JUICE: the first European mission to Jupiter and its Icy Moons

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European Space Agency (ESA)

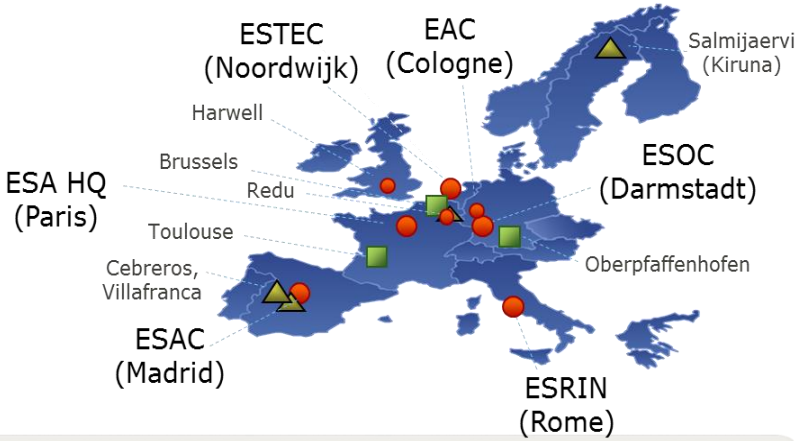
The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.

ESA's locations

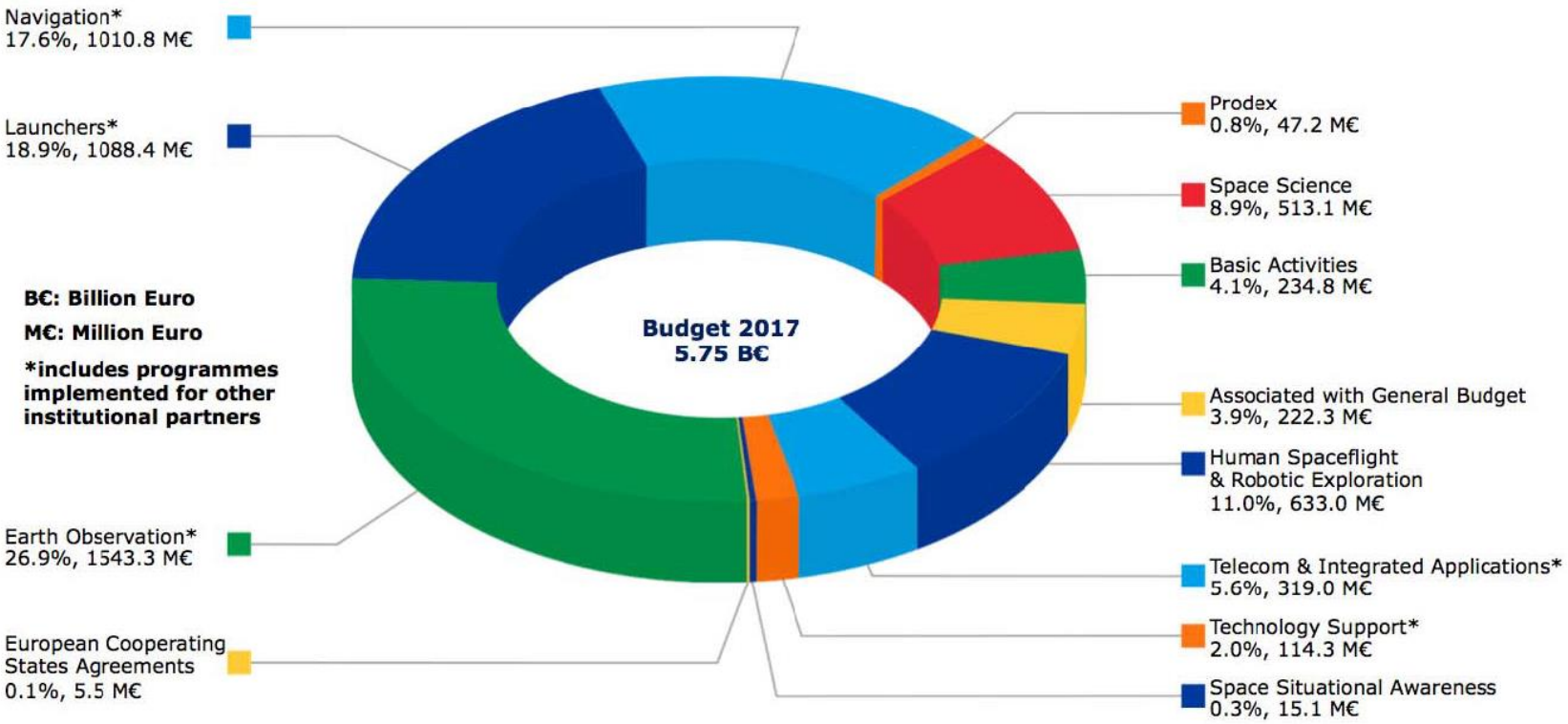
ESA sites/facilities

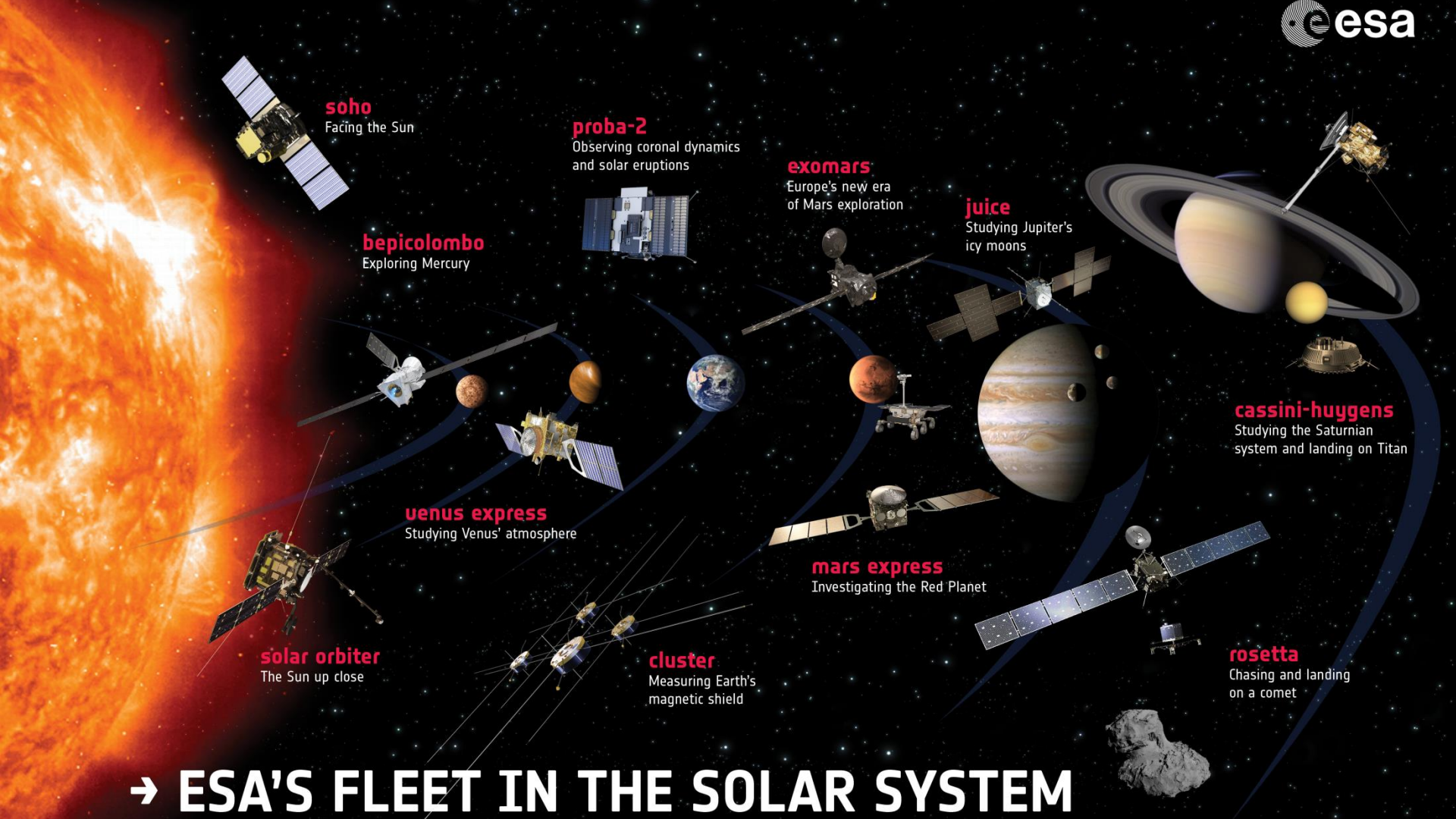
Offices

ESA ground stations

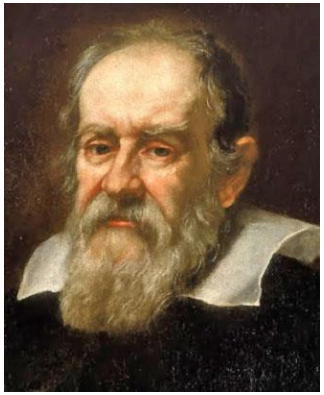


