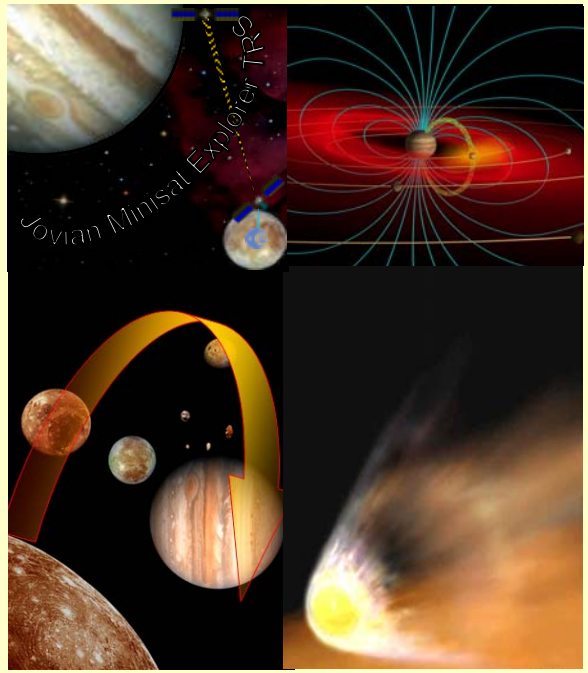
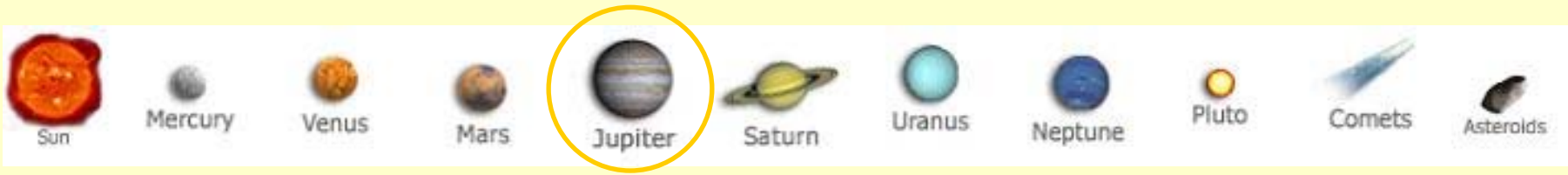
Overview of the Jovian Exploration Technology Reference Studies

The Challenge of Jovian System Exploration



Peter Falkner & Alessandro Atzei

Solar System Exploration Studies Section
Science Payload and Advanced Concepts Office
ESA/ESTEC
Peter.Falkner@esa.int , tel: +31 071 565 5363



Overview of Jovian Technology Reference Studies

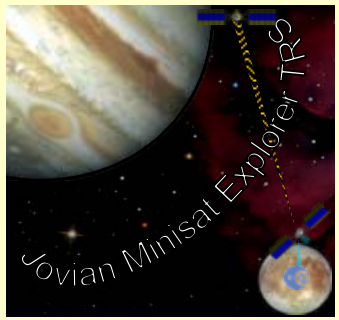
- Europa Explorer
  (Jovian Minisat Explorer)
- Magnetospheric Explorer
  (Jovian System Explorer)
- Atmospheric Entry Probe
  (Jupiter Entry Probe)

Jupiter related Technology Reference Studies

Motivation:

- providing **minimal** building blocks ('lego') for future science missions
- definition & development of **enabling technologies** for future science missions
- enable **realistic evaluation** of proposals in the frame of ESA's Cosmic Vision 1525
- **several 'theme proposals**' for Jovian System with in CV1525 exercise ⇨background

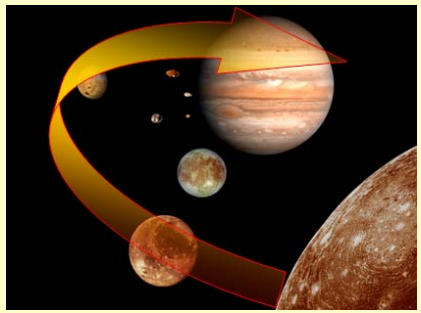
- Presently the first phase of Jovian studies has been completed & a new phase has been initiated:



✓ **Jovian Minisat Explorer:**
Focussing on the exploration of Europa
(or any other Galilean moon, except Io)

