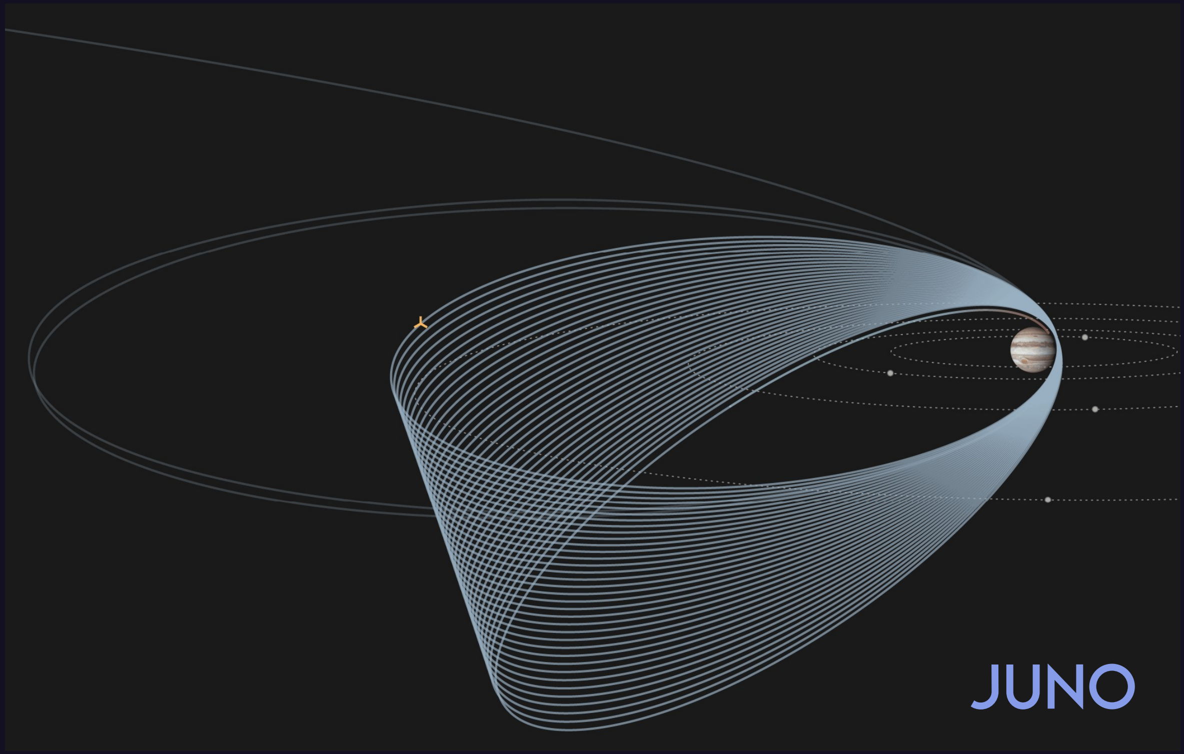


Departure Date:	**06/06/2042**
Arrival Date:	**16/01/2046**
C3 : .	**11.28** km^2/s^2
Vinf at arrival:	**7411.26** m/s

Node	Delta V [m/s]
Earth Departure	2863.13
DSM	7989.95
JOI	807.99
Final Insertion	≈ 500 [1]

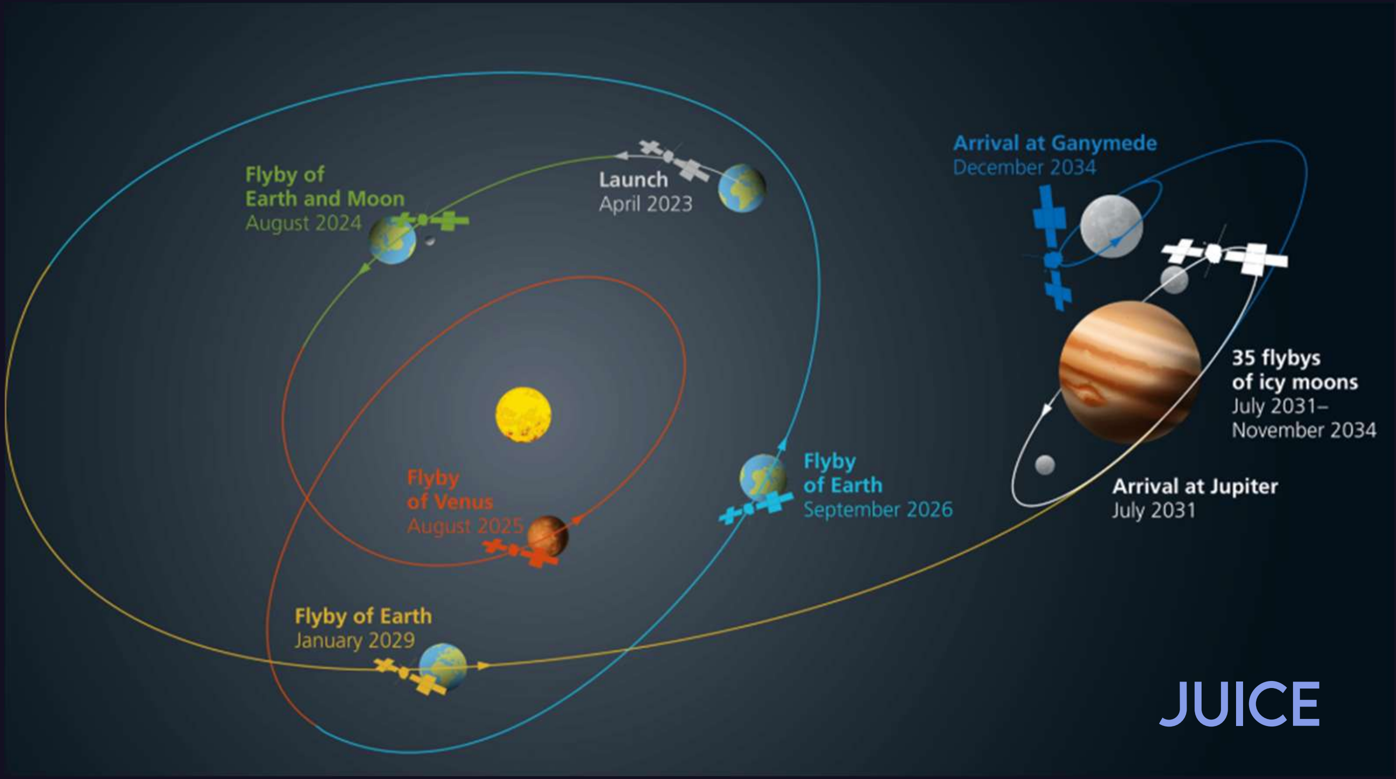
[1] European Space Agency, *Juice: Playing Pinball with Jupiter's Moons*, European Space Operations Centre, https://esoc.esa.int/juice-playing-pinball-jupiters-moons, accessed 20 July 2026.

JUNO AND JUICE ORBITS: HOW ARE WE DIFFERENT?



The New York Times (2016) 'NASA Juno mission to Jupiter', The New York Times, 28 June. Available at: https://www.nytimes.com/interactive/2016/06/28/science/space/nasa-juno-mission-to-jupiter.html (Accessed: 22 July 2026).

JUNO AND JUICE ORBITS: HOW ARE WE DIFFERENT?



German Aerospace Center. (2023, April 13). The journey – from Earth to Jupiter in a roundabout way. DLR. https://www.dlr.de/en/research-and-transfer/projects-and-missions/juice/the-journey-from-earth-to-jupiter-in-a-roundabout-way

WHEN DO WE WANT TO OBSERVE WITH WHICH INSTRUMENT?

Concept of Operations

SPACECRAFT MODES – MISSION OPERATIONS

- LEOP
- Commissioning — After LEOP and every 6 months on the way
- Standby
- Manouevre — Burn phases and insertions
- End of Life

Safe Modes

- **Safe State** — Minor failure, planned eclipse
- **Survival State** — Major failure, stabilize the spacecraft + restore a positive power balance

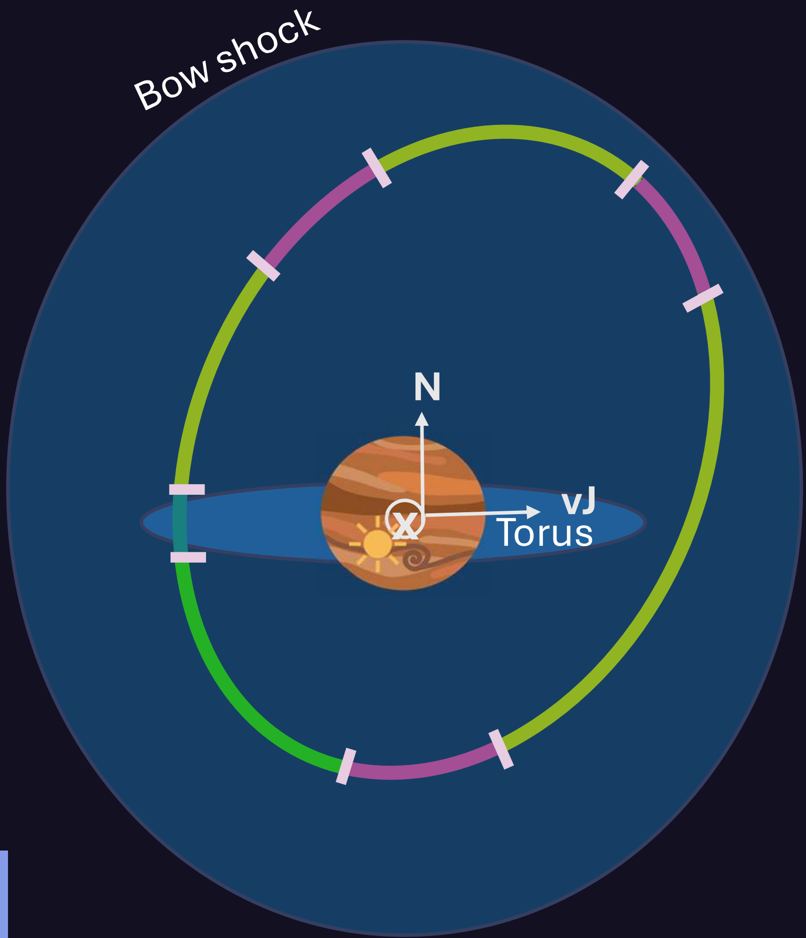
LEOP – Launch and Early Operations Phase

SPACECRAFT MODES – SCIENCE OPERATIONS

Science Operations (SciOps)

High Power State	Nominal Power State	Low Power State + Downlinking
Execute the most demanding science observation sequences during closest approach or critical flybys	Execute routine orbital science campaigns	Maintain essential science observations while minimizing payload power consumption + downlinking phase

