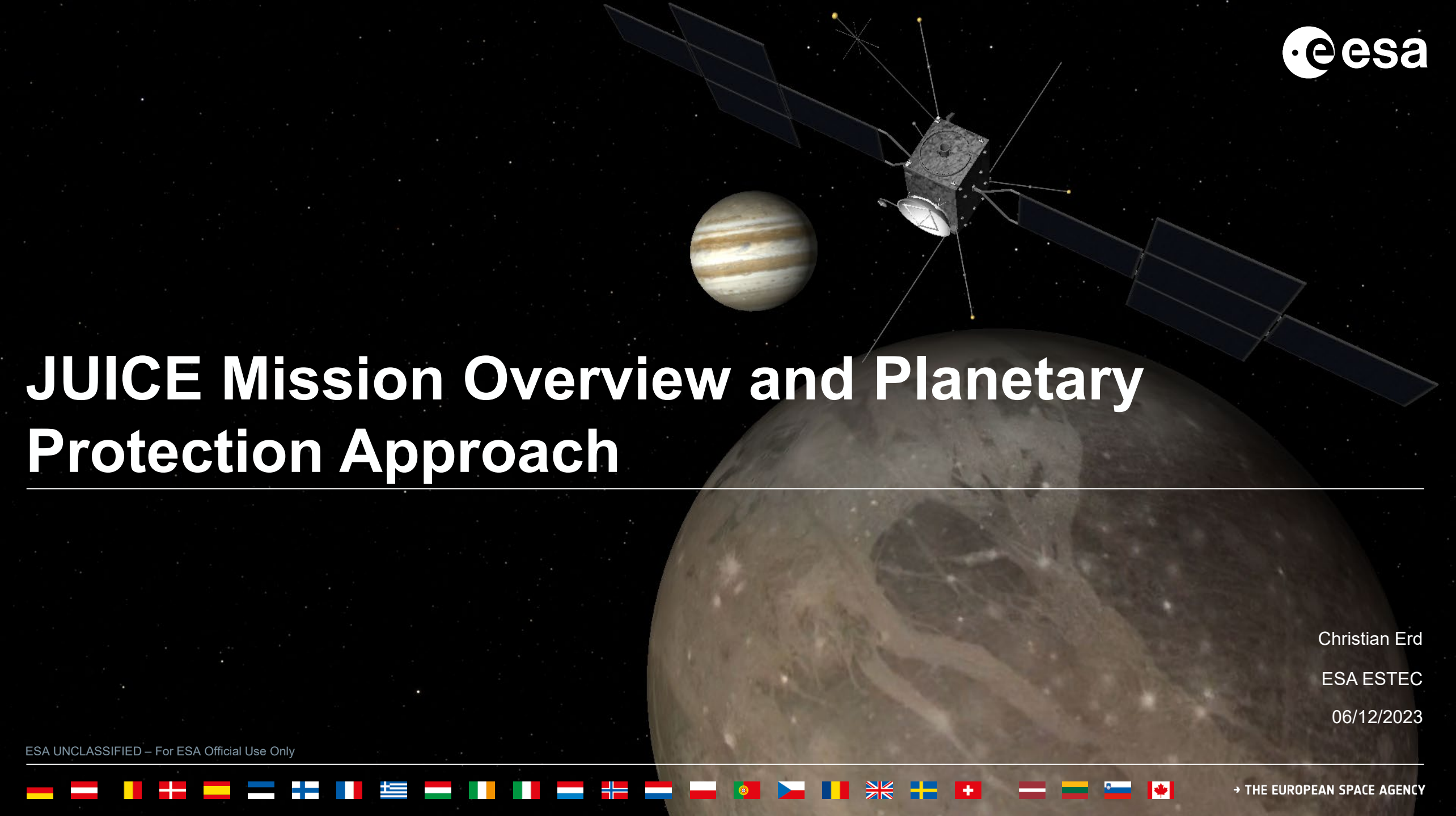


JUICE Mission Overview and Planetary Protection Approach

Christian Erd

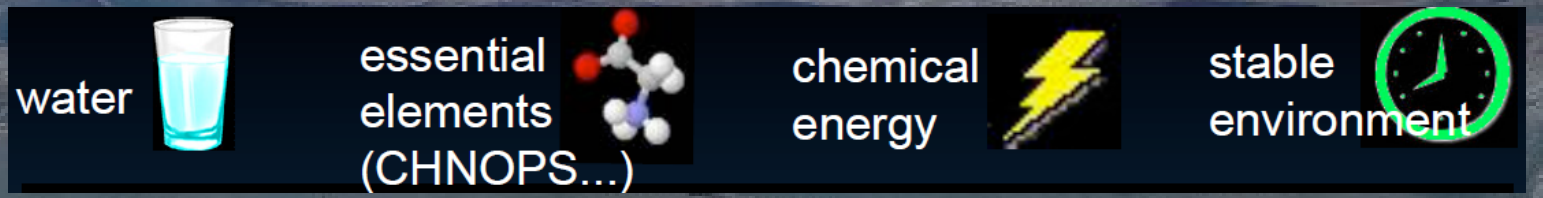