⇨ **Jovian System Explorer:**

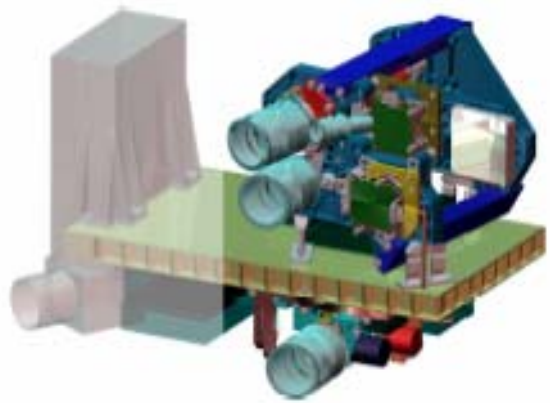
- ➢ Study of the **Jovian magnetosphere** (one or more magnetospheric S/C
- ➢ Study of the **Jovian atmosphere** (one or more entry probes, up to 100 bar)



Programme Concept - Europa

- Emphasis on a **cost & resource minimised mission scenario**:
  Small launcher, highly integrated payload & avionics, minisat

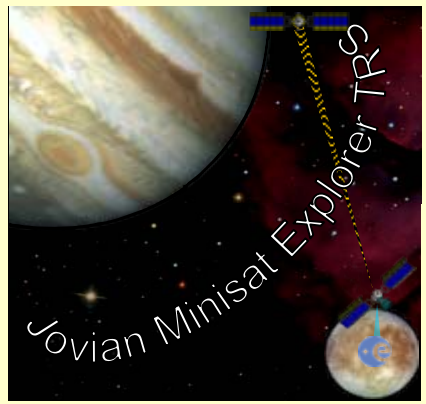
- Configuration of phase 1:
  1 Europa Orbiter & 1 Jovian Relay Spacecraft (in orbit around Jupiter)