NOMINAL ORBIT



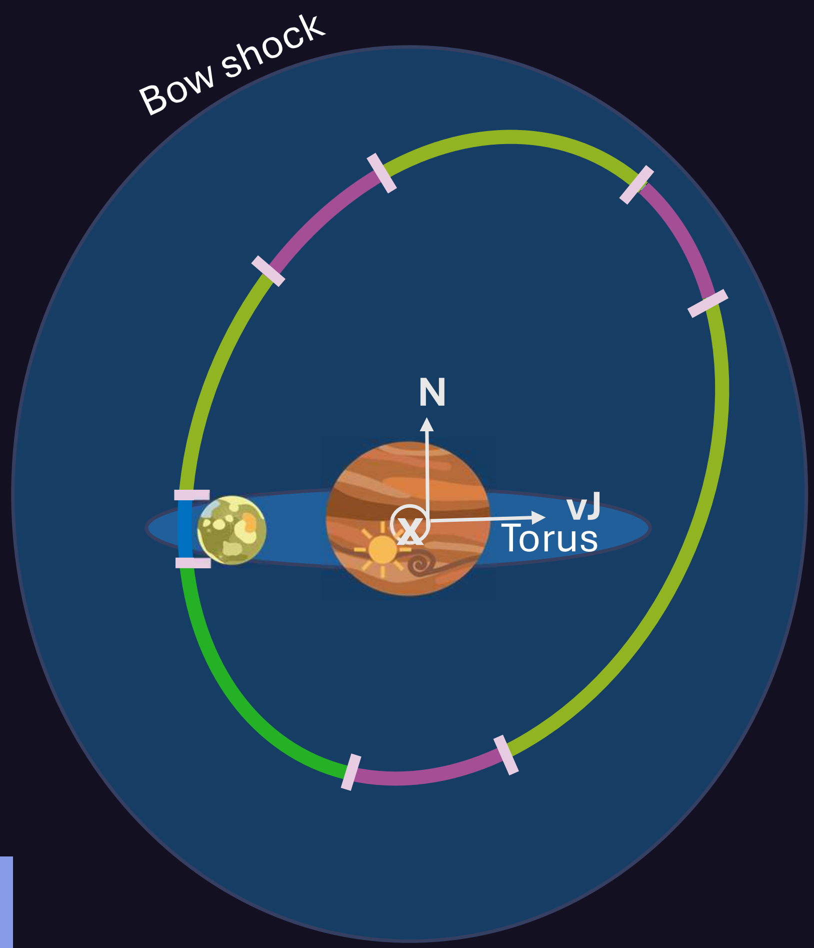
Low Power State + Downlinking

Nominal Power State

High Power State

> 30 orbits

SCIOPS IO FLYBY

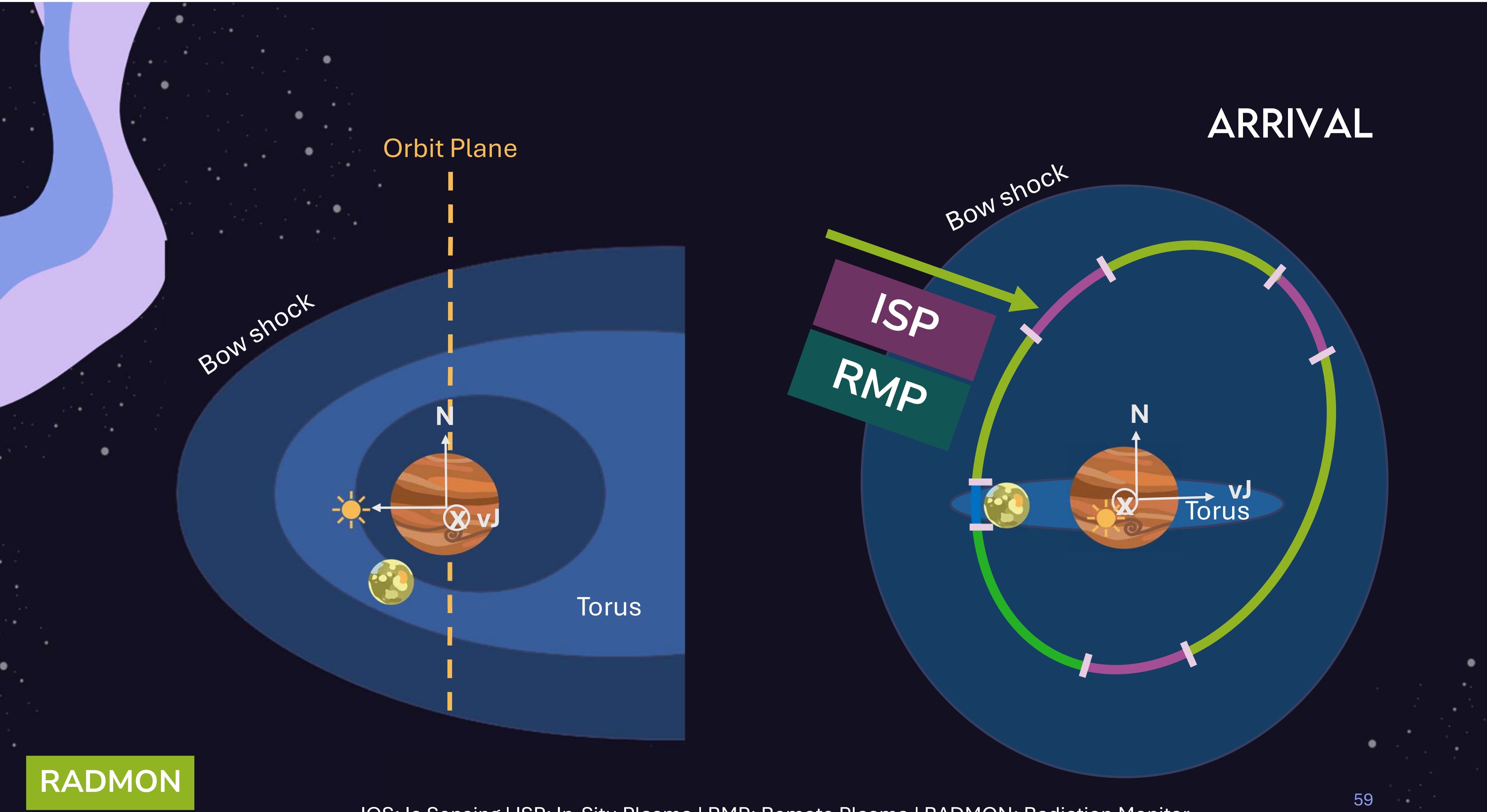


Low Power State + Downlinking

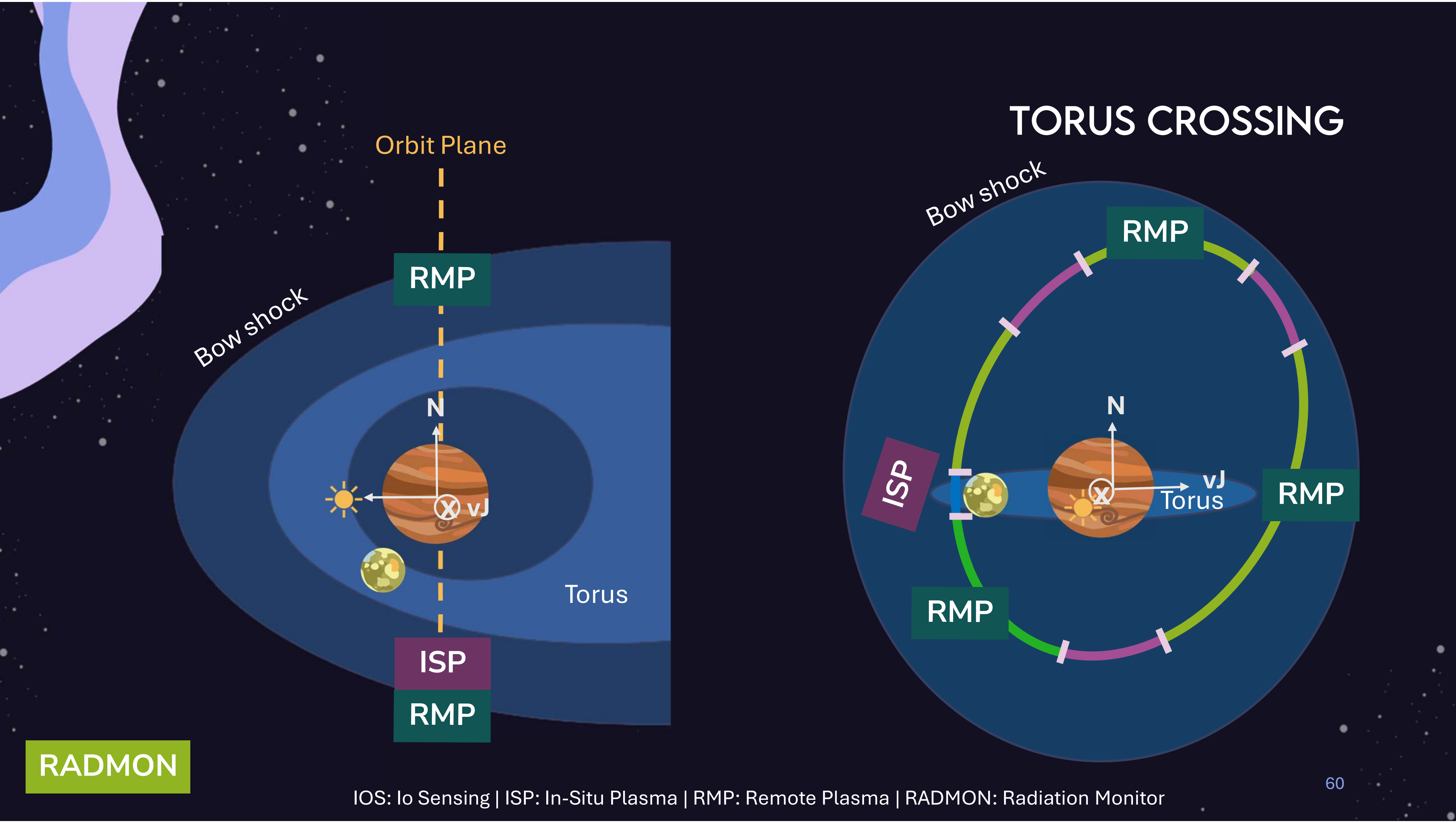
Nominal Power State

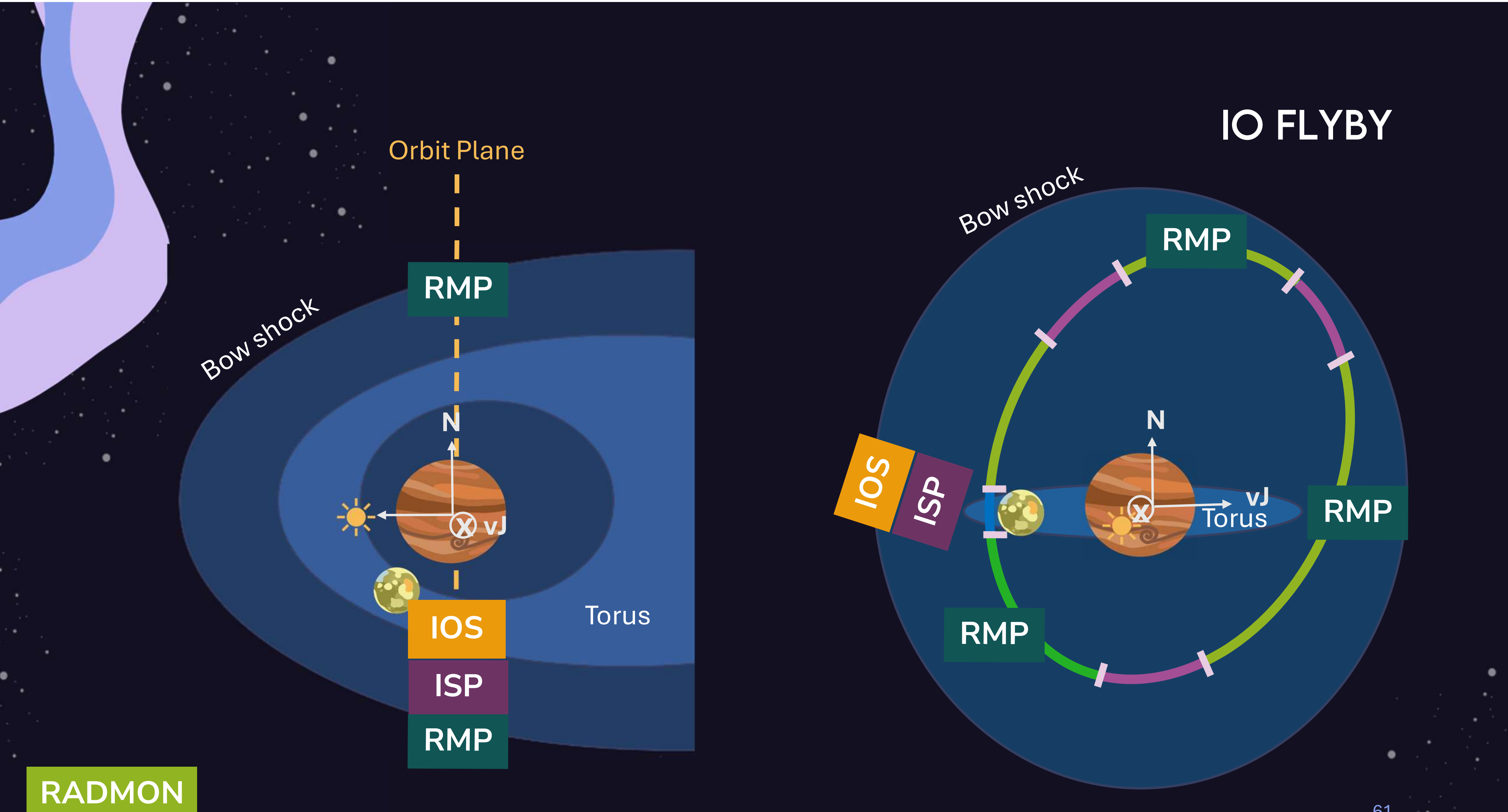
High Power State

6 orbits



IOS: Io Sensing | ISP: In-Situ Plasma | RMP: Remote Plasma | RADMON: Radiation Monitor