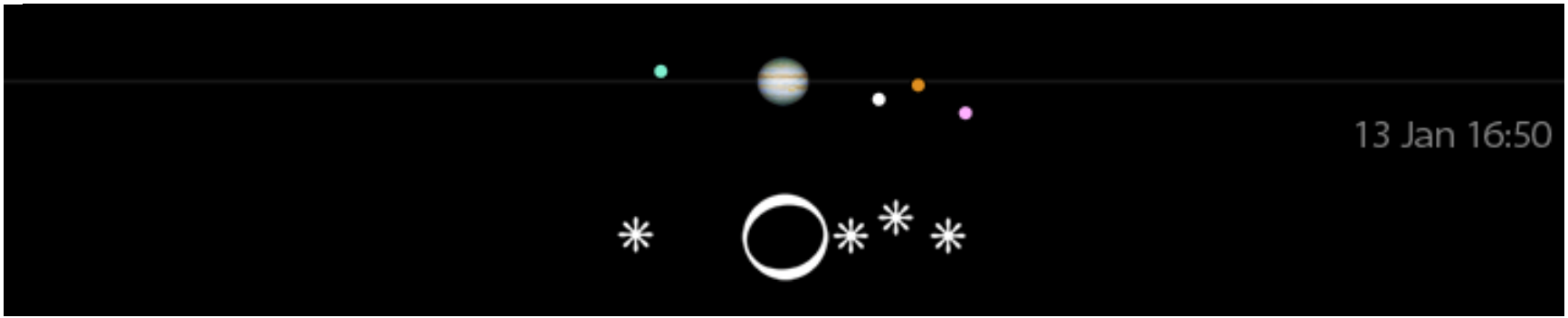
ESA budget by domain



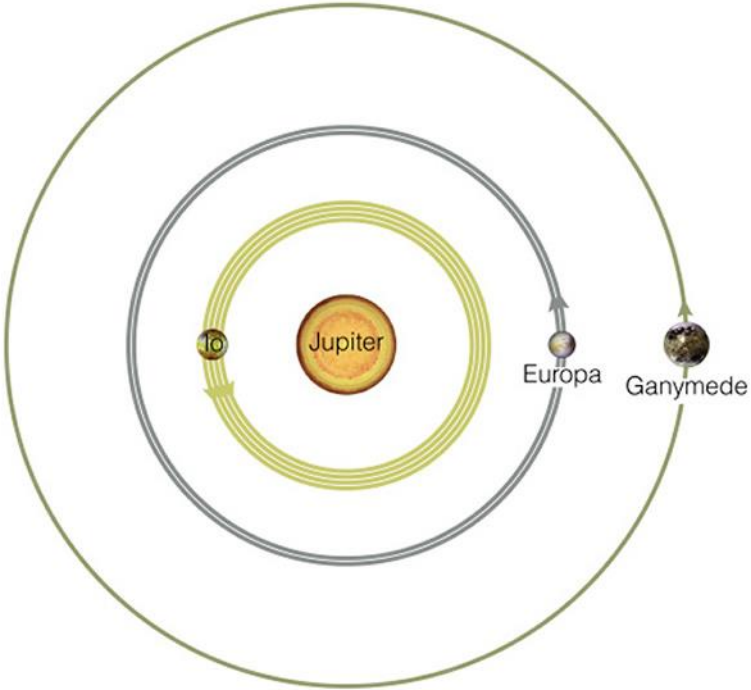

esa
soho
Facing the Sun
proba-2
Observing coronal dynamics and solar eruptions
exomars
Europe's new era of Mars exploration
juice
Studying Jupiter's icy moons
bepicolombo
Exploring Mercury
cassini-huygens
Studying the Saturnian system and landing on Titan
venus express
Studying Venus' atmosphere
mars express