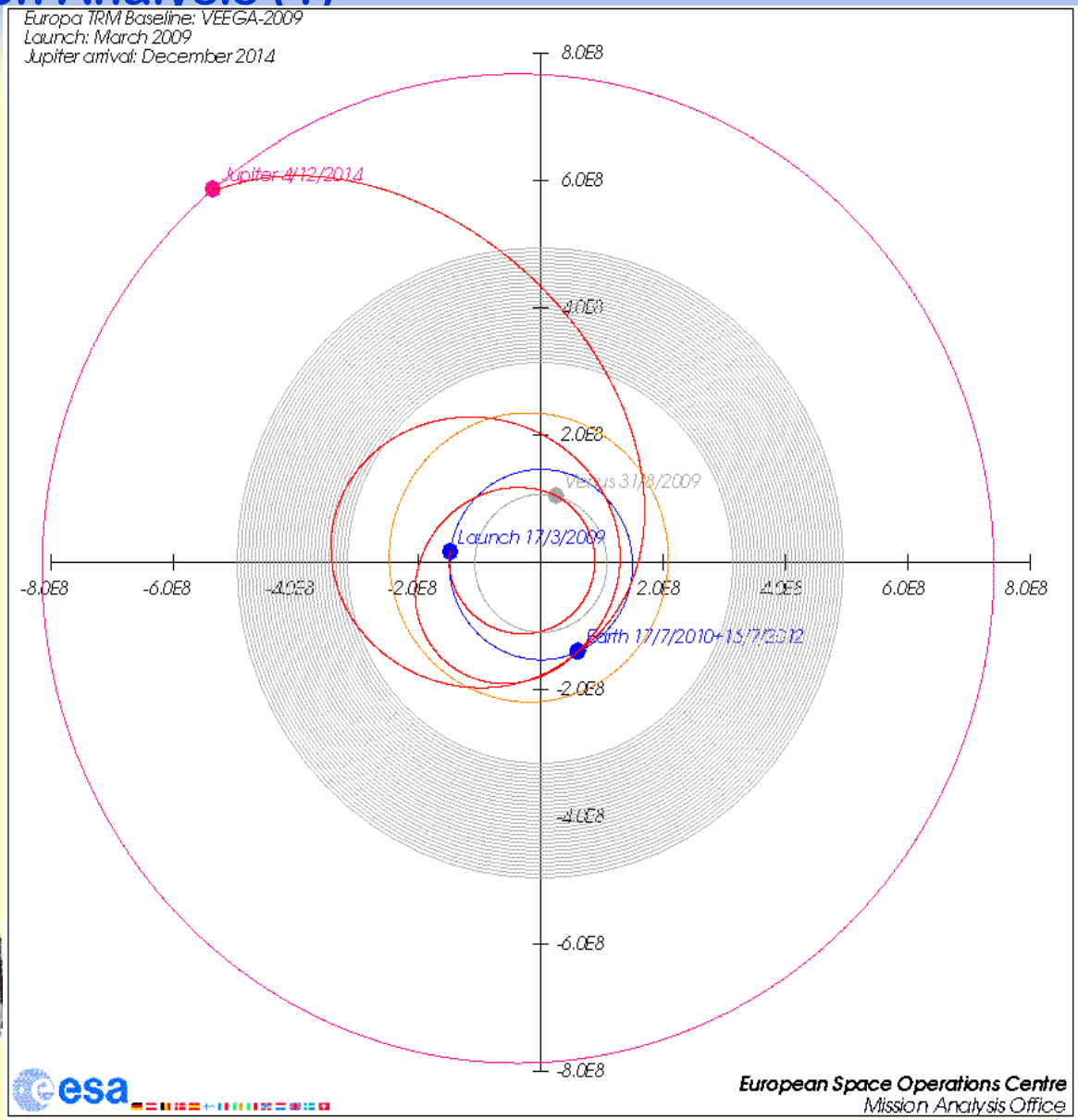
Highly Integrated P/L Suite

⇨ **2 S/C approach rationale:**

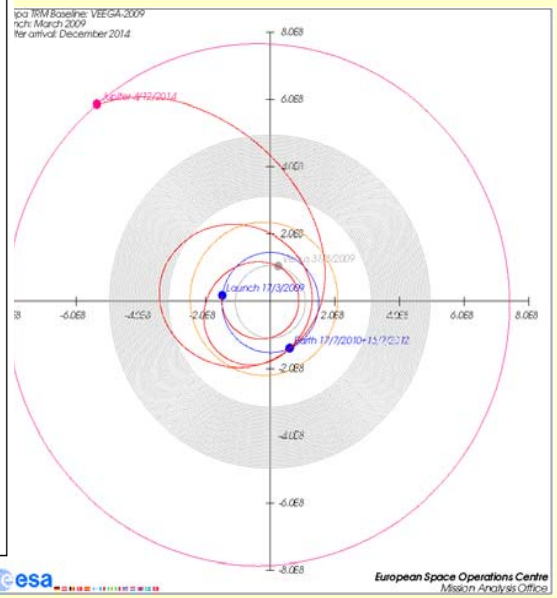
- **Lifetime, data rate and power limited:**
  transmission of all data is impossible in the ~66 day JEO lifetime.
  ⇨ a relay S/C is required capable of delivering all data to Earth
- **Europa radiation environment:**
  stay outside radiation belts with equipment which is not needed for Europa exploration
- **Delta-V requirements:**
  bring into Europa orbit only what is really needed there !
- **Additional JRS science:**
  JRS will be able to gather valuable scientific data on the Jovian system from its orbit during ~2 year in orbit lifetime
- **Additional Fly-by opportunities**:
  JRS: 1xCallisto & 5xGanymede GAM's, JEO: 4xGanymedeGAM