TORUS CROSSING
Orbit Plane
Bow shock
RMP
N
vJ
Torus
ISP
RMP
RADMON
Bow shock
RMP
N
vJ
Torus
ISP
RMP
RMP
IOS: Io Sensing | ISP: In-Situ Plasma | RMP: Remote Plasma | RADMON: Radiation Monitor
60



IOS: Io Sensing | ISP: In-Situ Plasma | RMP: Remote Plasma | RADMON: Radiation Monitor

KEY DRIVERS

Radiation Environment

Pointing accuracy for Wide Angle Camera of 41 arcsec

RADIATION ENVIRONMENT

Electrons: >100MeV

Protons: >1GeV

GCR: nuclei mostly hydrogen

Arrival at Jupiter: 2044
Solar maximum: 2046
High solar activity
→ more heliospheric protection against GCR

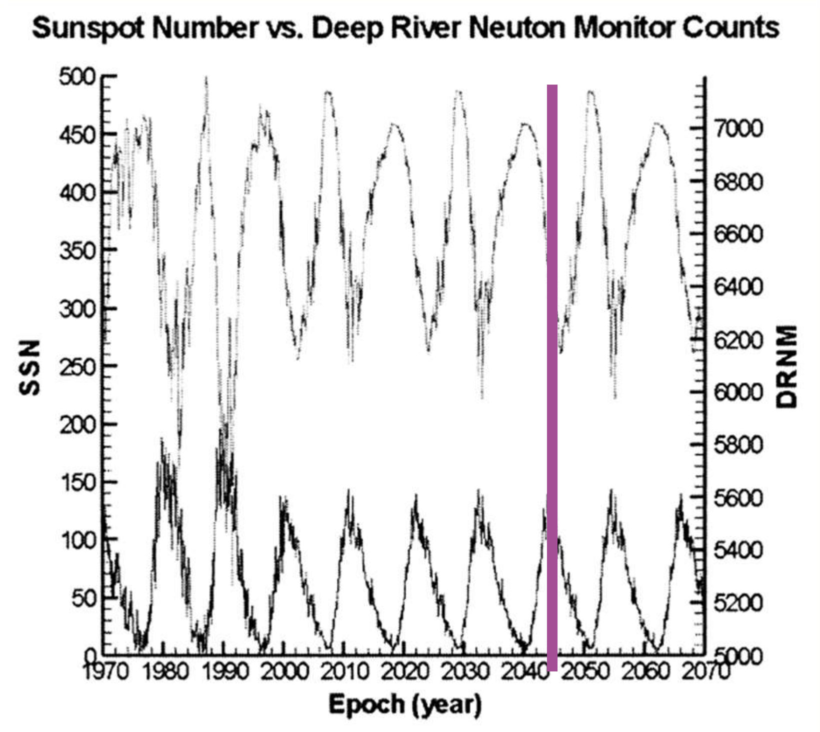


Fig. 1. Solar sunspot number (lower curve) and Deep River neutron monitor count rate (upper curve).

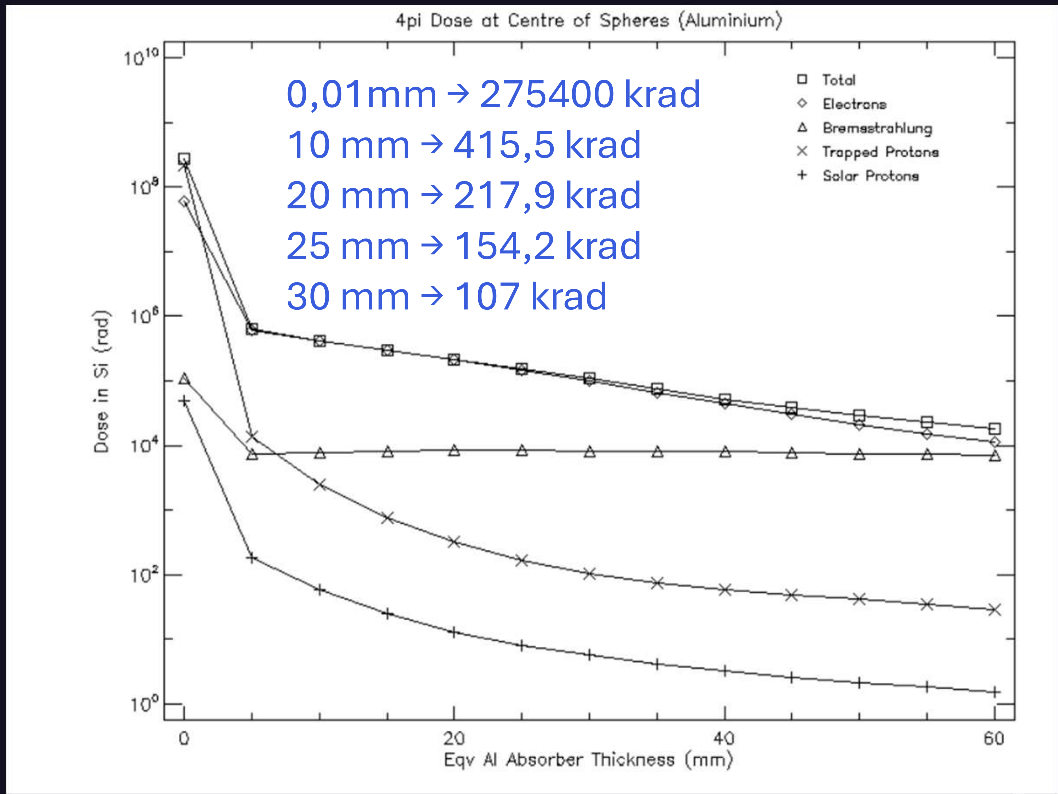
[De Angelis et al., 2003]

RADIATION EFFECTS

Total Ionizing Dose (TID)

Single Event Effects (Upset, Latch-Up,...)

Displacement Damage Dose



Simulation SPENVIS TID for 6 month in jovian orbit [Teuchert et. Team Blue, 2026]

RADIATION SHIELDING AGAINST TID, SEE AND DDD

1. **Shielding materials**
   - Separate aluminum shielding around units
   - Tungsten/Tantalum slabs for area shielding
   - Overall aluminum shielding around entire system
   - Multi-layered-Z-shielding against GCR
   - Glass-layer on solar panels

2. Shielding through efficient placing

3. Radiation shielding margins for units
- No shielding inherited -> +100% of unit mass (where mass margin is already applied)
- Inherited shielding for JUICE/JUNO -> +25% of unit mass
- Philosophy based on UVS Instrument

4. Usage of rad-hard components
- Radiation testing to at least 150 krad
- RDM of 2 → shielding to survive 300 krad

HOW DO THE INSTRUMENTS SURVIVE IN SPACE?

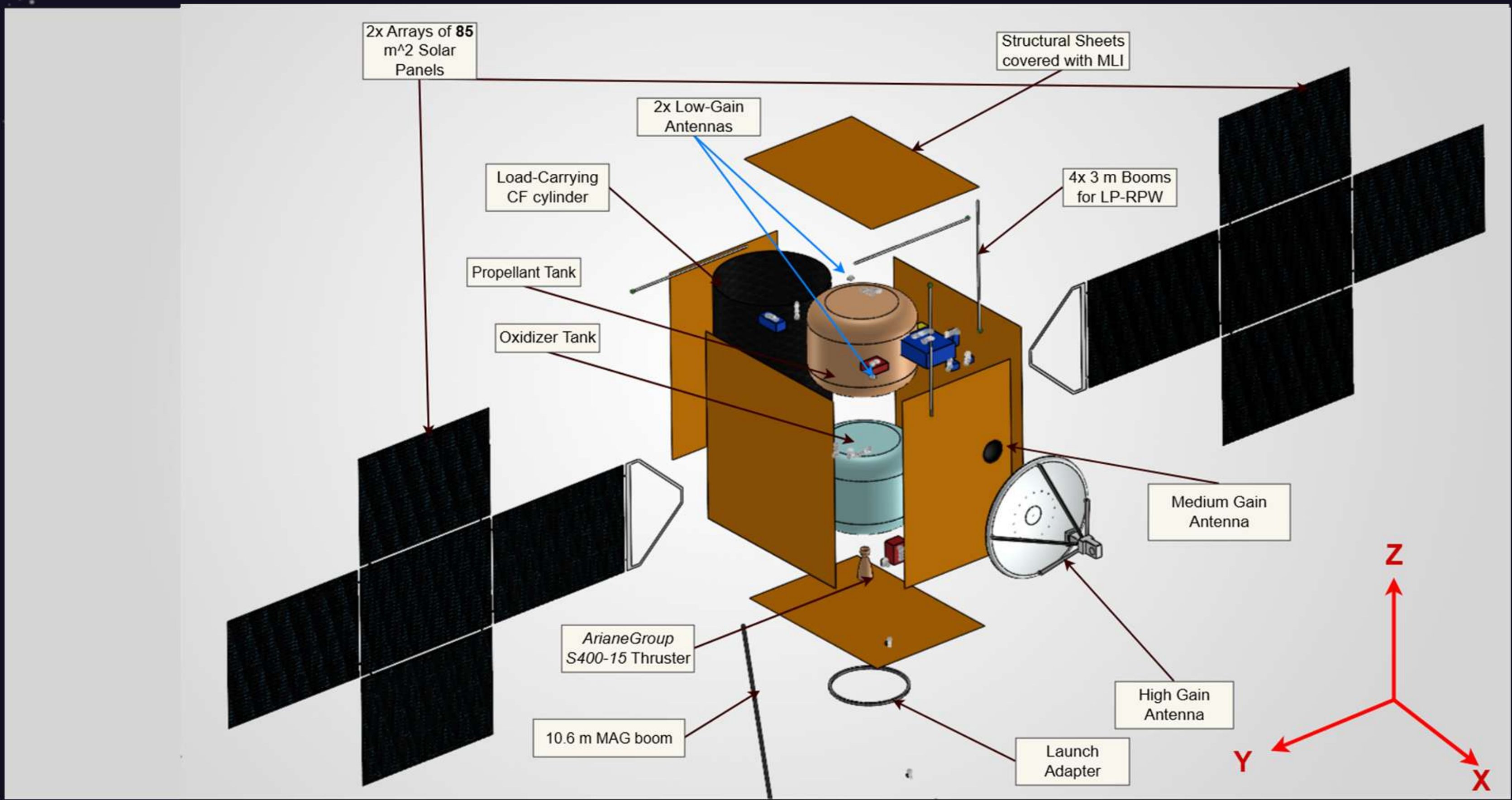
Spacecraft platfrom design

STRUCTURAL CONSIDERATIONS

- Spacecraft design is driven by ***two vertically stacked propellant tanks*** within a ***central load bearing cylinder***.
- ***Two radiation shielding vaults*** are built along the central cylinder, to ***protect sensitive electronics***.
- ***Microvibrations*** will affect ***pointing***, especially during:
  - Solar Array Deployment
  - Maneuvers (All types)