ESA ESTEC

06/12/2023

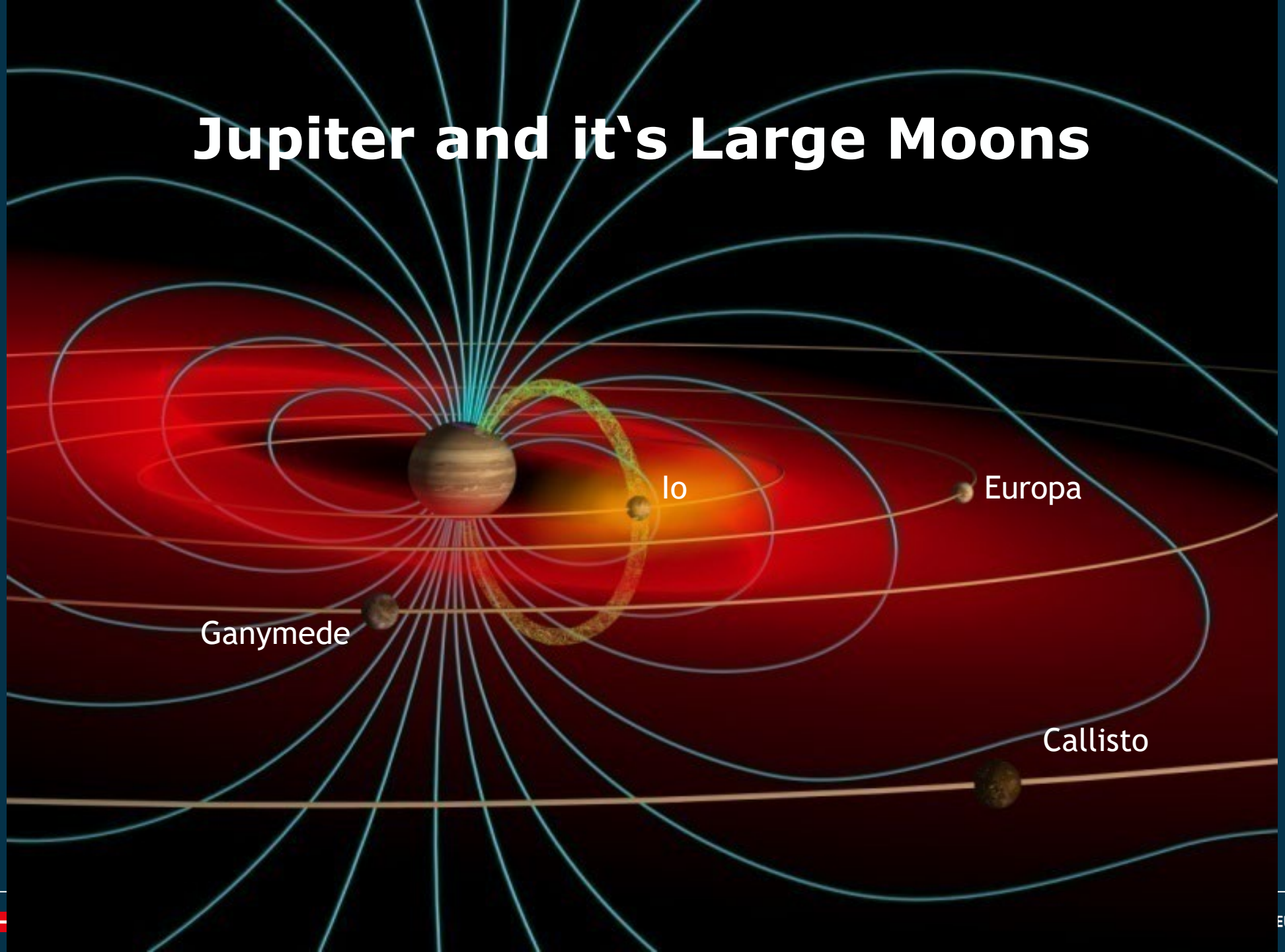
Jupiter ICy Moons Explorer JUICE Science Objectives