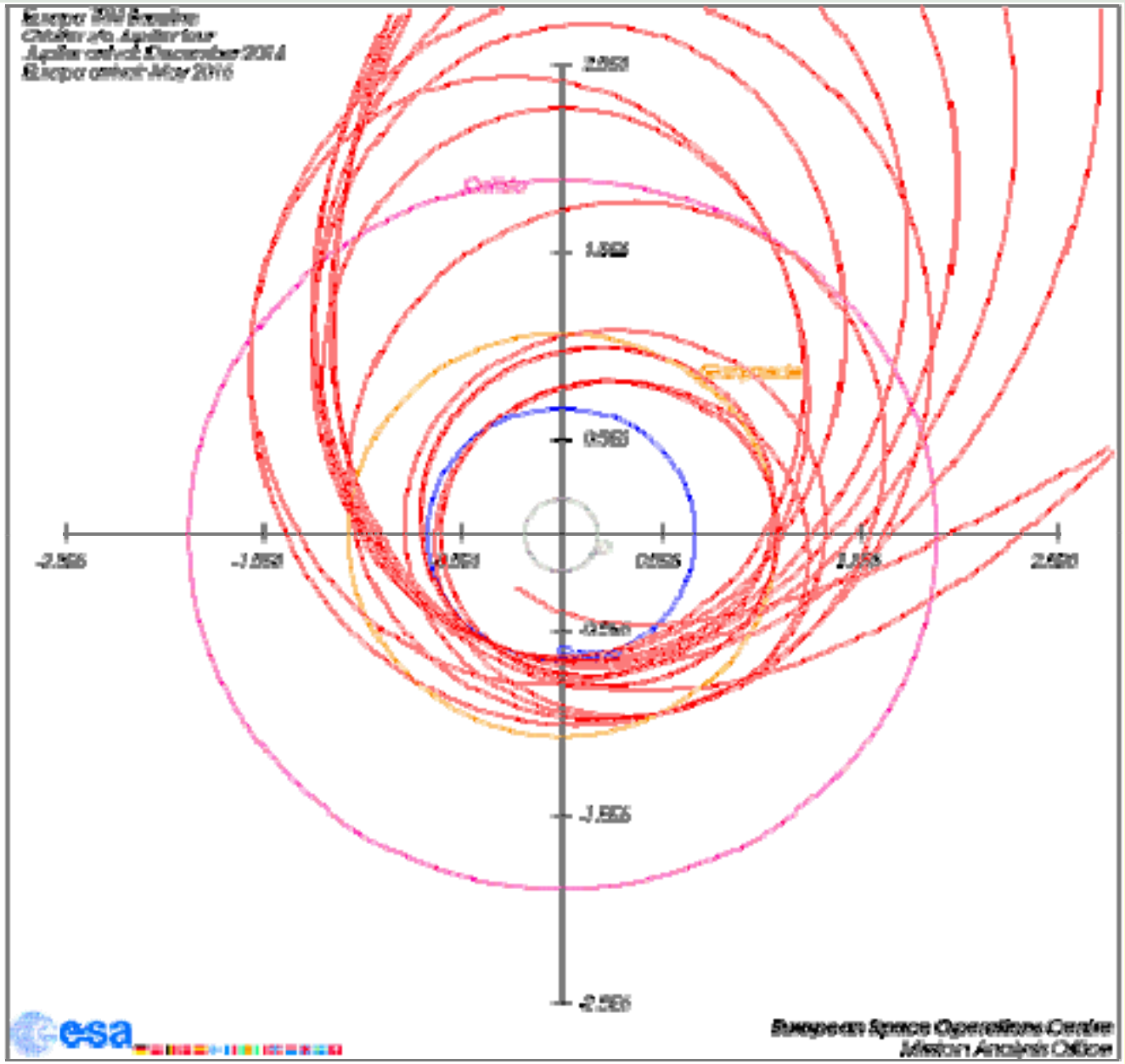
Mission Analysis (1)

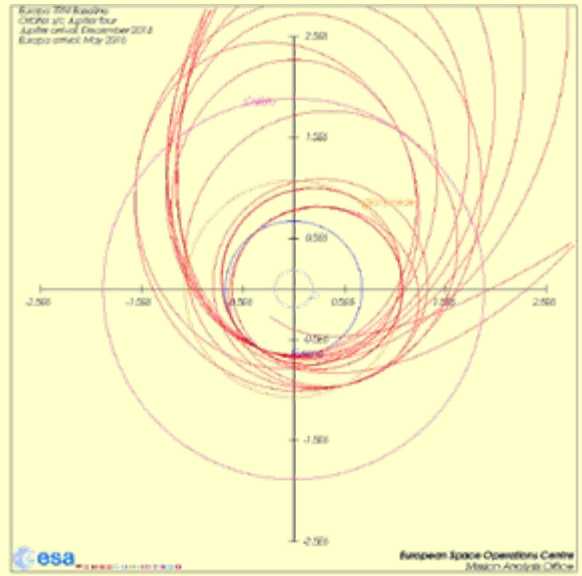


Launch Date	Total DV (m/s)	Duration (yrs)
19-Jul-10	2290	6.4
31-Jul-11	2380	6.2
21-Apr-12	1890	6.4
07-Oct-13	2300	6.2
01-Jan-17	2180	6
25-Jun-18	2240	9.1
08-Feb-20	2770	6.2
16-May-23	2140	6.2
26-Oct-24	2560	7.2
13-Aug-26	2210	6.1
20-Nov-29	2580	7.4