Investigating the Red Planet
solar orbiter
The Sun up close
cluster
Measuring Earth's magnetic shield
rosetta
Chasing and landing on a comet
→ ESA'S FLEET IN THE SOLAR SYSTEM

On January 7th, 1610 Galileo was the first to see a planetary system from outside: the Jupiter system

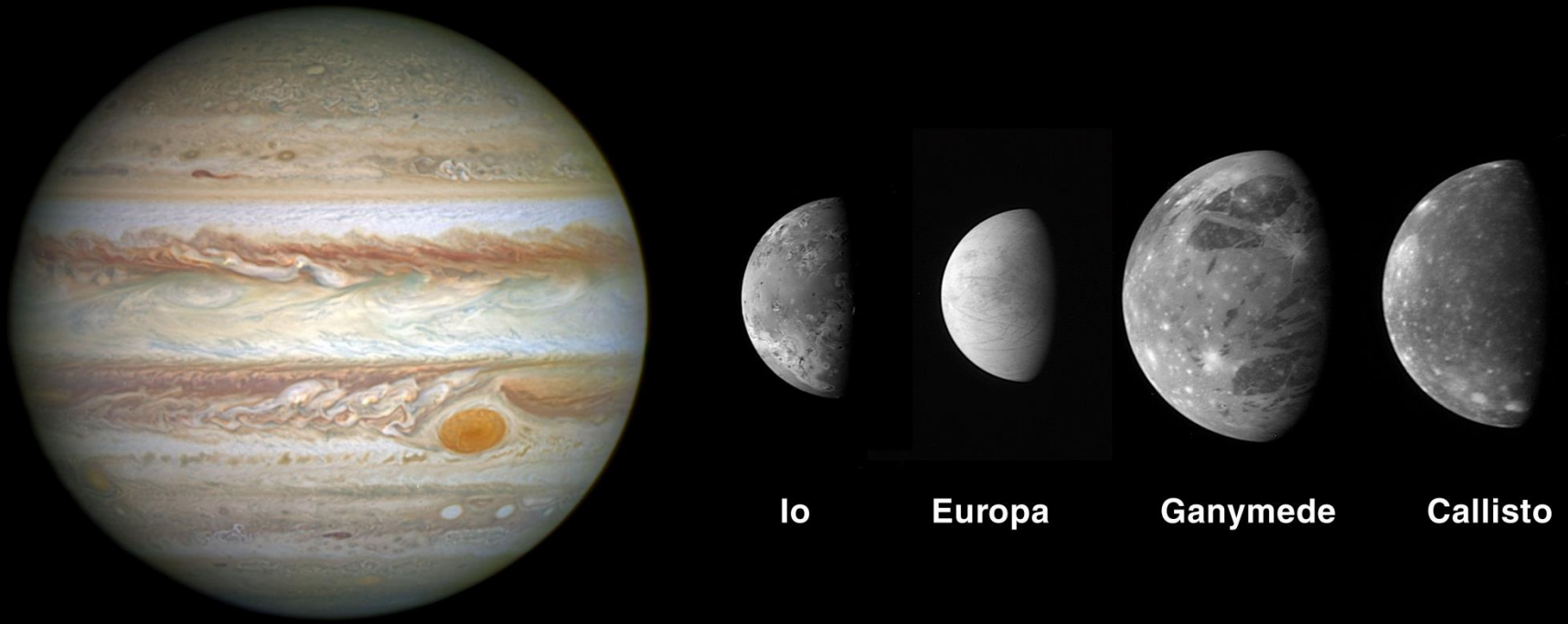




Pierre-Simon (De)Laplace studied the stability of planetary orbits and the resonance of the Galilean satellites: 4:2:1