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

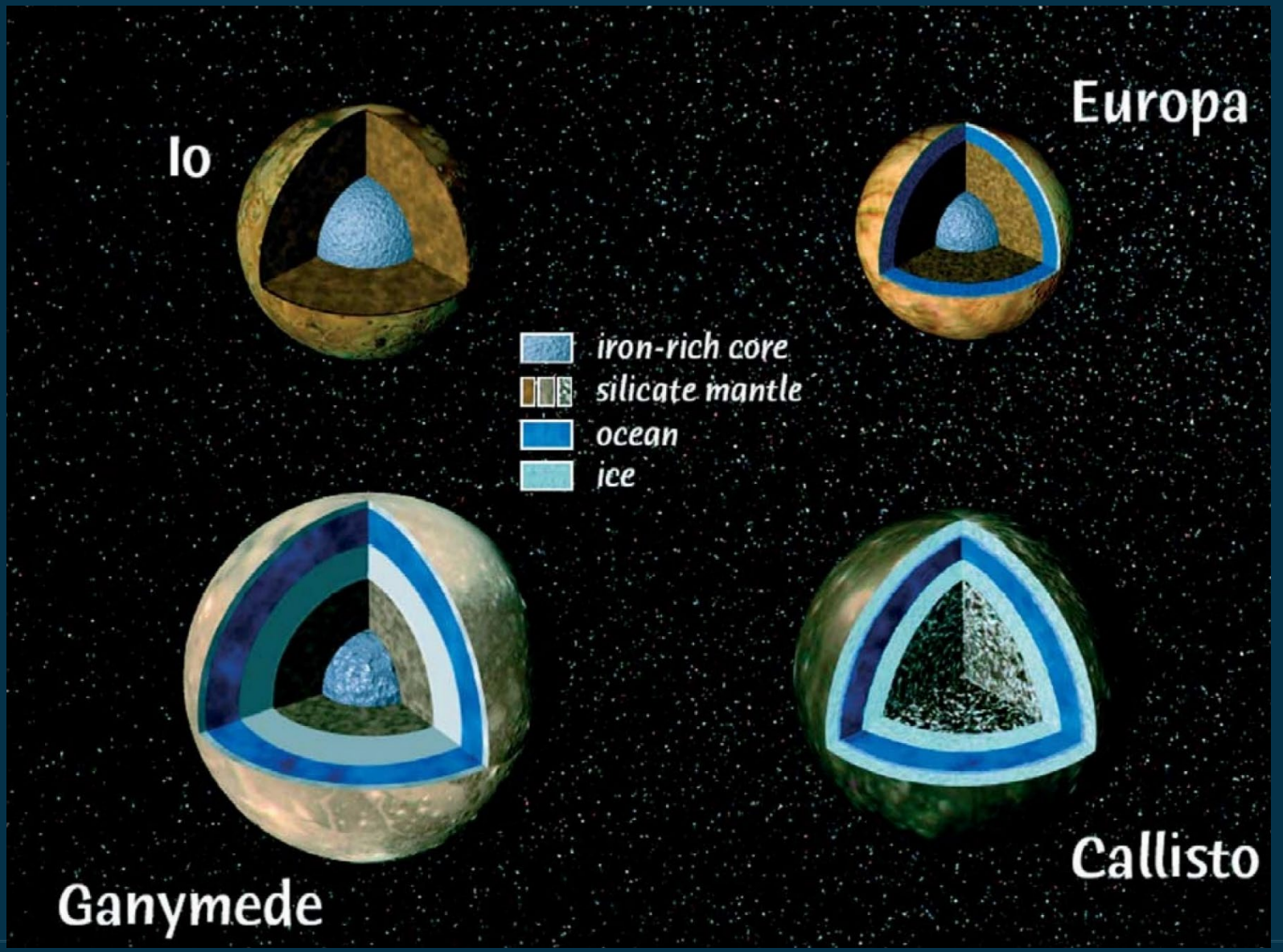
- Exploration of habitable worlds
  - Ganymede as a planetary object and possible habitat
  - Europa's recently active zones
  - Callisto as a remnant of the early Jovian system