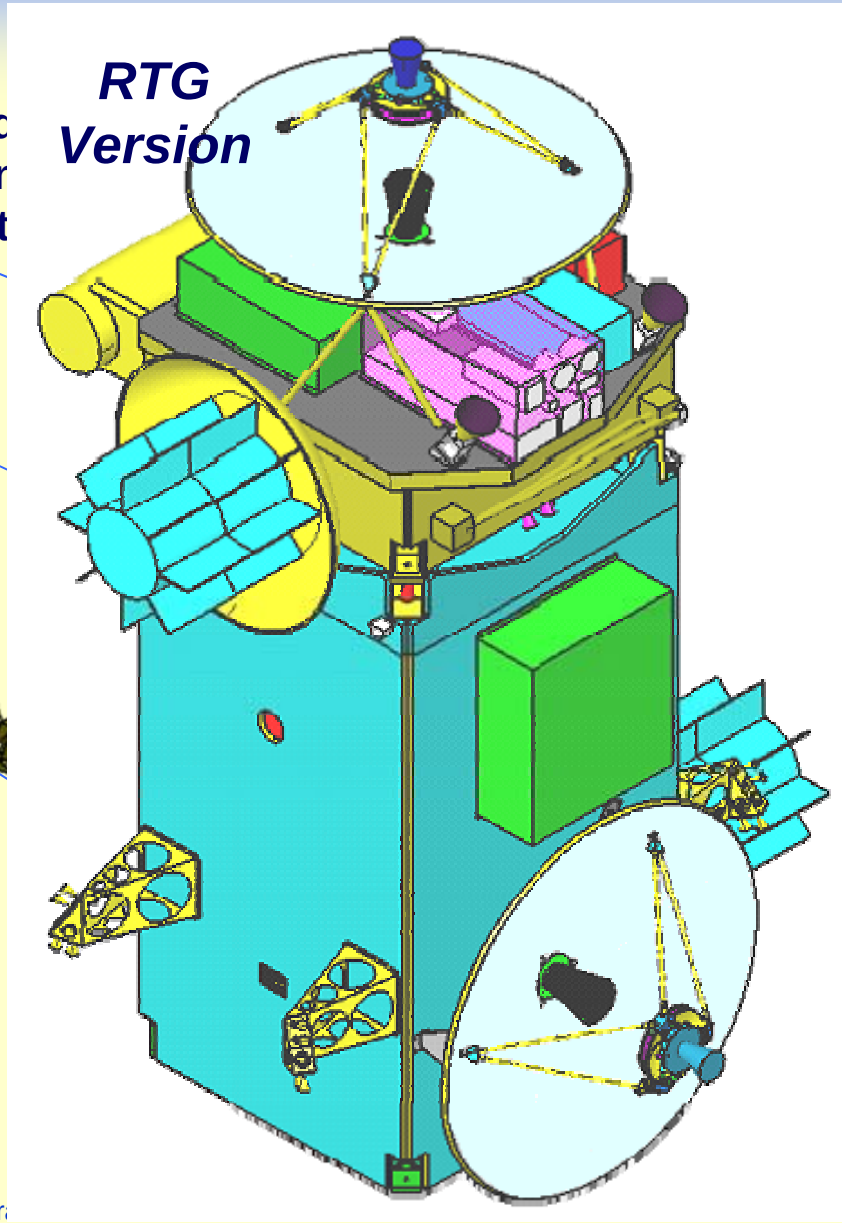


Mission Analysis (2)