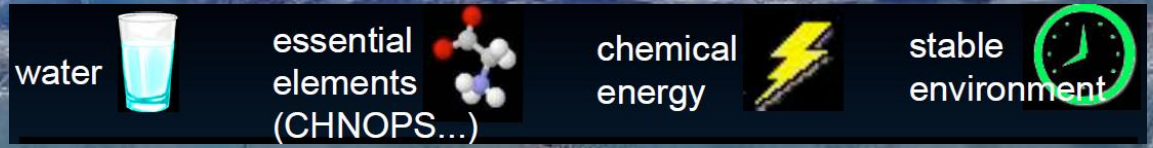
JUICE (JUpiter Icy Moons Explorer) is the first large mission (L1) of the ESA science programme “Cosmic Vision”



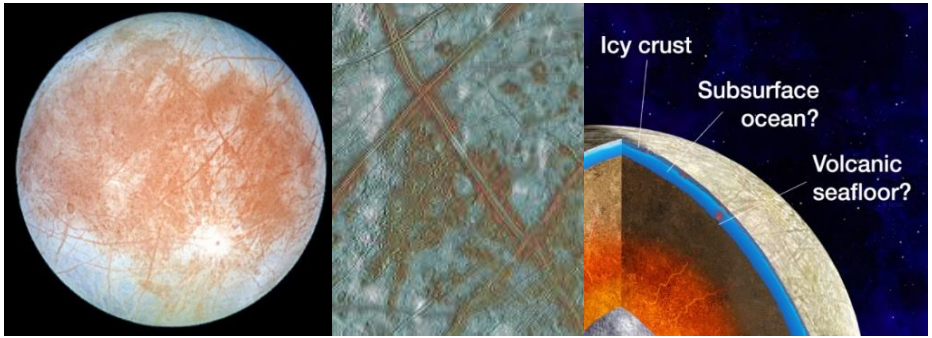
JUICE Science Objectives

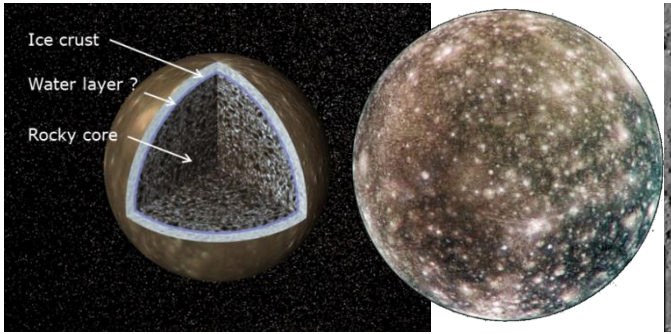
- Exploration of the Jupiter system
  - Jovian atmosphere
  - Jovian magnetosphere
  - Jovian satellite and ring systems

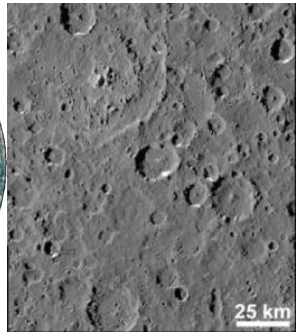
- Exploration of habitable worlds
  - Ganymede as a planetary object and possible habitat
  - Europa's recently active zones
  - Callisto as a remnant of the early Jovian system