Jupiter and it‘s Large Moons



Comparison of Structures



HOW DOES IT WORK?

SEARCH FOR LIFE

ORIGINS & FORMATION

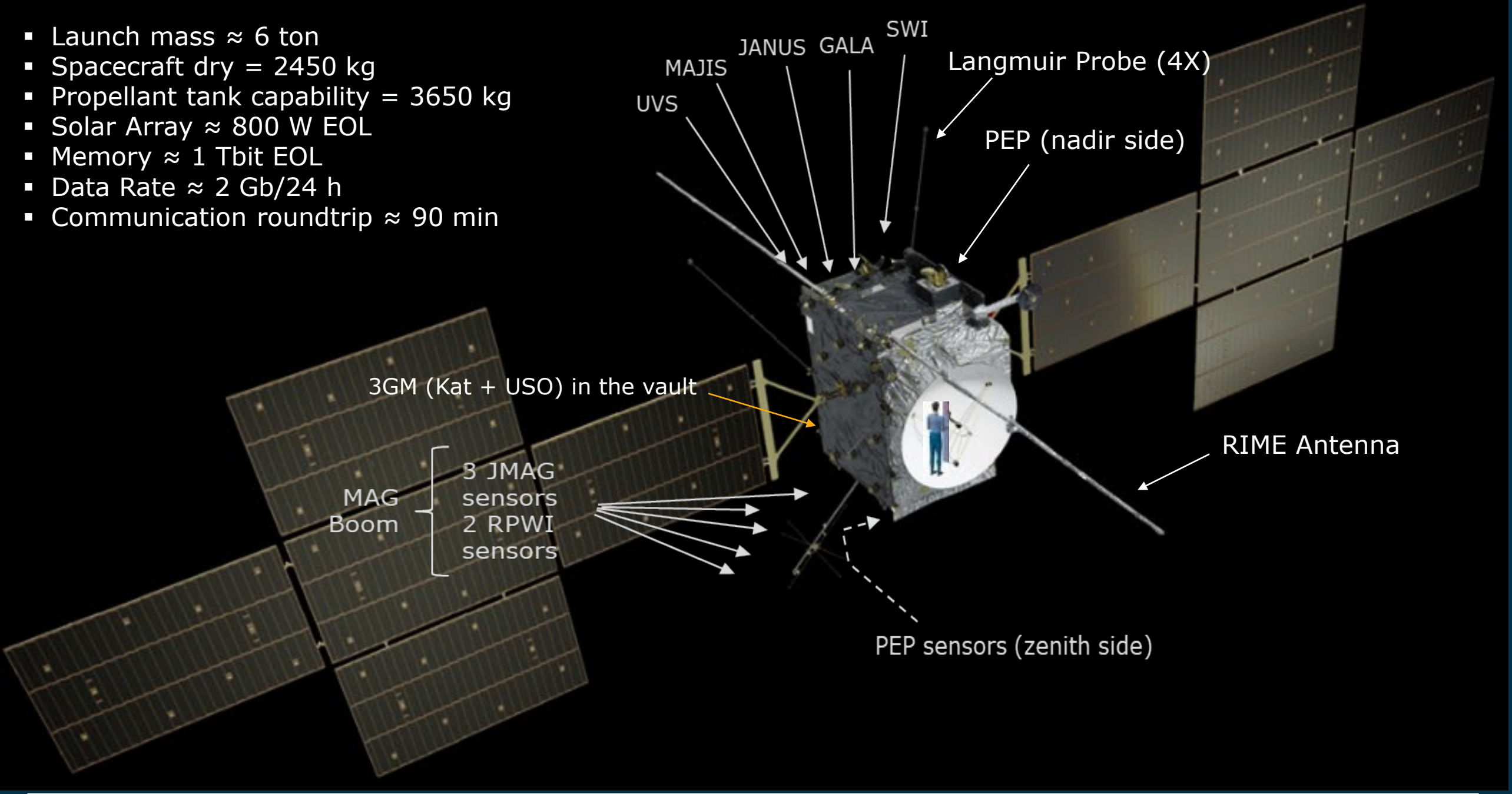
HABITABILITY

TYPE III HABITAT

TYPE IV HABITAT

Courtesy Michel Blanc ☺

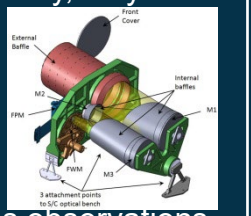
- Launch mass ≈ 6 ton
- Spacecraft dry = 2450 kg
- Propellant tank capability = 3650 kg
- Solar Array ≈ 800 W EOL
- Memory ≈ 1 Tbit EOL
- Data Rate ≈ 2 Gb/24 h
- Communication roundtrip ≈ 90 min



JUICE Payload: remote sensing

JANUS: Visible Camera System

PI: Pasquale Palumbo, Parthenope University, Italy.
Co-PI: Ralf Jaumann, DLR, Germany

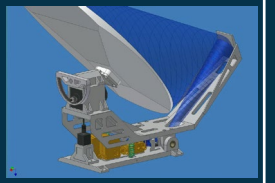


- ≥7.5m/pixel
- Multiband imaging, 380 - 1080 nm
- Icy moon geology
- Io activity monitoring and other moons observations
- Jovian atmosphere dynamics

SWI: Sub-mm Wave Instrument

PI: Paul Hartogh, MPS, Germany

- 600 GHz
- Jovian Stratosphere
- Moon atmosphere
- Atmospheric isotopes



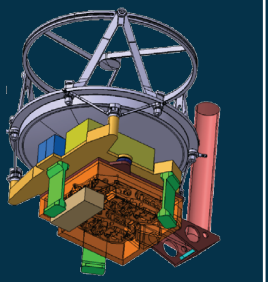
MAJIS: Imaging VIS-NIR/IR Spectrograph

PI: Yves Langevin, IAS, France