S/C Configuration (1): Launch



Ground penetrating rad
(accommodation doesn
reflect present concept

Pyro bolts

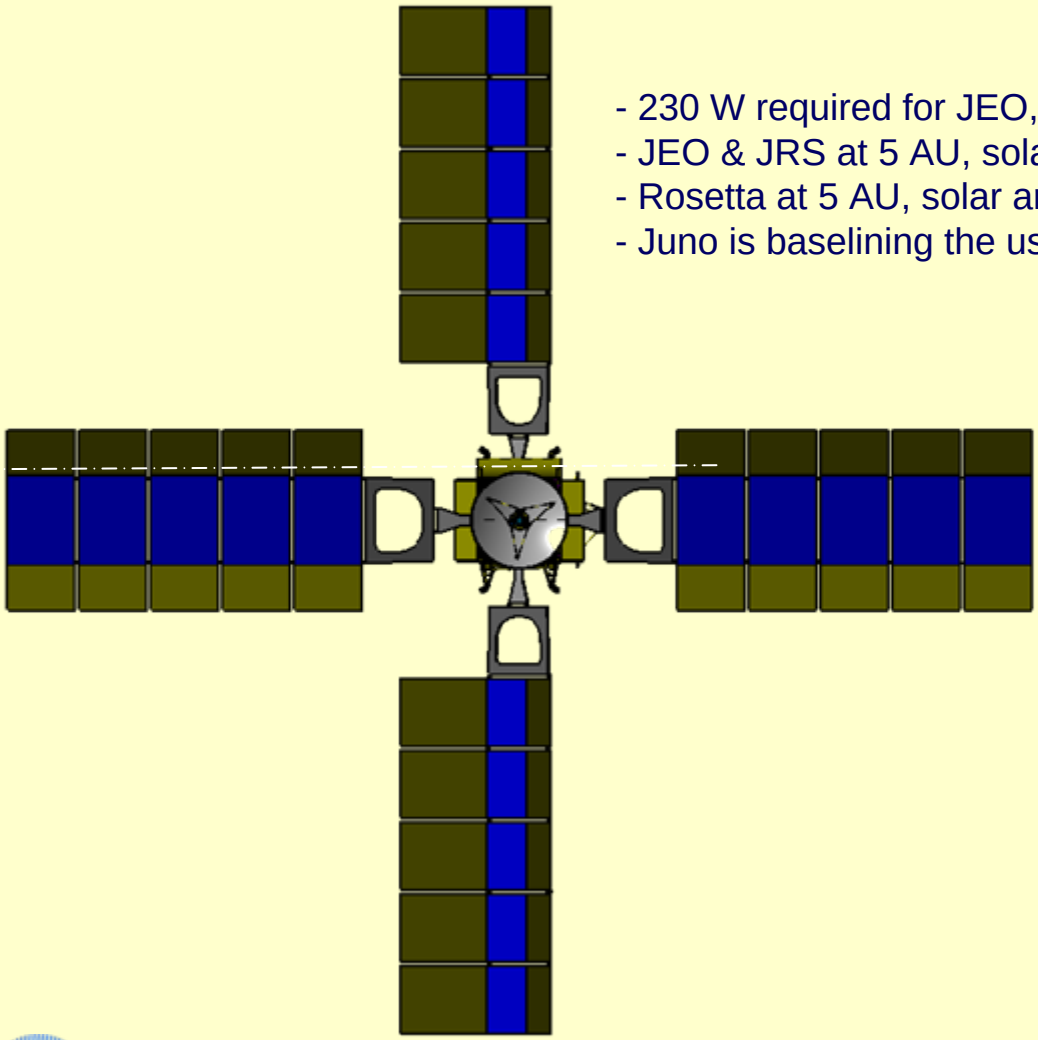
JRS volume for avionics
and science instruments