SATELLITE BUS

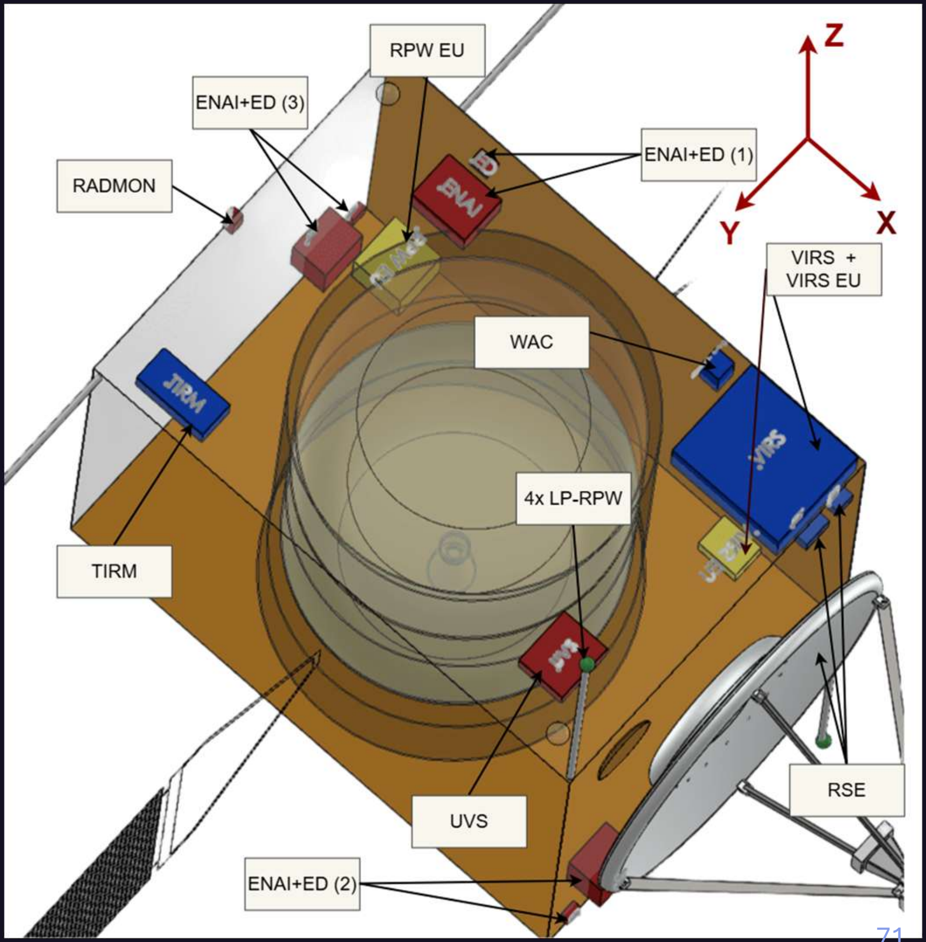
- +Z axis is *Nadir* (IO) pointing
- -X axis is *RAM* pointing
- Bus is JUICE Heritage
- Stowed Configuration fits in Ariane 64 fairing



[Selevicius, Dumitru et al., 2026]

INSTRUMENT PLACEMENT

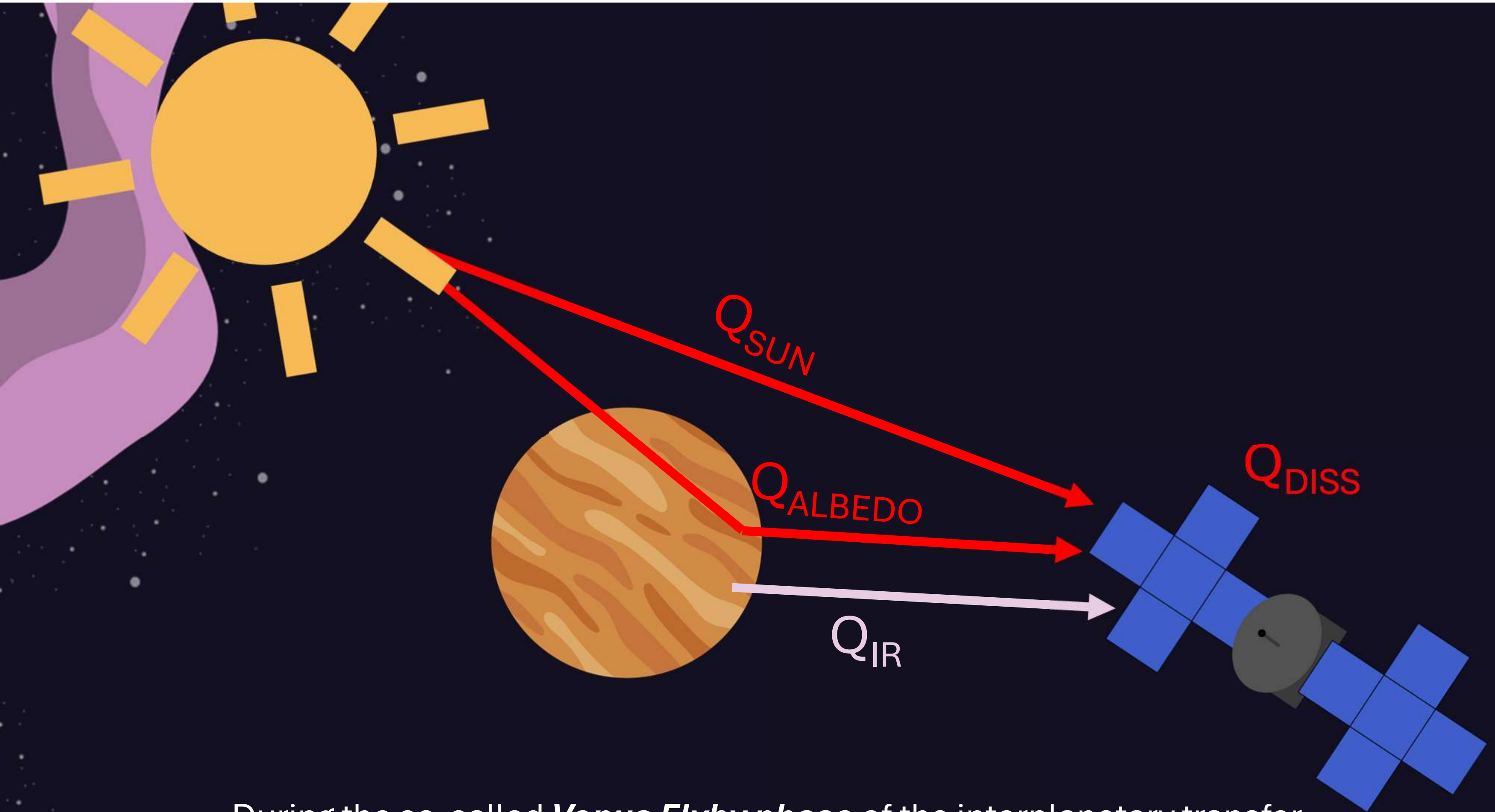
- UVS, VIRIS, WAC, TIRM on Nadir (IO) side
- ENAI/ED paired together
- RADMON on Ram pointing
- LP-RPW on 4x 3 m Booms
- RSE placement independent
- MAG/RPW instruments are placed on the Magnetic Boom



THERMAL CONSIDERATIONS

- Instruments shall be off during Venus Flyby.
- The Solar Array (SA) shall be tilted to minimize heat load.
- All subsystems, including instruments, shall have a dedicated heater.

- The TIRM shall have a dedicated built-in radiator (-195 °C).
  - Heritage : JUICE



EPS Modes

Survival mode

Commissioning

Hot Case

Flyby to Venus

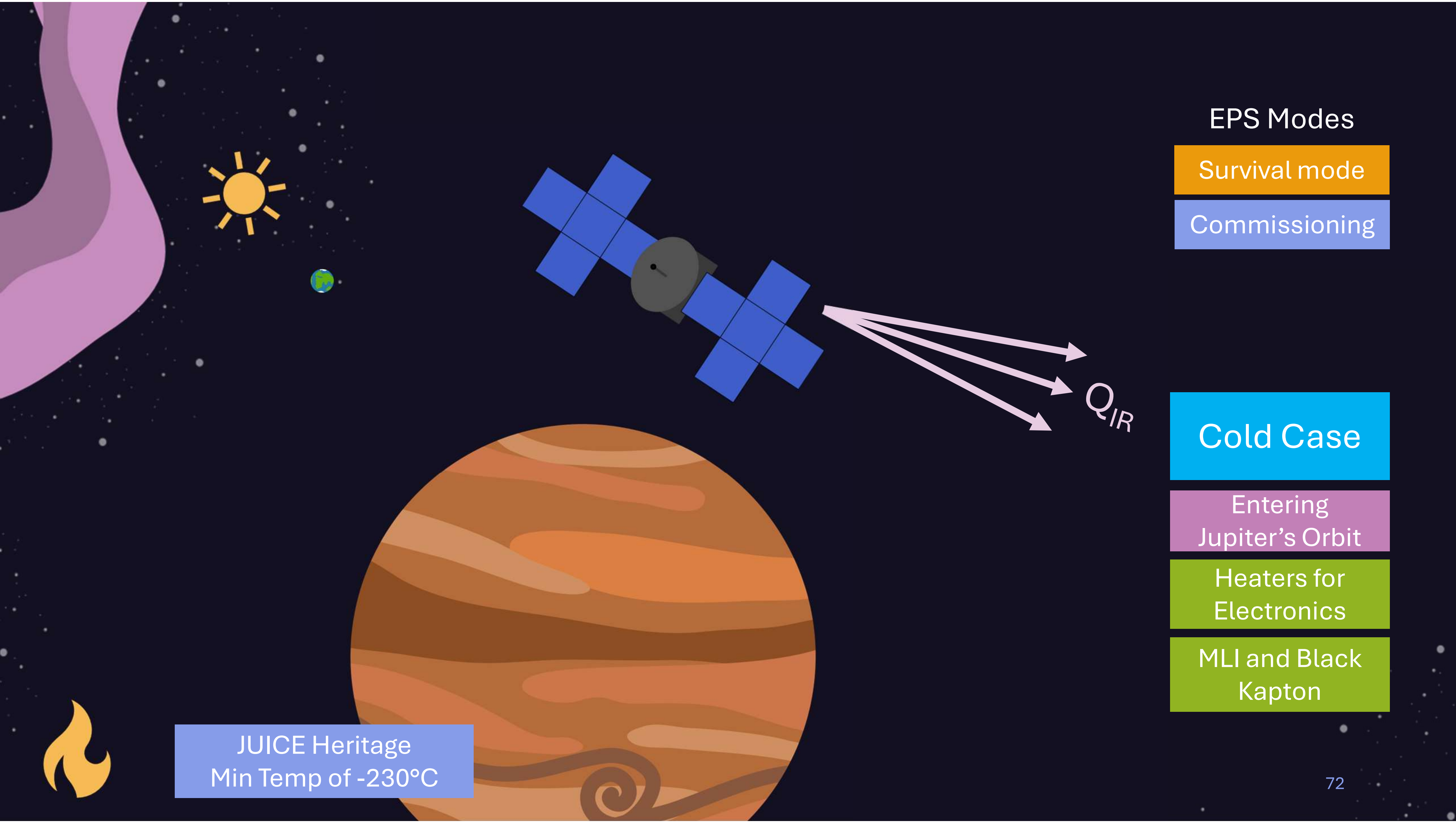
Tilted Solar Array

HGA oriented to act as Sunshield

Optimized S/C Pointing

During the so-called ***Venus Flyby phase*** of the interplanetary transfer
- when the spacecraft is less than 1.34 AU from the Sun
- This antenna also serves as a sunshield.

JUICE Heritage
Max Temp of SA 230°C


EPS Modes
Survival mode
Commissioning
Q_IR
Cold Case
Entering Jupiter’s Orbit
Heaters for Electronics
MLI and Black Kapton
JUICE Heritage
Min Temp of -230°C

AOCS: ATTITUDE AND ORBIT CONTROL SYSTEM

Driving **requirements**:

- The AOCS subsystem shall maintain **3-axis stabilization** with a pointing accuracy of **≤ 41 arcsec**
- The AOCS subsystem shall maintain a pointing stability of **≤ 41 arcsec** over the duration of Wide Angle Camera (WAC) exposure time.