Europa, Ganymede and Callisto







Elements of the JUICE program

Spacecraft:
Airbus D&S SAS

Ground Stations:
- ✓ Cebreros
- ✓ New Norcia
- ✓ Malargue

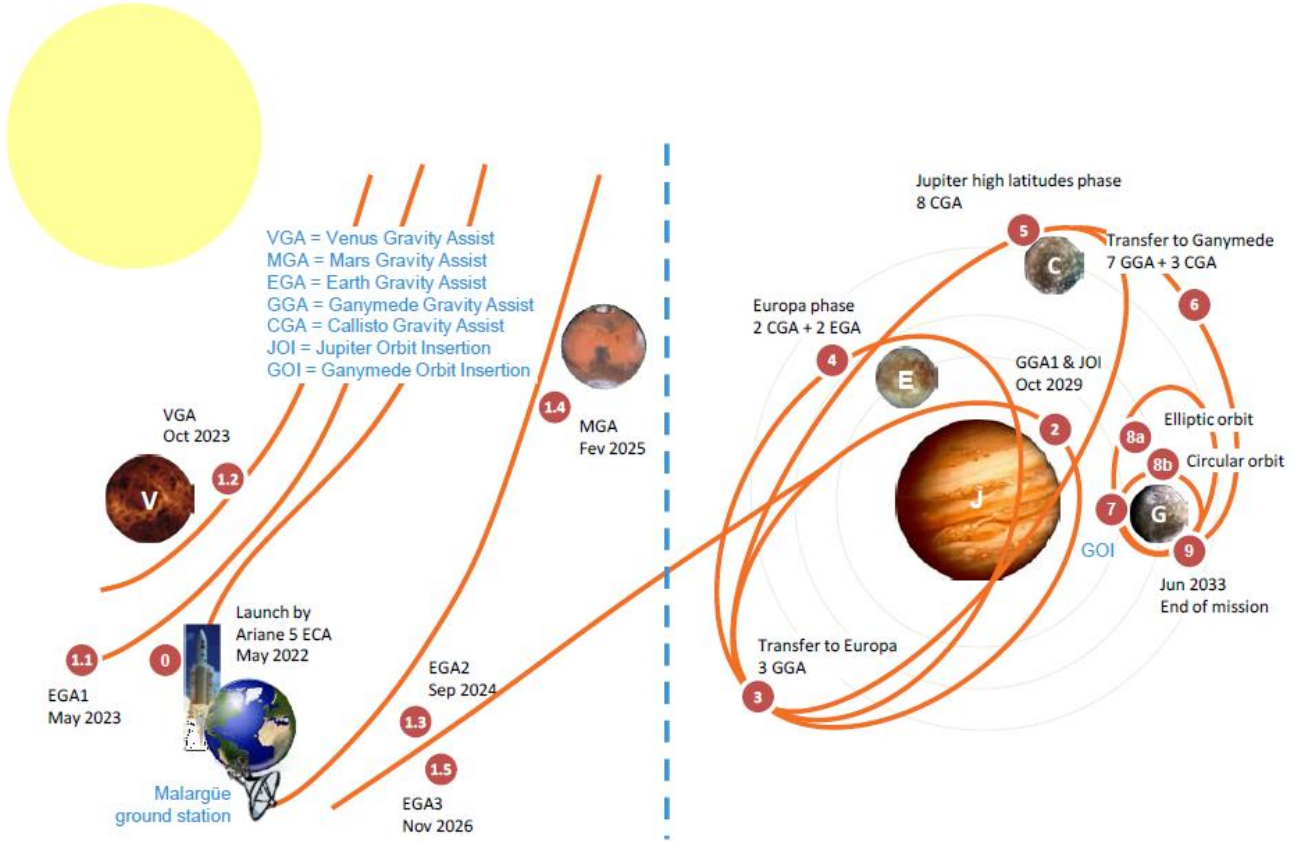
Mission Operation Centre (MOC)
ESOC

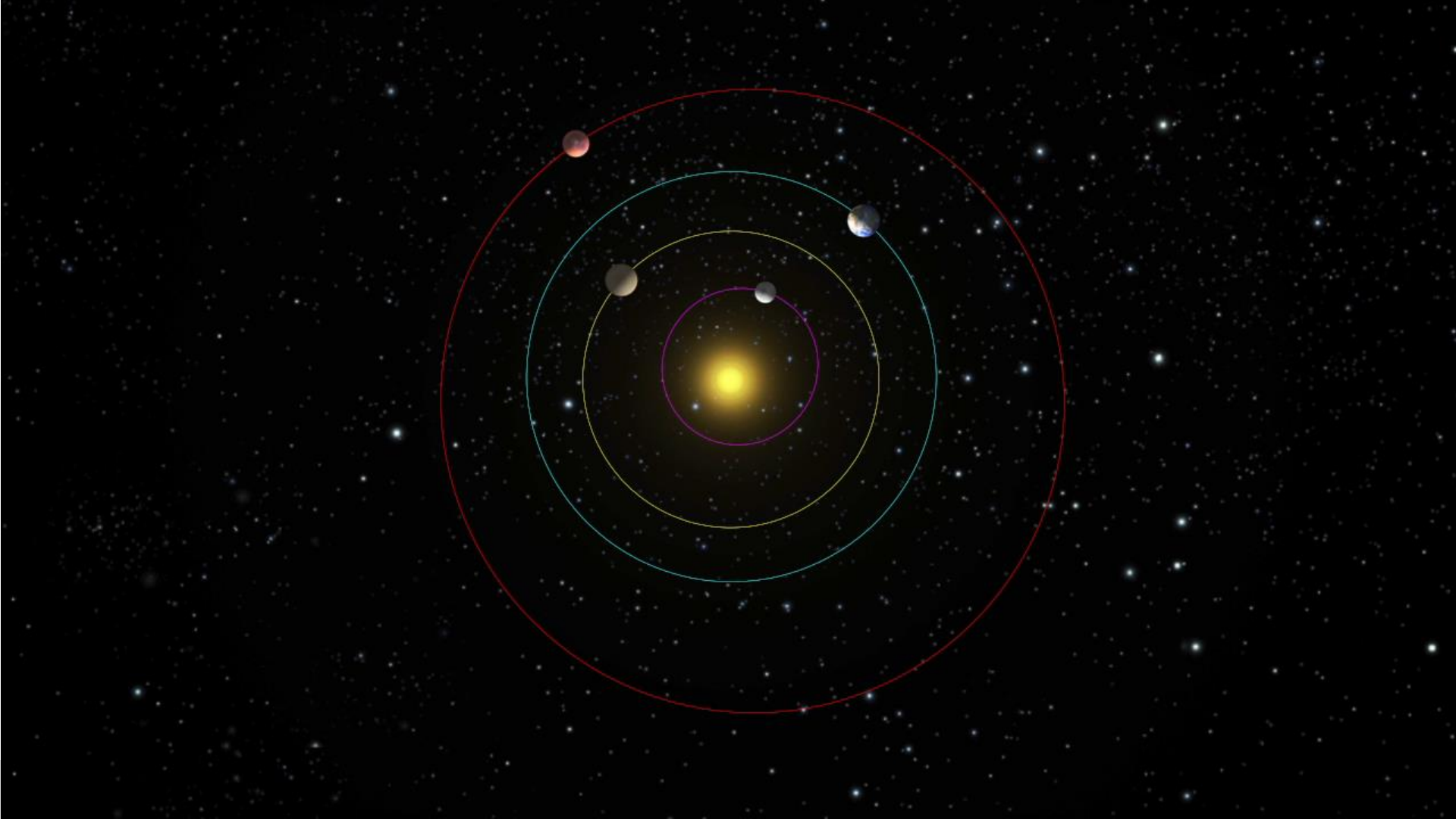
Launcher:
Ariane 5 ECA

European Science Community (with PI provided instruments)