Co-PI: Guiseppe Piccioni, INAF, Italy

- 0.9-1.9 μm and 1.5-5.7 μm
- ≥62.5 m/pixel
- Surface composition
- Jovian atmosphere

GALA: Laser Altimeter

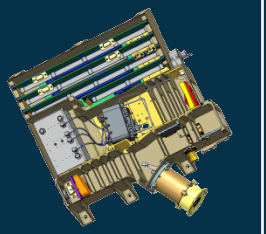
PI: Hauke Hussmann, DLR, Germany



- ≥40 m spot size
- ≥0.1 m accuracy
- Shape and rotational state
- Tidal deformation
- Slopes, roughness, albedo

UVS: UV Imaging Spectrograph

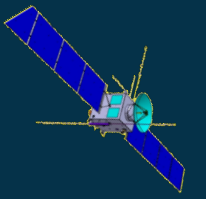
PI: Randy Gladstone, SwRI, USA



- 55-210 nm
- 0.04˚-0.16˚
- Aurora and Airglow
- Surface albedos
- Stellar and Solar Occultation

RIME: Ice Penetrating Radar

PI: Lorenzo Bruzzone, Trento, Italy
Co-PI: Jeff Plaut, JPL, USA



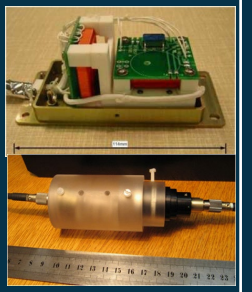
- 9 MHz
- Penetration ~9 km
- Vertical resolution 30 m
- Subsurface investigations

JUICE Payload: in situ & geophysics

JMAG: JUICE Magnetometer

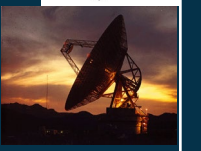
PI: Michele Dougherty, Imperial, UK

- Dual Fluxgate and Scalar mag
- ±8000 nT range, 0.2 nT accuracy
- Moon interior through induction
- Dynamical plasma processes