AOCS components and layout are JUICE heritage

4x Reaction Wheels	2x Sun Sensors	2 IMUs (3-axis Gyro) (Accelerometers)	1x Triple-head Star Tracker

COMPONENTS

Attitude **control**

RW:
Collins Aerospace
RSI 68- 220/60

Angular momentum at angular speed:
68 Nms

TRL 6

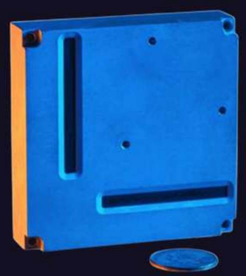
[RTX]

Attitude **determination**

Sun Sensor:
Redwire Space
Digital Sun Sensor

FOV:
128° X **128°**
Accuracy: ± **0.25°**

TRL 6



[Redwire Space]

IMU:
Honeywell MIMU v3.2

Range:
± **375** °/s

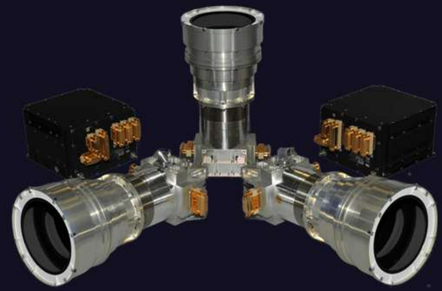
TRL 6

[Honeywell]

Star tracker:
Sodren Hydra

High frequency spatial error @ 3σ:
3.4 (XY) / **27** arcsec

TRL 6



[ESA]

PROPULSION ARCHITECTURE

Main engine: ArianeGroup S400-15-class (425 N)

- Jupiter Orbit Insertion

Spacecraft control thrusters: ArianeGroup S25 (23N): 12 + redundant 4 units

- TCM
- IO impact targeting
- Reaction wheel desaturation
- Attitude stablization during main engine burns
- Attitude control

MAIN ENGINE

ArianeGroup 400 N Bipropellant Apogee Motors

Nominal thrust: 425 N

Thrust range: 340 - 400 N

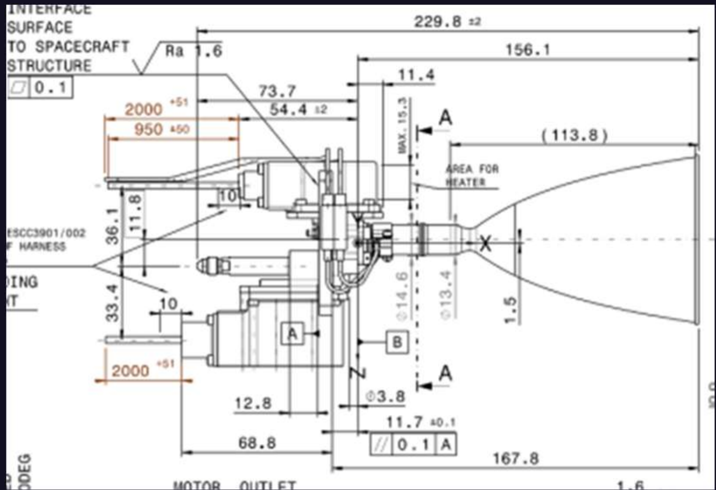
I sp: 321 s

Fuel: Monomethelhydrazine

Oxidiser: MON-3

SECONDARY PROPULSION

ArianeGroup S25



Nominal thrust: 23N

Thrust range: 18- 29 N

I sp: 295 s

Fuel: Monomethelhydrazine

Oxidiser: MON-3

PROPELLANT LOADED AND PRESSURIZATION SYSTEM

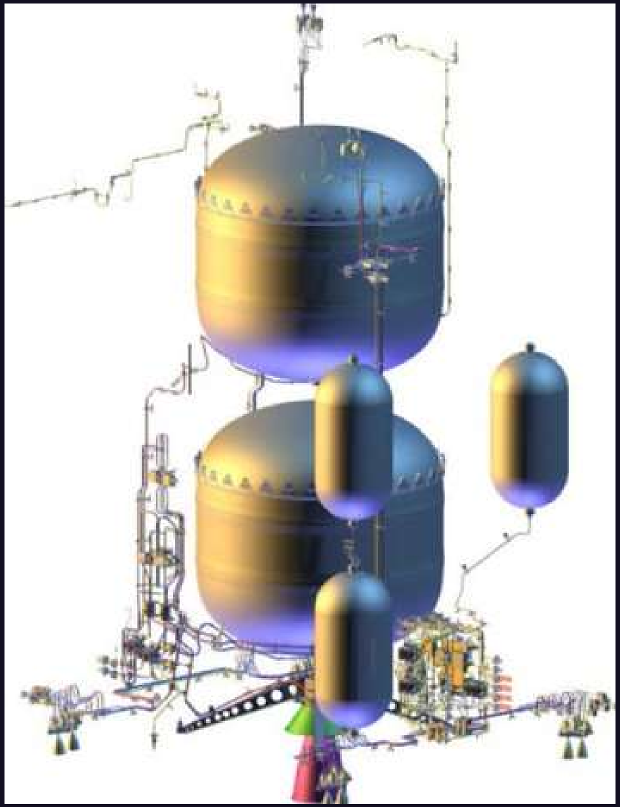
All thrusters supplied by a single bi-propellant system

MMH:
998,8 Kg

MON-3:
1648,02 Kg

Helium:
7,44 Kg

Helium pressurant tanks (neccessary to keep the propulsion system at its operational pressure



https://link.springer.com/article/10.1007/s11214-026-01289-4

OBC - ON BOARD COMPUTER

Driving requirements:
- The OBC subsystem shall work in a high-radiation enviroment
- The OBC subsystem shall store at least 1Tbit of data

Next Generation On Board Computer (OBC NG) **x2**

TRL 7

SPARC V8 LEON FT processor **x4**

EDAC software protocols

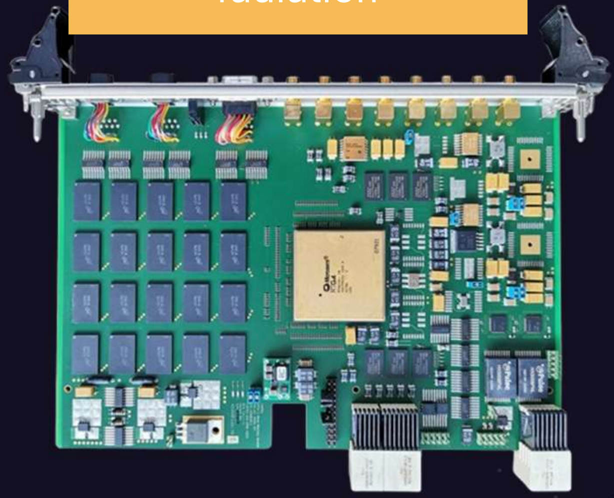
Source : Beyond Gravity

DSI's Science mass memory (SSMM) **x2**

TRL 7

1 TBit (EOL)

Data copied x3 to prevent errors by radiation

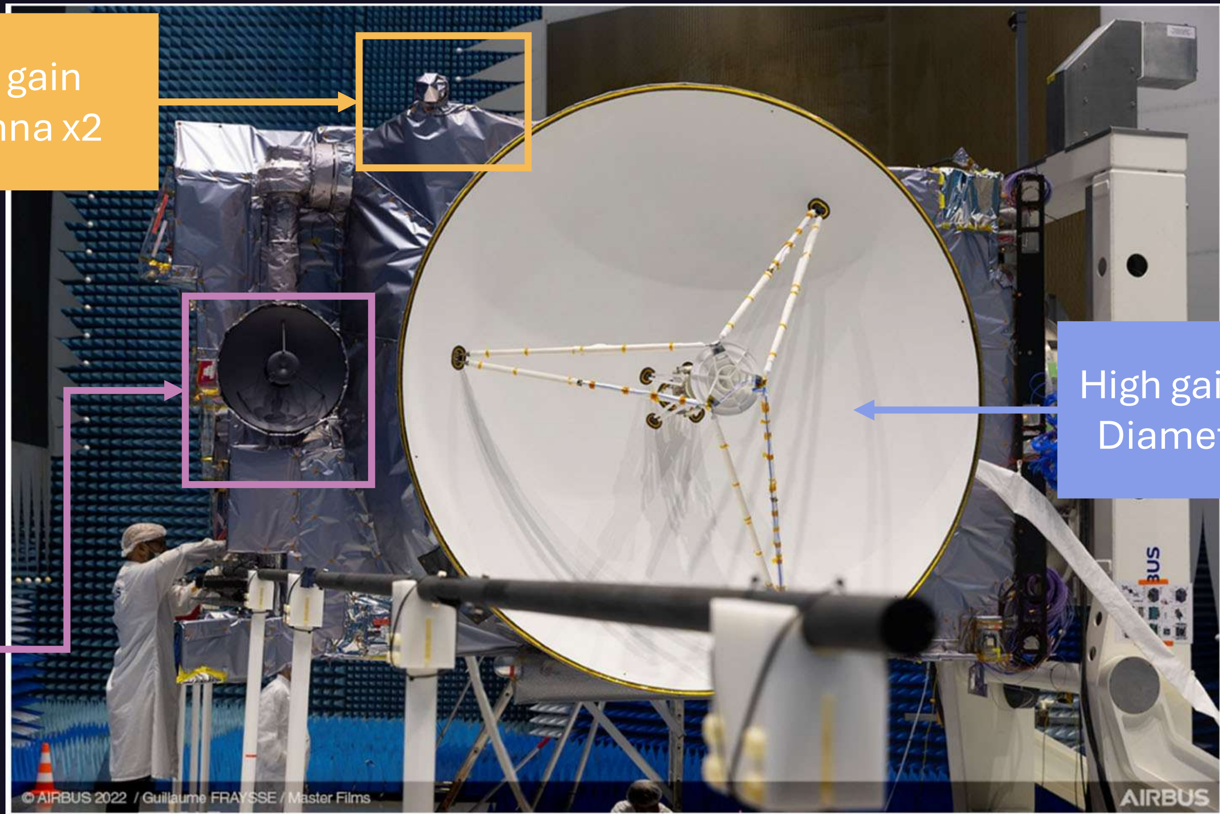


Source : DSI aerospace

Heritage: ExoMars Rover, Hispasat 36W-1, JUICE

COM - ANTENNAE

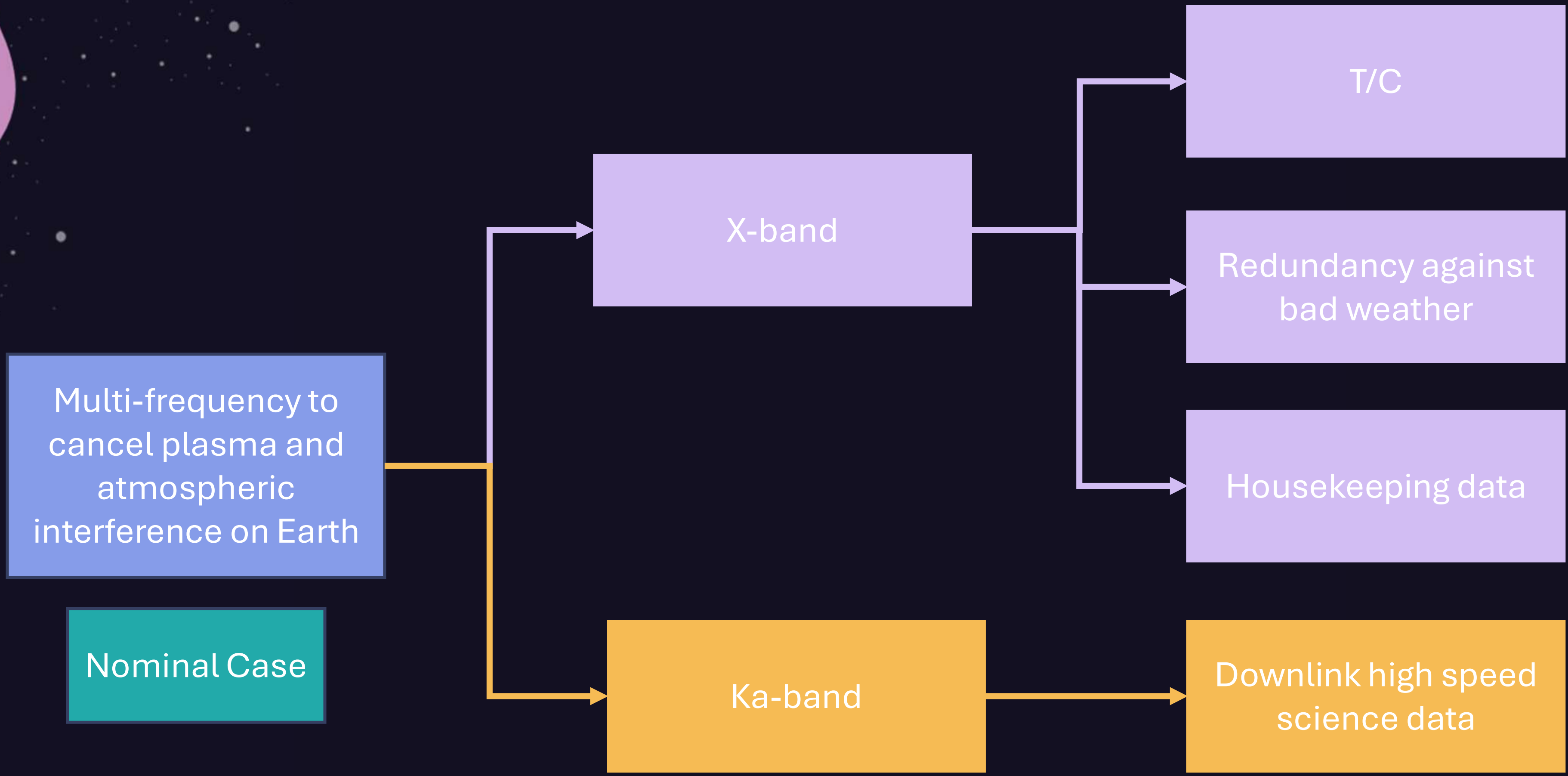
Low gain antenna x2



High gain antenna
Diameter: 2.5 m

Medium gain antenna
Diameter: 0.5 m

COM - FREQUENCY BANDS



COM - GROUND STATION

- ESTRACK deep space network
  - Available for Ka and X band multifrequency reception at the time of the mission