Science Operation Centre (SOC)
ESAC

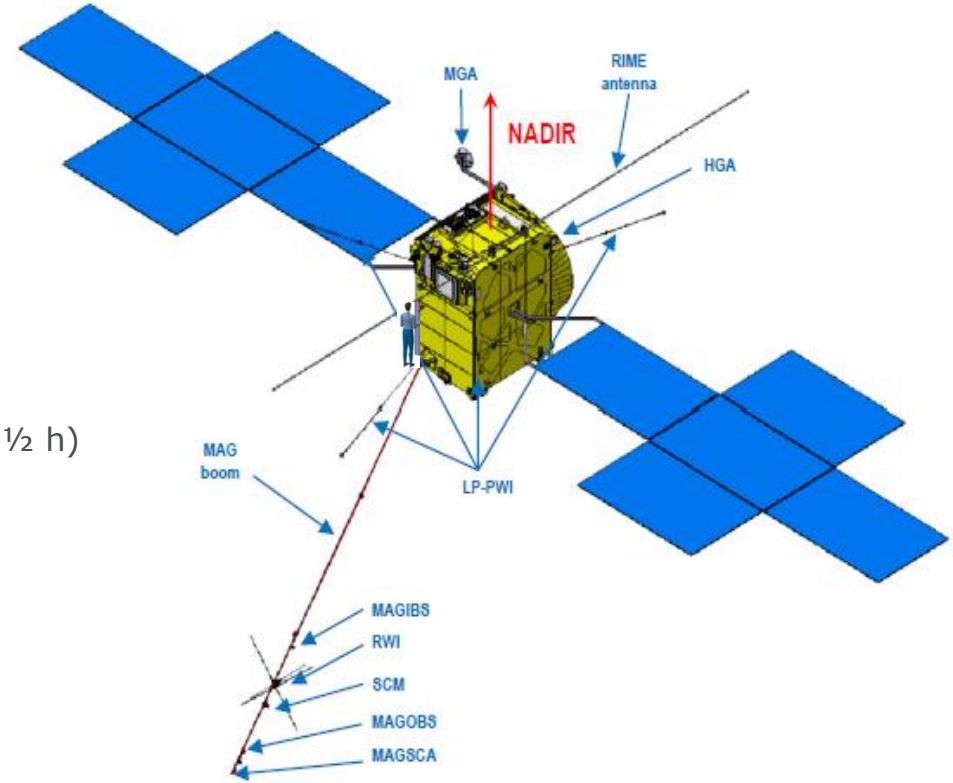
Mission overview





JUICE spacecraft configuration

- Mass
  - ✓ Dry ≈ 2200 kg
  - ✓ Propellant ≈ 2900 kg
  - ✓ Total > 5000 kg
  - ✓ Instruments = 260 kg
- Power
  - ✓ Solar Array ≈ 725 W EOL
  - ✓ Instruments GCO500 = 180 W
  - ✓ Instruments fly-by = 230 W (360 W for ½ h)
- Memory = 1 Tbit EOL
- Δv ≈ 2400 m/s
- Data Rate: 1.4 Gb/24 h



Wheels & batteries accommodated outside close to vaults contribute to radiation shielding

PEP Nadir units & **RIME** antenna

∅0,5 m two axis **MGA**

∅2,54 m **HGA** in X- and Ka-band for nominal operations, Science data download & RSE. Used as sunshield when close to the Sun

Calibration coils for JMAG

∅1666 mm **central cone/cylinder**

RIME antenna

Vault gathering most of the **electronic units** for radiation, ESD & EMC mitigation as well as to ensure a warm thermal environment throughout mission

Optical bench accommodated instruments with stringent pointing requirements close to STR-OH and NAVCAM and their proximity electronics inside +X vault