3GM: Gravity, Geophysics, Galilean Moons

PI: Luciano Iess, Rome, Italy
Co-PI: David J. Stevenson, CalTech, USA



- Ranging by radio tracking
- 2 μm/s range rate
- 20 cm range accuracy
- Gravity fields and tidal deformation

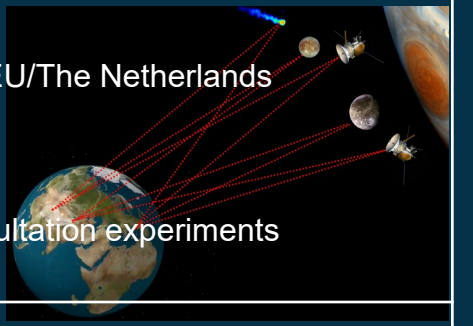
PEP: Particle Environment Package

PI: Stas Barabash, IRF-K, Sweden
Co-PI: Peter Wurz, UBe, Switzerland

- Six sensor suite
- Ions, electrons, neutral gas (in-situ)
- Remote ENA imaging of plasma and torus

PRIDE: Planetary Radio Interferometer & Doppler Experiment

PI: Leonid Gurvits, JIVE, EU/The Netherlands

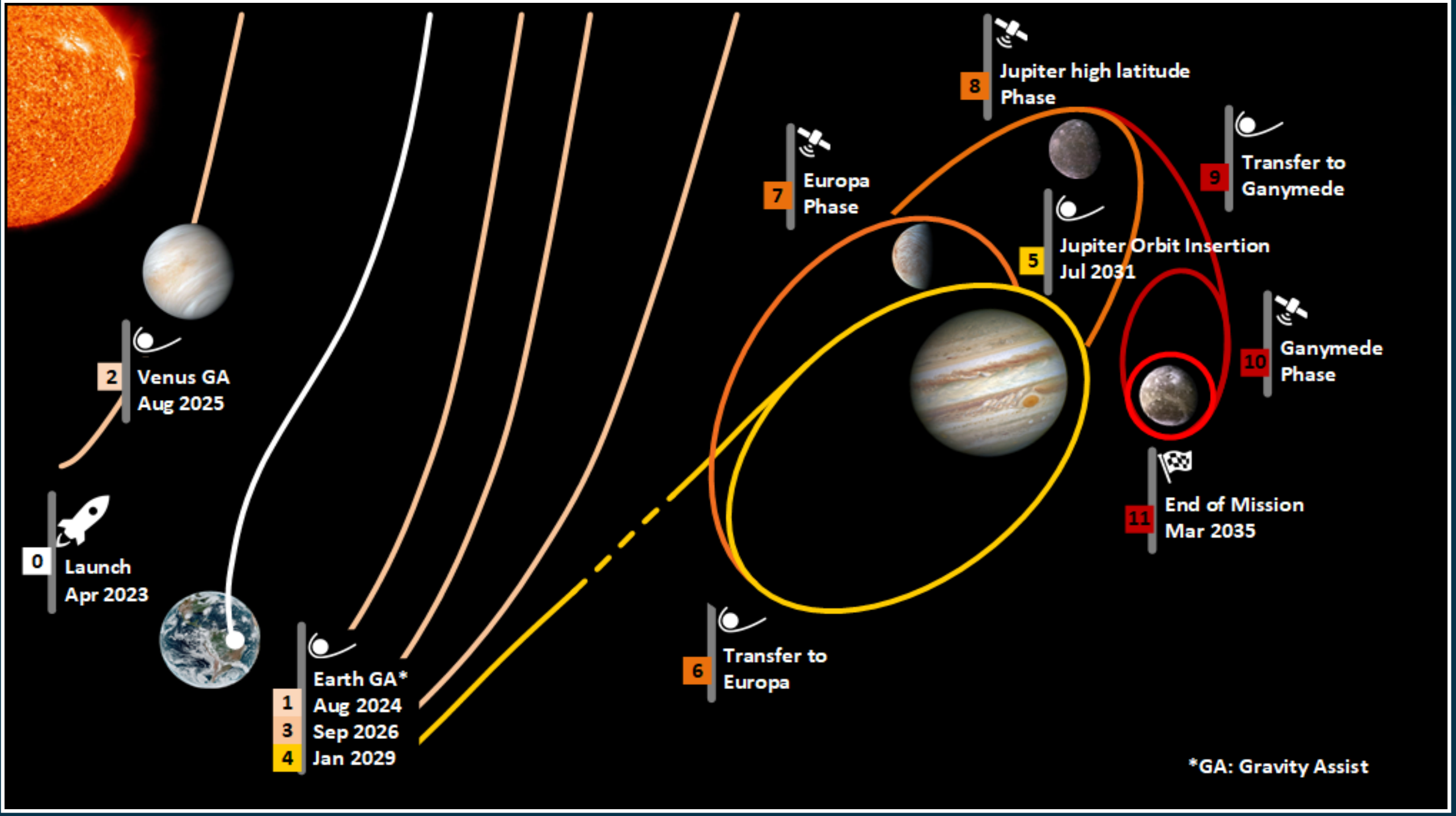


- S/C state vector
- Ephemerides
- bi-static and radio occultation experiments

RPWI: Radio and Plasma Wave Investigation

PI: Jan-Erik Wahlund, IRF-U, Sweden

- Langmuir Probes
- Search Coil Magnetometer
- Tri-axial dipole antenna
- E and B-fields
- Ion, electron and charged dust parameters

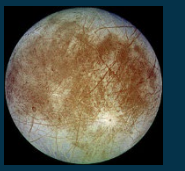

0 Launch Apr 2023
1 Earth GA* Aug 2024
2 Venus GA Aug 2025
3 Sep 2026
4 Jan 2029
5 Jupiter Orbit Insertion Jul 2031
6 Transfer to Europa
7 Europa Phase
8 Jupiter high latitude Phase
9 Transfer to Ganymede
10 Ganymede Phase
11 End of Mission Mar 2035
*GA: Gravity Assist

La trajectoire

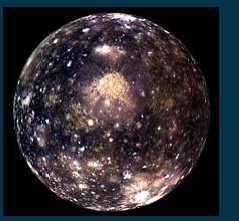