[ESA]

DATA BUDGET

Data rate (bps)	Volume per orbit (Gbit)	Compressed volume per orbit (Gbit)
Total (flyby orbit)	**9.50**	**4.02**
Total (non-flyby orbit)	**5.00**	**2.75**

SciOps Data Produced

Storage worst case (Gbit)
31
15

Available storage per orbit: 1000 Gbit

LINK BUDGET

Link budget (Ka band)	
Average distance (km)	7.78E+08
Transmitting Antenna Gain (dBi)	48.7
G/T (dB/K)	60
Data rate (kbps)	**50**
FSPL (dB)	300
Margin (dB)	**1.1**
Power (dBW)	10.5
Comms window duration (h)	**8**
Total data downlinked per window (GBit)	**1.44**

Link budget (X band)	
Average distance (km)	7.78E+08
Transmitting Antenna Gain (dBi)	44.7
G/T (dB/K)	52.5
Data rate (kbps)	**50**
FSPL (dB)	287
Margin (dB)	**1.9**
Power (dBW)	14.4
Comms window duration (h)	**8**
Total data downlinked per window (GBit)	**1.44**

POWER DEMAND

EPS | OBC | AOCS | COM | PL | TCS

Worst-case: all subsystems on maximum power

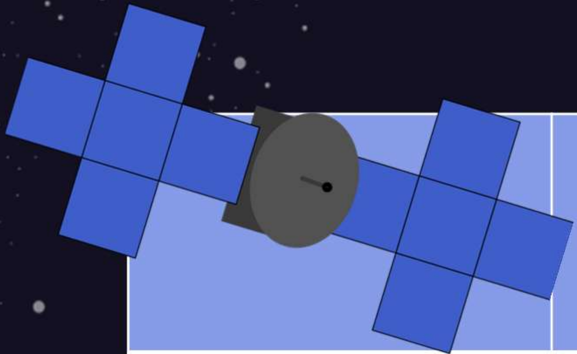
Peak power (incl. margin): **1075 W**

Nominal power (incl. margin): **892 W**

REALISTIC CASE:
all subsystems work according to subsystem modes

LEOP:	598,6 W
Commissioning:	634,6 W
Standby/Cruise:	558 W
Safe:	401,1 W
Survival:	324,0 W
Maneuver:	661,2 W
EOL:	529,1 W

WORST CASE POWER GENERATION



	Worst-case scenario (Peak power + Margins)	Nominal-case scenario (Nominal power + Margins)
Maximum EOL Power (W)*	1075	892
Solar Arrays Surface (m2)	110	88
Battery (kWh)	4	4

*Arrays can be tilted to modify solar power received

Battery sized on worst case scenario
7h eclipse in Safe Mode + 40% Margin

Juice EOL Data !
850W
85m2

OPTIMIZED CASE POWER GENERATION

BUT

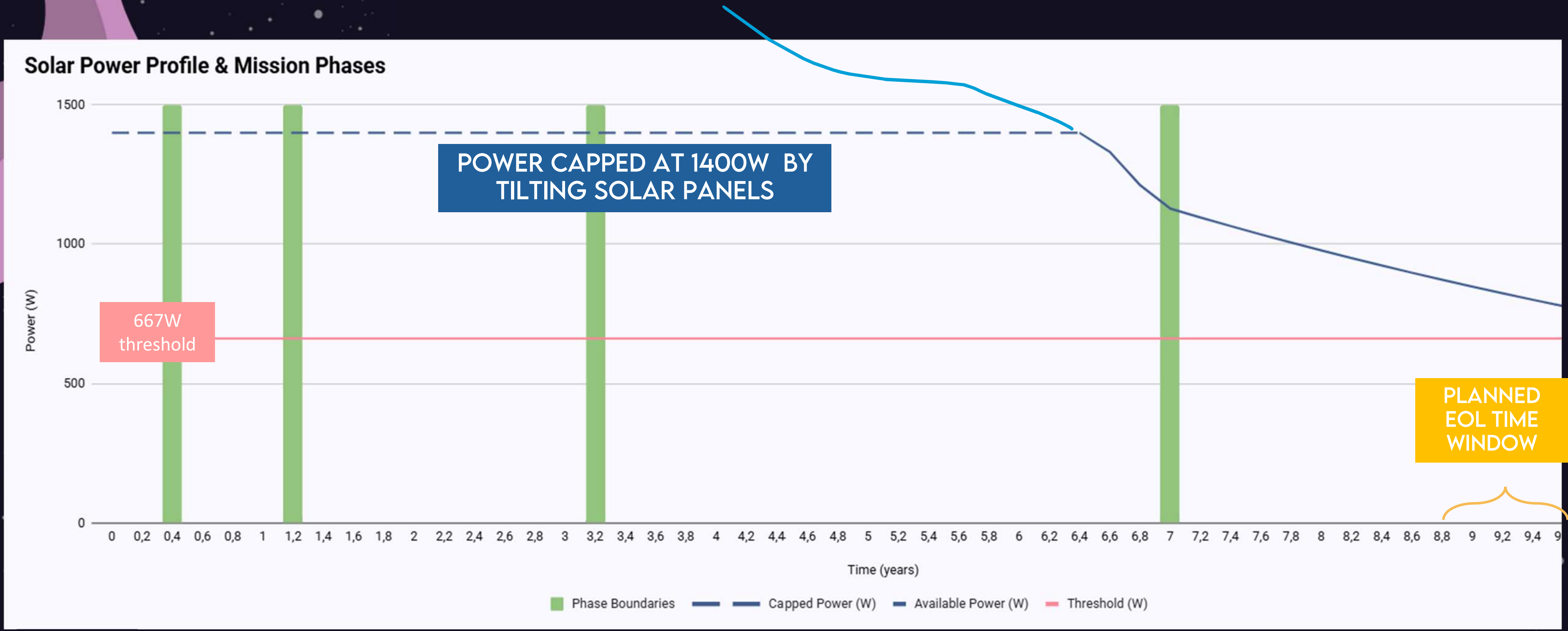
We can reduce the size of the arrays and increase battery to optimize total cost

95M2 Solar Panel Size

5KWH Battery Capacity

Considered for mass budget

SOLAR ARRAYS DEGRADATION



POWER BUDGET IN (W) FOR SCIENCEOPS MODES

Unit	SciOps High	SciOps Normal	SciOps Low + Coms
Payload Io sensing	96,17	40,18	40,18
Payload In situ	76,5	53,3	9,68
Payload left	5,06	13,96	13,96
Subsystems			
EPS	66,0	66,0	66,0
OBC	90,5	70	90,5
AOCS	134,4	134,4	134,4
COMS	72,40	17,00	72,40
Thermal	104,50	242,0	242,0
TOTAL	**645,55**	**636,86**	**669,14**

incl,. 10% margin

MASS BUDGET AND MARGINS

Subsystem	Mass incl. DMM [kg]
STR_TCS	360.00
HAR_SCRW	215.71
AOCS	101.19
PROPSYS (tanks and thrusters)	197.73
EPS	690.24
COM	94.63
OBC_PDH	25.92
PL (incl. margin)	295.98
Launch Adapter	95.00
NOMINAL DRY MASS AT LAUNCH	**2076.92**
TOTAL DRY MASS AT LAUNCH	**2492.30**
TOTAL SHIELDED DRY MASS AT LAUNCH	**2866.15**
Propellant	2646.82
Pressurizer	7.40
TOTAL PROPELLANT MASS	**2707.30**
LAUNCH MASS	**5573.45**

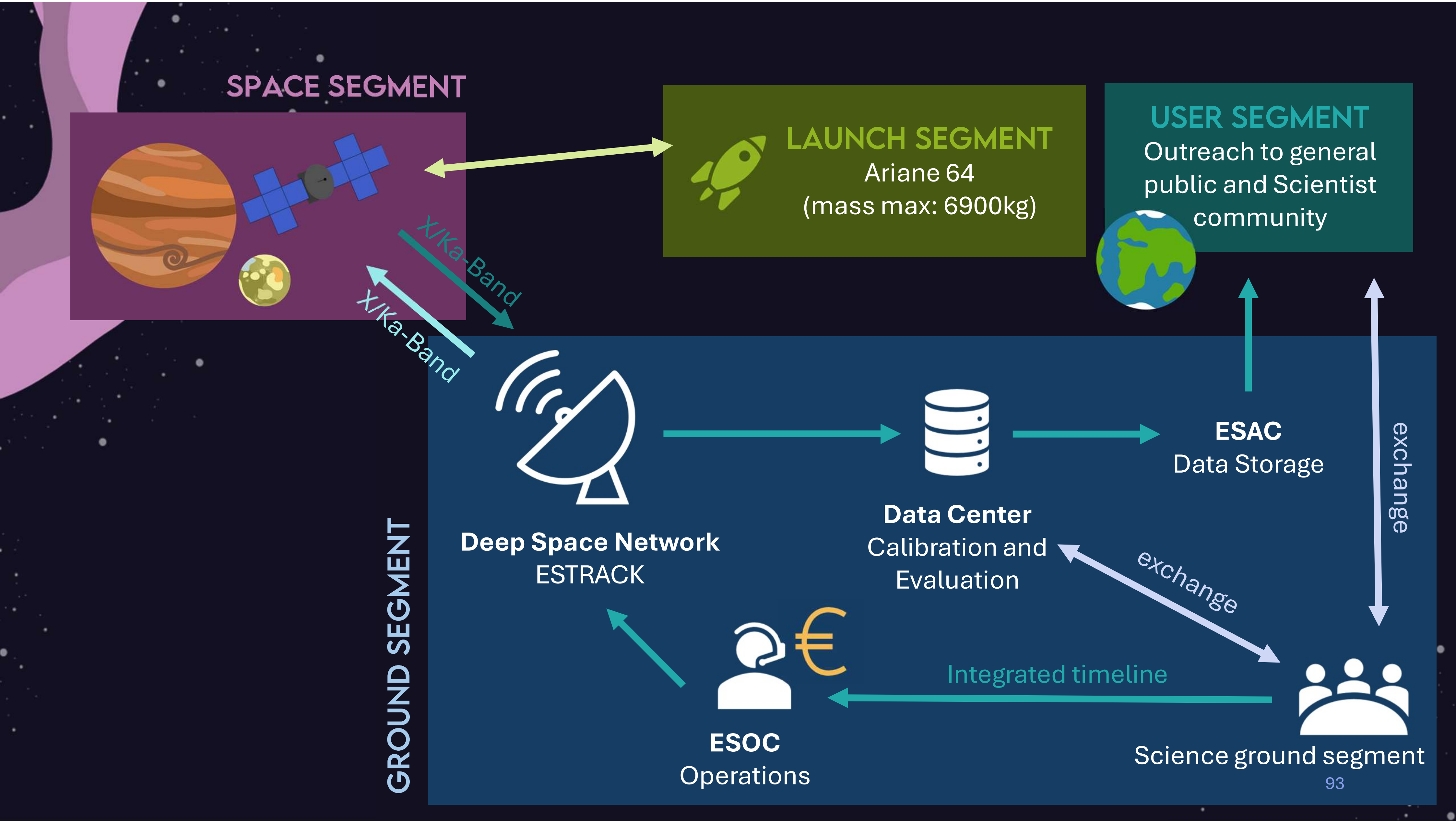
Design Maturity Margins on Subsystem level