10,6 m MAG boom in three parts

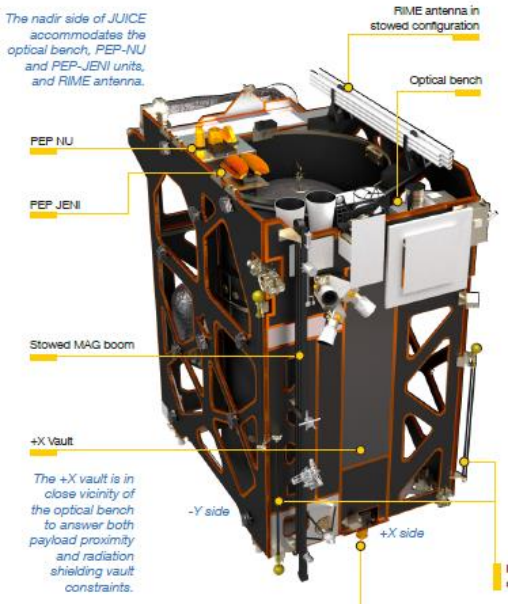
PEP Zenith unit

Propellant tanks (2x1630l) & **pressurant tanks**

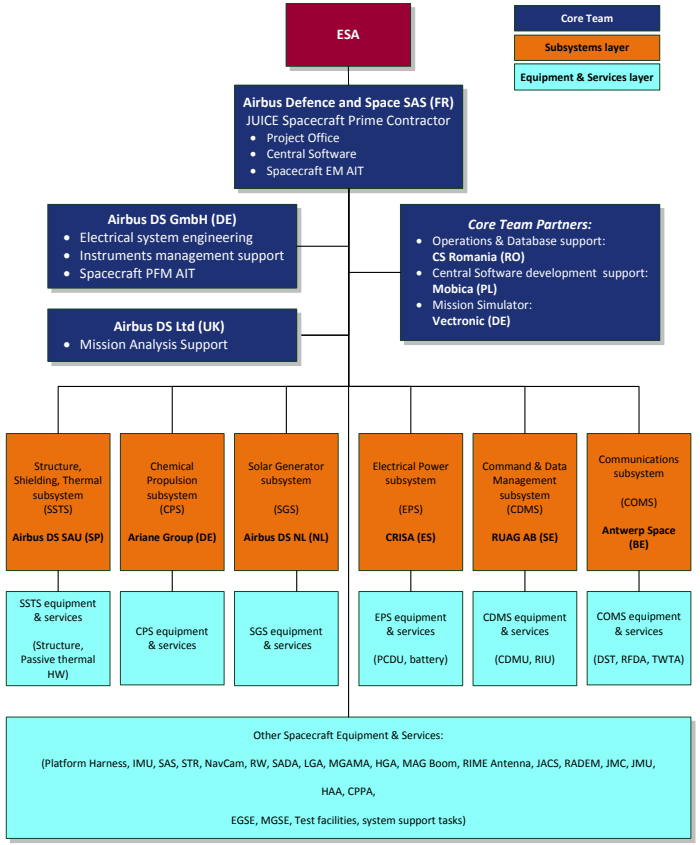
97 m² solar generator 860 W EOL @ Jupiter

450 N bi-propellant main engine with **2x4 22 N thrusters** for MEBM and **2x6 10 N thrusters** for orbit control and wheel offloading

Shear walls & lighten **external walls**



JUICE Industrial Consortium



Key design drivers (1/3)

- Power availability
  - Jupiter is at 778.5 million km from the Sun
  - Solar flux is around 50 W/m^2
  - Solar cell efficiency 26% (BOL), degradation (EOL), power distribution efficiency, margins for failure cases
  - Solar array size 85 m^2 → 725 W
- High and low temperatures
  - Very hot around Venus fly-by (0.64 AU) → 3.3 kW/m^2 → solar array at 150 C
  - Very cold at Jupiter (5.5 AU) → 50 W/m^2 → solar array down to -220 C

Key design drivers (2/3)

- Radiation Environment
  - Harsh radiation environment in the Jovian system → TID up to 25 Mrad external to the spacecraft
  - TID up to 250 krad inside the spacecraft
  - TID max 50 krad acceptable for units, sometime less
  - Careful selection of radiation resistant electrical component and materials
  - Shielding → mass

- Electro Magnetic Cleanliness
  - Instruments measuring fields and particles are very sensitive to EMC disturbances
  - Wish to measure the space electric/magnetic fields and not the spacecraft disturbances
    - ✓ Reaction Wheels
    - ✓ Solar array drive mechanisms
    - ✓ Power Control and Distribution Unit
    - ✓ Solar array
  - E.g. the spacecraft generated magnetic field shall be < 1 nT (10^{-9} Tesla) which is 50000 times less than the Earth magnetic field.

Key design drivers (3/3)

- Navigation and autonomy
  - 5 fly-by during the cruise to Jupiter
  - 26 fly-by during the Jupiter Tour: Europa (2x), Ganymede (11x), Callisto (13x)
  - Ganymede orbit insertion and 500 km polar orbit
  - Signal turnaround time at Jupiter (Earth station-spacecraft-Earth station) 1.5 h
  - Navigation Camera for autonomous operation
- Propulsion
  - Overall ΔV about 2.6 km/s
  - Large amount of propellant, in the range of 2.9 tons for a 2.2 tons spacecraft
  - Highest ΔV manoeuvres:
    - ✓ Jupiter orbit insertion 900 m/s
    - ✓ Ganymede orbit insertion 600 m/s