8.4 ans de trajet

Swing-by:
3 x Terre
1 x Vénus

3.4 ans autour de Jupiter



Fly-by:
2 x Europe
12 x Ganymède
21 x Callisto



10 mois autour de Ganymède

Flux solaire:
50 W/m² -> 3300 W/m²

Correction vitesse
> 2400 m/s

6 milliards de kilomètres

Requirements of Launcher Upper Stage – Mars

The probability of impact on Mars by any element shall be $<10^{-4}$ for the first 50 years after launch (no parts assembled in ISO 8)

- Spacecraft: probability of impact is 5×10^{-5} until Jupiter orbit
- Launcher upper stage: no impact on Mars was simulated; 9.6×10^{-5} at 99% confidence limit

JUICE Planetary Protection Requirements – Europa

Cat III: forward bioburden <10^{-4} likelihood, demonstrated by accidental collision probability

Analysis by trajectory evolution analysis:

- Short term loss of control (failure during targeting)
  - Verify availability of redundancy
  - Navigate flyby by step-in target during approach
- Long term loss of control (during bound orbit around Jupiter, but before Ganymede orbit insertion):
  - Reliability and redundancy of spacecraft control equipment
  - Trajectory evolution after each planned manoeuvre, random loss of control – calculated the collision probability
  - Probability is 7.4×10^{-5}