- 5%
- 10%
- 20%

System level margin of 20%

Radiation shielding margin 15% (according to experts and reserved for spot shielding)

Propellant Residuals of 2%



SPACE SEGMENT
LAUNCH SEGMENT
Ariane 64
(mass max: 6900kg)
USER SEGMENT
Outreach to general public and Scientist community
X/Ka-Band
X/Ka-Band
GROUND SEGMENT
Deep Space Network
ESTRACK
Data Center
Calibration and Evaluation
ESAC
Data Storage
exchange
exchange
€
Integrated timeline
ESOC
Operations
Science ground segment

TECHNICAL MISSION SCHEDULE

Q1 2028: Kick-Off

Phase 0 A B C D

Q1 2029: Mission Definition Review

Q1 2030: Preliminary Design Review

Q1 2032: Critical Design Review

2032-37: Instrument/Platform development/verification

Q3 2037: Launch

Phase E

Every 6 months: Health-check S/C

Q2 2043: Wake up Operations Team for Arrival

Q2 2044: Arrival Jovian System

Phase E

Q1 2045: Science Operations done

Operate more as long as possible

Phase F

EOL Operations

Tbd: Disposal (Crash into Io)

RISKS

Severity/Impact

Likelihood/Probability	1	2	3	4	5
1					
2					RISK-SCH-01
3			RISK-SCH-02, RISK-SCH-03, RISK-BDG-01		
4					
5					RISK-TEC-01

RISKS

Risk ID	Description of risk	Description of impact	PS	IR	RISK	Risk mitigation
RISK-TEC-01	Radiation exposure	Destruction or malefunction of electronics and sensors	5	5	25	Shielding for components which cannot be redundant and for redundant components as well, annealing process and switch to second satellite bus OR spend time outside radiation belts OR reduce mission lifetime
RISK-SCH-01	Launch gets delayed	Launch window closes and transfer to Jupiter gets impossible or dV heavy	2	5	10	multiple proposed transfer orbits
RISK-SCH-02	Component procurement not possible due to unavailability	Delay of project	3	3	9	Early developement and multiple component selection
RISK-SCH-03	Long-lead time components	Delay of project	3	3	9	Early developement and multiple component selection
RISK-BDG-01	Spent budget exceeds proposed budget	Descope science	3	3	9	Early developement and margins

COST BUDGET

Item	Price [MIO EUR]
Hardware payload and instruments	20
Hardware platform	200
Platform engineering	250
ESA project management (25% of all the above mentioned)	117,5
Mission operations	74
Spacecraft operations	60
Launcher	135
TOTAL	**721.5**
TOTAL with 20% margin	**1000.8**

Hardware

Engineering

Operations

Launcher

ESA L-class mission

Payload engineering and procurement done by ESA member states

DESCOPING

First instrument to descope

ED
Electron Detector

WAC
Wide Angle Camera

VIRIS
Visual and Near Infra Red Imaging Spectrometer

Last instrument to descope

Reduce:

- Cost
- Development Time
- Mass

ARE YOU COMING WITH US?

BACKUP SLIDES

IO'S ATMOSPHERE

Dayside

Nightside

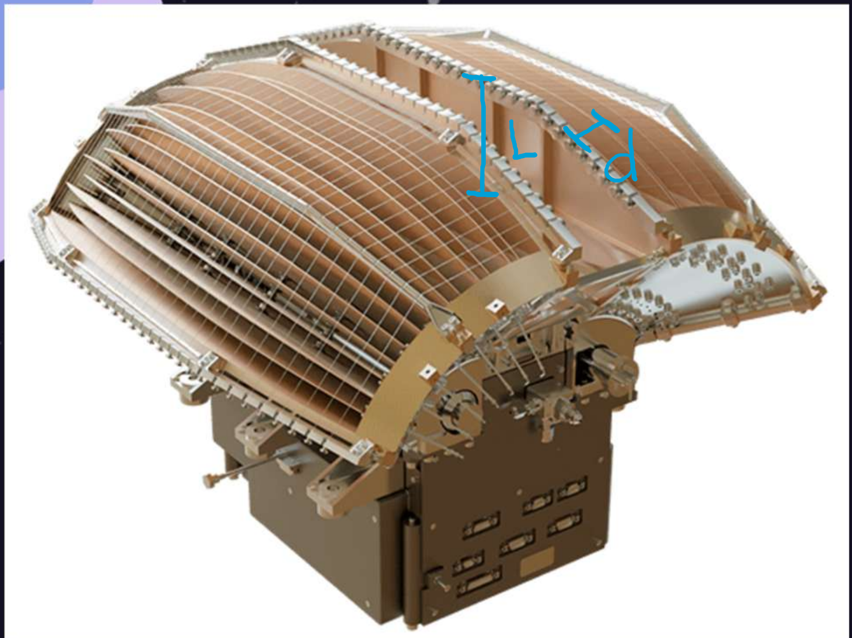
- Solar heating causes sulfur dioxide frost to sublimate
- Thin continuous atmosphere
- Atmosphere thicker around equator due to:
  - Locations of volcanos
  - More exposed to solar radiation - heating

- SO2 gas from exosphere freezes to surface
- Only gas supplied by eruptions remains in small regions around volcanos

ENAI

Energetic neutral atom and ion imager

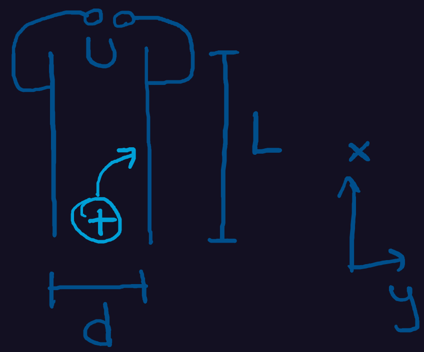
$$v_{max,ion} = \sqrt{\frac{2\langle E_{th}\rangle_{max,ions}}{m}}$$



(https://www.jhuapl.edu/destinations/instruments/joeejeni (Johns Hopkins University – APL))

Source: Juice Red Book

JUICE PEP-JENI heritage



$$E = U \cdot d$$

$$F = q \cdot E$$

$$(I) \quad a = \frac{F}{m} = \frac{qU}{md}$$

$$v = \frac{L}{t} \Longleftrightarrow t = \frac{L}{v}$$

$$y = \frac{1}{2}at^2 \overset{!}{=} \frac{d}{2} \quad (II)$$

$$\Longrightarrow (I) + (II):$$

$$\frac{d}{2} = \frac{1}{2}\left(\frac{qU}{md}\right)\left(\frac{L}{v}\right)^2$$

$$\Longrightarrow U = \frac{md^2v^2}{qL^2}$$

ENAI

Energetic neutral atom and ion imager

(https://www.jhuapl.edu/destinations/instruments/joeejeni (Johns Hopkins University – APL))

Source: Juice Red Book

JUICE PEP-JENI heritage

$$U = \frac{m d^2 v^2}{q L^2}$$

$$v_{max,ion} = \sqrt{\frac{2 E_i}{m_i}}$$

ion	E [eV] →	v [km/s]	U [V]
e^- (fastest 0,2%)	40 eV	3751	1,25
O^+	$2 \cdot \langle E \rangle_{max,i} \rightarrow 180$	47	5,7
S^+	$2 \cdot \langle E \rangle_{max,i} \rightarrow 180$	33	5,6
p	$2 \cdot \langle E \rangle_{max,i} \rightarrow 180$	186	5,6

↳ add 100% margin because missing info on max velocities

[F. Bagenal, 2020]

DATA BUDGET I

Instrument	Data rate (bps)	Compression factor	Volume per orbit (Gbit)	Compressed volume per orbit (Gbit)	Duty basis
UVS	28,000	2	1.01	0.504	One 10 h torus campaign per orbit
VIRIS	1,500,000	4	2.7	0.675	Flyby orbits only, 30 min window
TIRM	200,000	3	0.36	0.12	Flyby orbits only, 30 min window
MAG	4,000	2	1.44	0.72	Continuous
RPW	3,000	2	1.08	0.54	Continuous outside 1.5 R_J
ENAI	5,000	2	1.26	0.63	+/-2 h around a gravity flyby
RSE	200	2	0.00288	0.00144	Continuous
RADMON	70	2	0.03	0.01512	Continuous, co-pointed with ENAI
ED	500	2	0.18	0.09	Flyby orbits only, +/-20 min around CA
WAC	600,000	4	1.45	0.3618	10% of science data
Housekeeping	-	-	-	0.25	
	Total (flyby orbit)		**9.5**	**4.02**	
	Total (non-flyby orbit)		**5**	**2.75**	

DATA BUDGET II

	Non-flyby orbit	Flyby orbit	Worst case non-flyby (X-band only)	Worst case flyby (X-band only)
Downlink data rate (kbps)	50	50	50	50
Comms window duration (hours)	8	8	8	8
Total downlink size available per comms window (Gbits)	1.44	1.44	1.44	1.44
Total downlink size available per orbit (Gbit)	**2.88**	**4.32**	**2.88**	**4.32**
Total downlink size required per orbit (Gbit)	**2.5**	**3.66**	**2.75**	**4.02**
Storage available (Tbit)	**1**	**1**	**1**	**1**
Storage required (Tbit)	**0.015**	**0.031**	**0.015**	**0.031**

POWER FOR SCIOPS

RESULTS IN W INCLUDING A 10% MARGIN

Unit	SciOps High	SciOps Normal	SciOps Low + Coms
Io sensing + MAG			
VIRIS	28,60	2,86	2,86
TIRM	14,30	1,02	1,02
RSE	40,00	35,00	35,00
WAC	13,20	1,30	1,30
In situ Plasma			
MAG	4,30	3,30	3,30
RPW	14,30	12,00	1,10
ED	48	30	4,95
ENA imager	9,90	8,00	0,33
Remote Plasma + ENAI, RSE,MAG			
UVS	1,10	10,00	10,00
RADMON	3,96	3,96	3,96
Subsystems			
EPS	66,0	66,0	66,0
OBC	90,5	70	90,5
AOCS	134,4	134,4	134,4
COMS	72,40	17,00	72,40
Thermal	104,50	242,0	242,0
TOTAL	**645,48**	**636,86**	**669,14**

POWER FIGURES

Unit	Total Power (W)	Total Peak Power (W)	Margin (%)	Power w/ margin (W)	Peak Power w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W)	Safe Mode Power (W)	Survival Mode Power (W)	Manoeuvre Power (W)	EOL Power (W)
EPS	60	70	10%	66,0	77,0	84,00	84,00	84,00	84,00	72,00	84,00	84,00
OBC	92	122	10%	101,2	134,2	53,50	53,50	53,50	53,50	35,00	53,50	67,10
AOCS	122,2	125	10%	134,4	137,5	101,60	111,70	111,70	101,60	55,00	111,70	111,70
COMS	116,6	120	10%	128,3	132,0	84,50	72,40	17,00	17,00	17,00	17,00	139,90
Payload	152	208	10%	168,0	231,6	0,00	168,01	16,80	0,00	0,00	0,00	126,43
Thermal	220	330	10%	242,0	363,0	275,00	145,00	275,00	145,00	145,00	145,00	0,00
											250	
TOTAL	762,8	975,0		839,9	1075,3	598,6	634,6	558,0	401,1	324,0	661,2	529,1