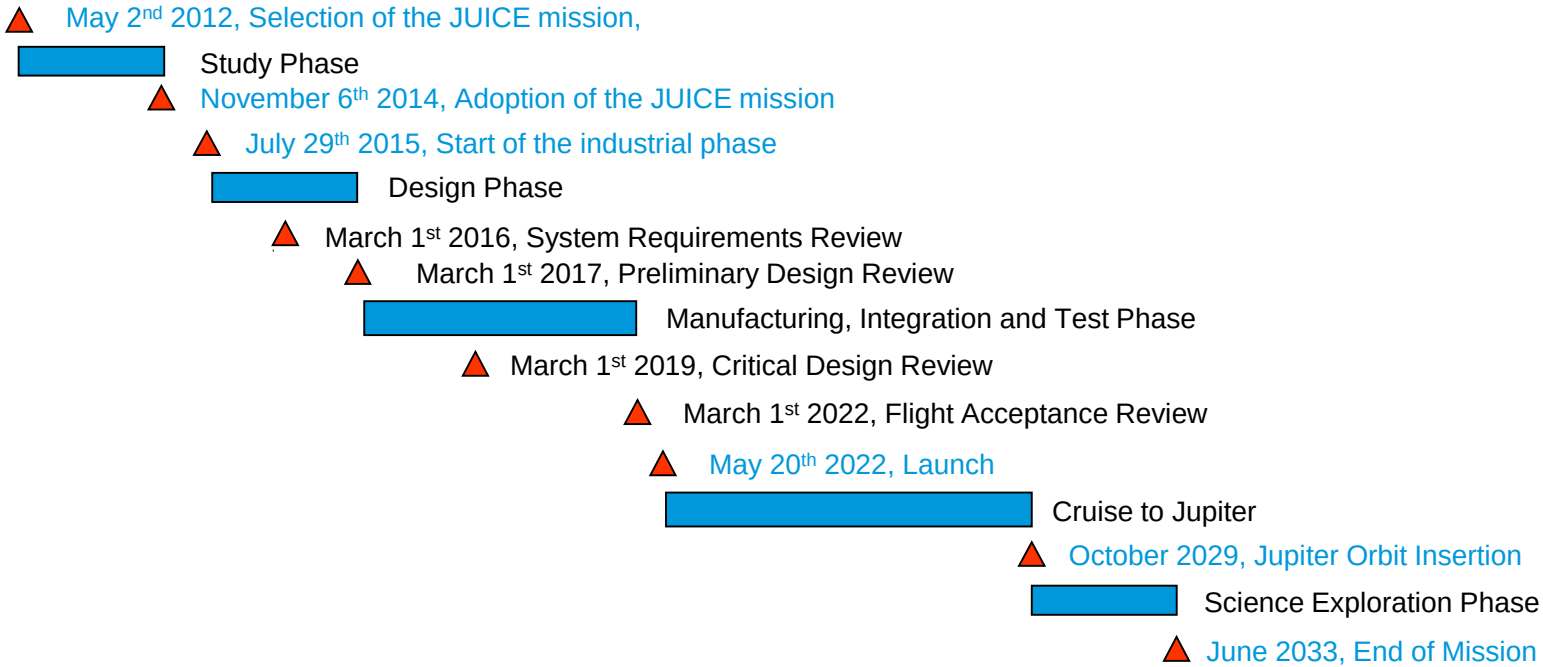
The instruments suite

		Instrument Name	Scientific purpose
Remote Sensing	1	Jovis, Amorum ac Natorum Undique Scrutator (**JANUS**)	Moons geology, cloud morphology and dynamics
	2	Moons And Jupiter Imaging Spectrometer (**MAJIS**)	Chemistry - Atmospheric & surface composition
	3	UV Spectrograph (**UVS**)	Atmosphere of moons & Aurora of JUPITER
	4	Sub-mm Wave Instrument (**SWI**)	JUPITER Wind + JUPITER Moons atmospheric temperatures and composition
Geophysics	5	GAnymede Laser Altimeter (**GALA**)	Moons shape & topography
	6	Radar for Icy Moons Exploration (**RIME**)	Moons sub-surface study
	7	Gravity & Geophysics of Jupiter and Galilean Moons (**3GM**)	Gravity field and moon interiors (S/C position)
	11	***PRIDE***	*Ephemerides of the Jovian system*
In situ Particles and Fields	8	JUICE Magnetometer (**J-MAG**)	Magnetic field (& Ganymede ocean)
	9	Particle Environment Package (**PEP**)	Plasma environment & Study of the neutral and ion composition of exospheres
	10	Radio & Plasma Wave Investigation (**RPWI**)	Plasma environment

RIME Antenna Field Test

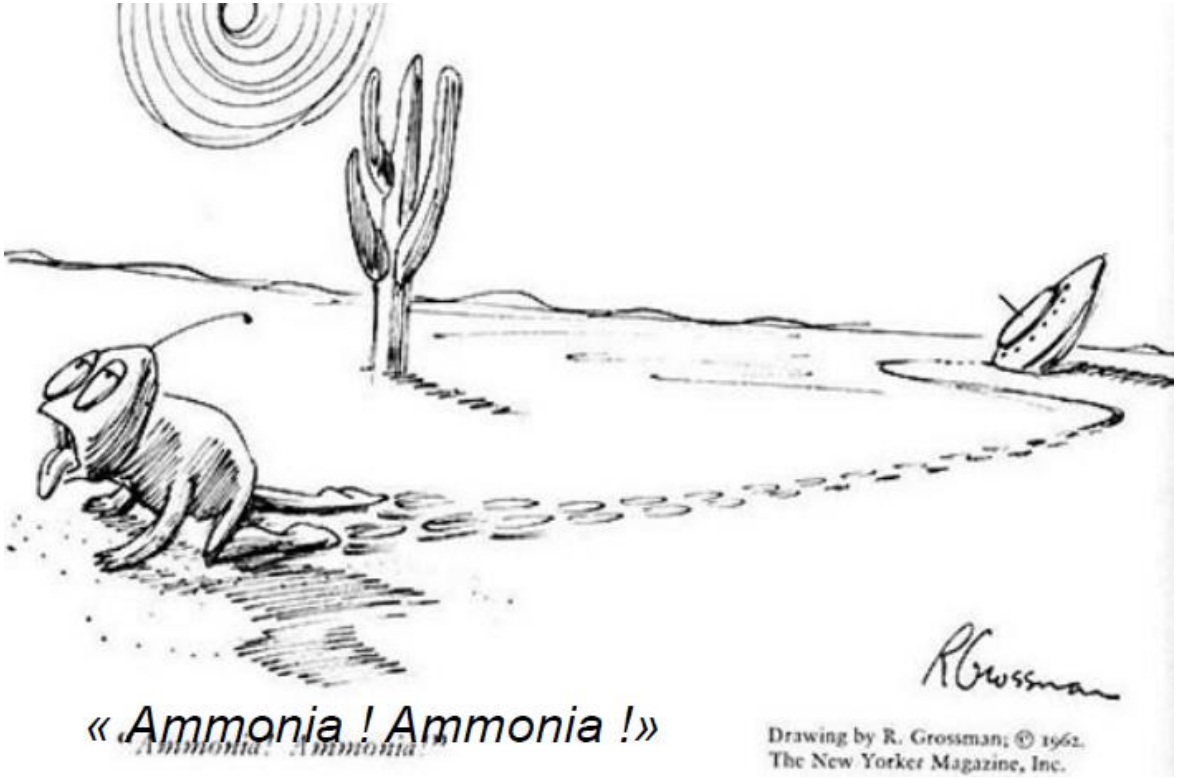
Thermal Development Model

Overall mission schedule




Venus FlyBy 2023-10-22
Venus
Velocity
Sun

http://sci.esa.int/juice/



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