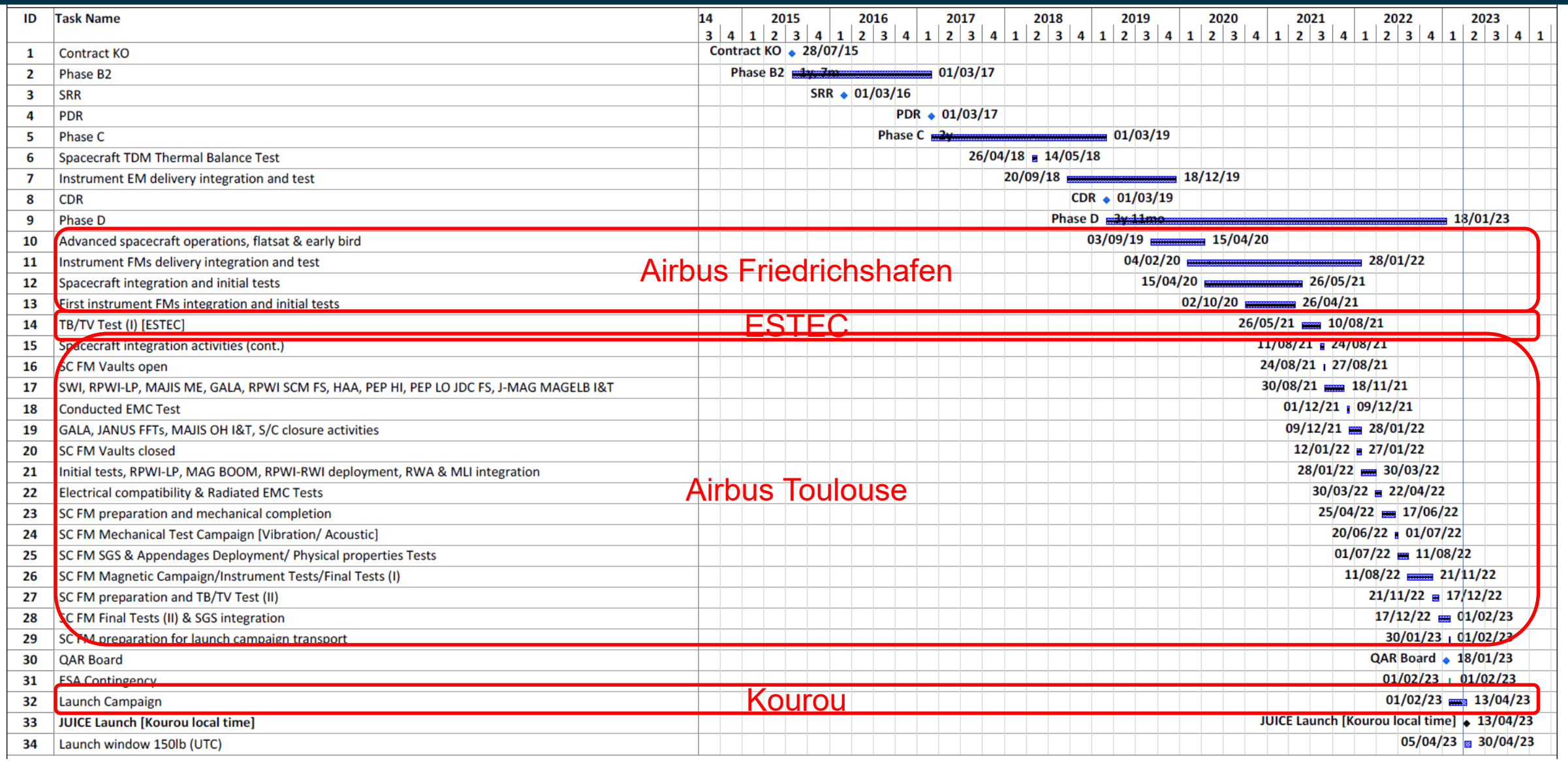
JUICE Planetary Protection Requirements – Ganymede

Cat II+: no requirement placed, documented bioburden

- Sampling of cleanrooms, where JUICE was present over extended periods, including
- Airbus/Friedrichshafen integration room: 4 March 2019
- Airbus/Toulouse, Astrolabe, Pascal D: 9 Nov 2021 with JUICE present
- KSC S5A, CCU3, BAF-HE (encapsulation): 11 & 12 October 2021 – preparations and background with different satellite
- KSC S5C & S5A: 18 & 19 March 2023 with JUICE present
- ESTEC: part of nominal facility monitoring

Bioburden Sampling in Kourou S5C

JUICE Implementation Schedule



Conclusions

- All planetary protection requirements are met
- Planetary Implementation and reports were reviewed and approved by ESA Planetary Protection Officer and Quality Control during all steps
- All spacecraft subsystems are fully operational after launch, no update of PP pre-launch documentation needed
- In addition, bioburden was sampled during all main assembly stages