Unit	Margin (%)	Nominal power w/ margin (W)	PeakPower w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W)	Safe Mode Power (W)	Manoeuvre Power (W)	SciOps HIGH pw Power (W)	SciOps NORMAL pw Power (W)	SciOps LOW pw Power (W)	EOL Power (W)
UVS	10%	10,7	13,2	0,00	10,67	1,07	0,00	0,00	13,20	10,67	1,10	13,20
VIRIS	10%	28,6	31,9	0,00	28,60	2,86	0,00	0,00	31,90	28,60	2,86	31,90
TIRM	10%	10,2	14,3	0,00	10,23	1,02	0,00	0,00	14,30	10,23	1,02	14,30
MAG	10%	3,6	4,7	0,00	3,63	0,36	0,00	0,00	4,73	3,63	3,63	4,73
RPW	10%	11,0	14,3	0,00	11,00	1,10	0,00	0,00	14,30	11,00	1,10	14,30
3 ENAI	10%	30,0	48,0	0,00	30,00	3,00	0,00	0,00	48,00	30,00	0,99	48,00
RSE	10%	35,0	40,0	0,00	35,00	3,50	0,00	0,00	40,00	35,00	3,00	40,00
RADMON	10%	3,6	4,0	0,00	3,60	0,36	0,00	0,00	3,96	3,60	3,96	3,96
3 ED	10%	30,0	48,0	0,00	30,00	3,00	0,00	0,00	48,00	30,00	4,95	48,00
WAC	10%	5,3	13,2	0,00	5,28	0,53	0,00	0,00	13,20	5,28	0,53	13,20
Total par mode		168,0	231,6	0,00	168,01	16,80	0,00	0,00	231,59	168,01	23,14	231,59

POWER FIGURES

Unit	Power CBE (W)	Peak Power (W)	Margin (%)	Power w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W)	Safe Mode Power (W)	Manoeuvre Power (W)	SciOps HIGH pw Power (W)	SciOps NORMAL pw Power (W)	SciOps LOW pw Power (W)	EOL Power (W)
OBC 1	26	30	10%	28,6	26,00	26,00	26,00	26,00	26,00	28,60	26,00	26,00	28,60
OBC 2 (Redundant)	26	30	10%	28,6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SSMM 1	15	25	10%	16,5	16,50	16,50	16,50	16,50	16,50	27,50	16,50	27,50	27,50
SSMM 2 (Redundant)	15	25	10%	16,5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
RTU	10	12	10%	11,0	11,00	11,00	11,00	11,00	11,00	11,00	11,00	11,00	11,00
Total par mode	**92**	**122**		**101,2**	**53,50**	**53,50**	**53,50**	**53,50**	**53,50**	**67,10**	**53,50**	**64,50**	**67,10**

Unit	Power CBE (W)	Margin (%)	Power w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W)	Safe Mode Power (W)	Manoeuvre Power (W)	SciOps HIGH pw Power (W)	SciOps NORMAL pw Power (W)	SciOps LOW pw Power (W)	EOL Power (W)	Source
Sodren Hydra Star Tracker OH1	0,7	10	0,8	0,00	0,80	0,80	0,00	0,80	0,80	0,80	0,80	0,80	https://api.sodern.com/uploads/VISEUR_HP_8_PAGE_2b387a8966.pdf
Sodren Hydra Star Tracker OH2	0,7	10	0,8	0,00	0,80	0,80	0,00	0,80	0,80	0,80	0,80	0,80	https://api.sodern.com/uploads/VISEUR_HP_8_PAGE_2b387a8966.pdf
Sodren Hydra Star Tracker OH3	0,7	10	0,8	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	https://api.sodern.com/uploads/VISEUR_HP_8_PAGE_2b387a8966.pdf
Sodren Hydra Electrical Unit (EU)	7,7	10	8,5	0,00	8,50	8,50	0,00	8,50	8,50	8,50	8,50	8,50	https://api.sodern.com/uploads/VISEUR_HP_8_PAGE_2b387a8966.pdf
Honeywell IMU 3.2	32	10	35,2	35,20	35,20	35,20	35,20	35,20	35,20	35,20	35,20	35,20	https://prod-edam.honeywell.com/content/dam/honeyw
Collins Aerospace RSI 68- 220/60 RW1	20	10	22,0	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	https://satsearch.co/products/redwirespace-digital-sun-sensor-64
Collins Aerospace RSI 68- 220/60 RW2	20	10	22,0	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	
Collins Aerospace RSI 68- 220/60 RW3	20	10	22,0	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	
Collins Aerospace RSI 68- 220/60 RW4	20	10	22,0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
Redwire Space Digital Sun Sensor	0,4	10	0,4	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	
Total per mode	**122,2**		**134,4**	**101,60**	**111,70**	**111,70**	**101,60**	**111,70**	**111,70**	**111,70**	**111,70**	**111,70**	

Unit	Power CBE (W)	Peak Power (W)	Margin (%)	Power w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W)	Safe Mode Power (W)	Manoeuvre Power (W)	SciOps HIGH pw Power (W)	SciOps NORMAL pw Power (W)	SciOps LOW pw Power (W)	EOL Power (W)
PCDU	30	32	20%	38,4	38,4	38,4	38,4	38,4	38,4	38,4	38,4	38,4	38,4
Battery Managment Unit	5	6	20%	7,2	7,2	7,2	7,2	7,2	7,2	7,2	7,2	7,2	7,2
Bus	15	20	20%	24,0	24,0	24,0	24,0	24,0	24,0	24,0	24,0	24,0	24,0
SADE (Solar Array Drive Electronics)	10	12	20%	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4
Total EPS	**60**	**70**		**84,0**	**84,00**	**84,00**	**84,00**	**84,00**	**84,00**	**84,00**	**84,00**	**84,00**	**84,00**

Unit	Power CBE (W)	Margin (%)	Power w/ margin (W)	LEOP Power (W)	Commissioning Power (W)	Standby/ Cruise Power (W) (beacon	Safe Mode Power (W)	Manoeuvre Power (W)	SciOps HIGH pw Power (W)	SciOps NORMAL pw Power (W)	SciOps LOW pw Power (W)	EOL Power (W)
Total power X band	70,4	20%	84,5	84,50	17,00	17,00	17,00	17,00	17,00	17,00	17	84,50
Total power Ka band	46,2	20%	55,4	0,00	55,40	0,00	0,00	0,00	55,40	0,00	55,40	55,40
Total per Mode	**116,6**		**139,9**	**84,50**	**72,40**	**17,00**	**17,00**	**17,00**	**72,40**	**17,00**	**72,40**	**139,90**

MODE DEFINITION: ONE EXAMPLE

Standby Mode Definition		
Objective	Maintain safe state while awaiting further commands.	
Entry/Exit criteria	Entry: LEOP completion or anomaly. Exit: Command to switch to other mode.	
Duration	Indefinite.	
Autonomy	Maximum (fail-safe mode).	
Ground segment	Periodic telemetry checks.	
Subsystem Configuration		
Subsystem	**Initial State**	**Target State**
AOCS	Active (sun pointing)	Maintain Sun pointing
Power	Battery charging, non-essential loads OFF	Maintain positive power margin, batteries fully charged
Comms	Rx ON, Tx ON (beacon)	Rx ON, Tx ON (beacon only)
Thermal	Survival heaters ON	Survival heaters ON (thermostatically controlled)
Payload	Off	Off
Propulsion	Locked	Locked
Power Budget	Minimal power consumption while being able to receive commands.	

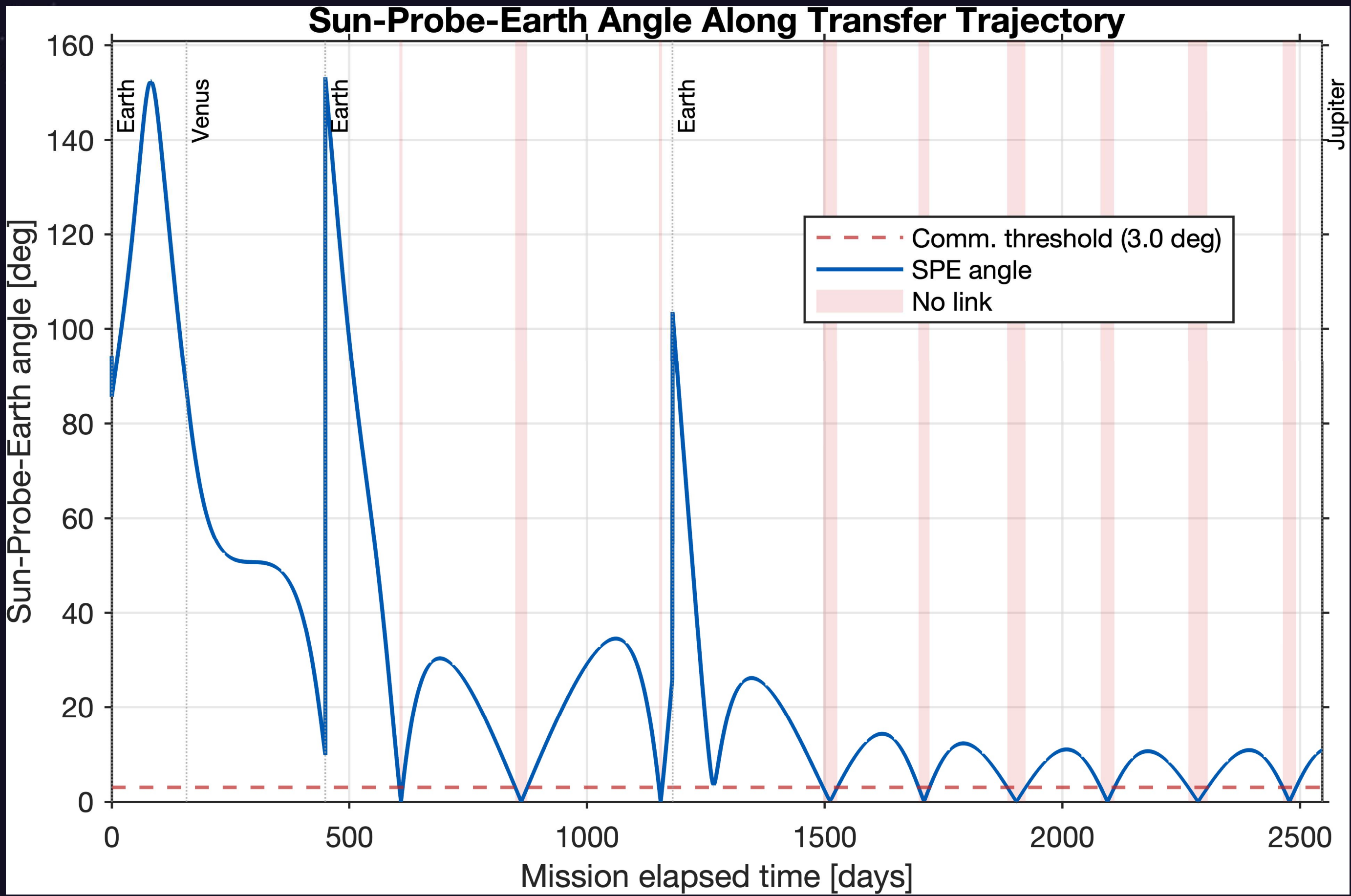
LAUNCH PERFORMANCE ARIANE 6-4

V_∞ (km/s)	Payload Mass (kilograms)							
	ULPM Single Burn, DLA (°)			ULPM Double Burn, DLA (°)				
	-5.0	0.0	+5.0	-40.0	-20.0	0.0	+20.0	+40.0
1.0	8661	8447	7872	7518	7485	7438	7367	7300
2.0	8056	7650	6867	7029	6963	6888	6800	6701
3.0	7127	6515	5426	6149	6079	6002	5915	5798
4.0	5943	5245	3734	4995	4911	4812	4711	4622
5.0	4594	3952	2394	3793	3710	3613	3520	3385
6.0	3167	2669	1108	2578	2487	2395	2305	2174

Figure 2: Representative Performance for Earth Escape Missions, Ariane 64

[ESA-SCI-F-MGT-MAN-002, page 11]

COMMUNICATION CAPABILITIES DURING TRANSFER TO JUPITER



COMMUNICATION CAPABILITIES DURING JOVIAN ORBITS