GA mounted on top HGA

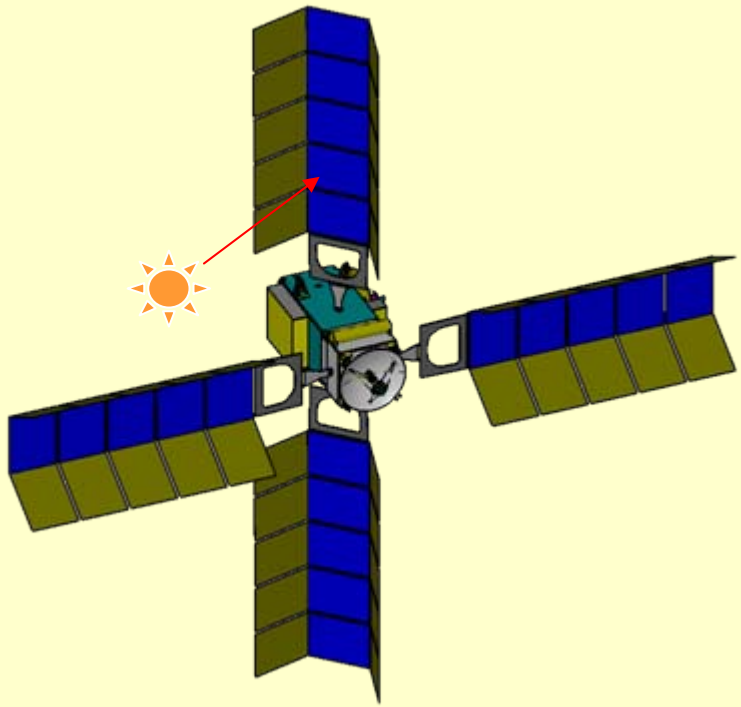
22N Leros 20H
thrusters

0N EADS-Astrium
thrusters

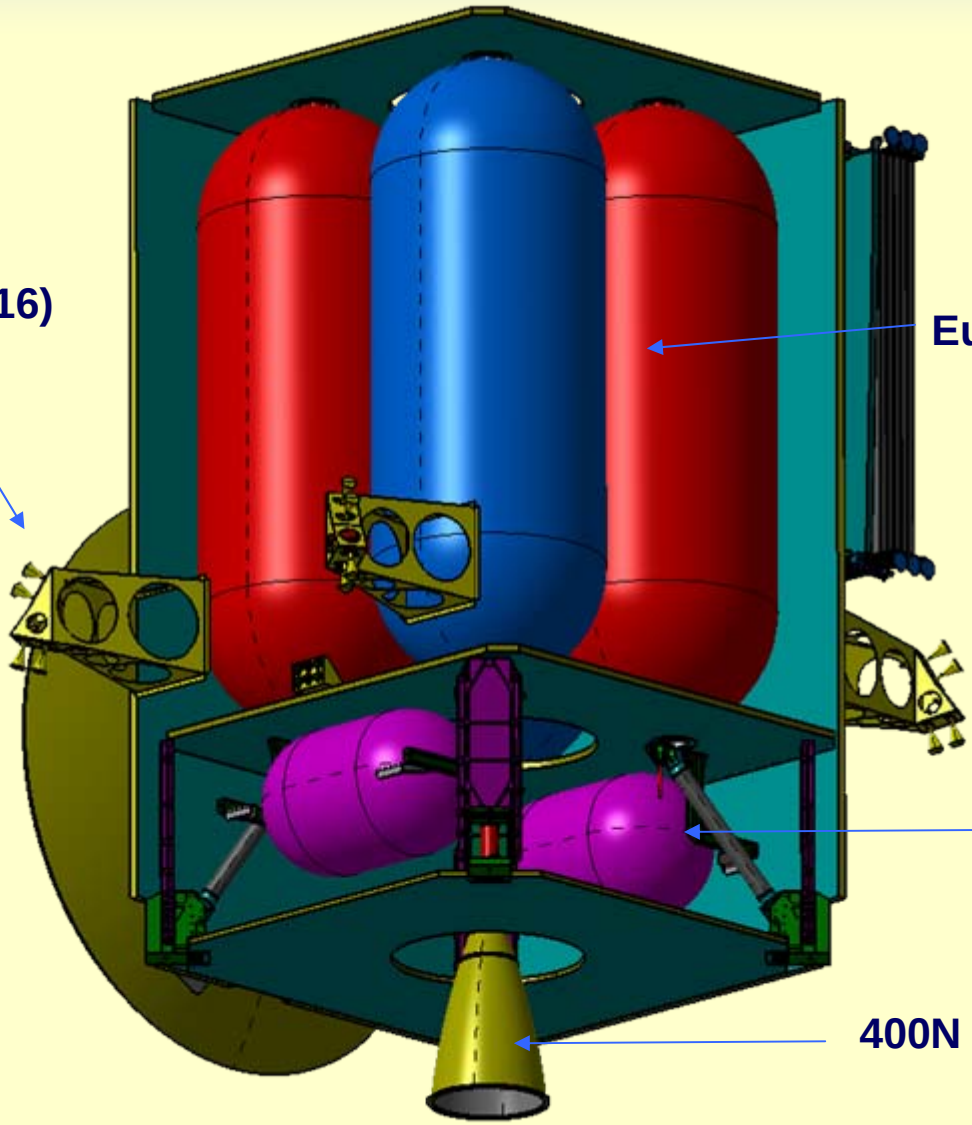
S/C Configuration (2): transfer configuration



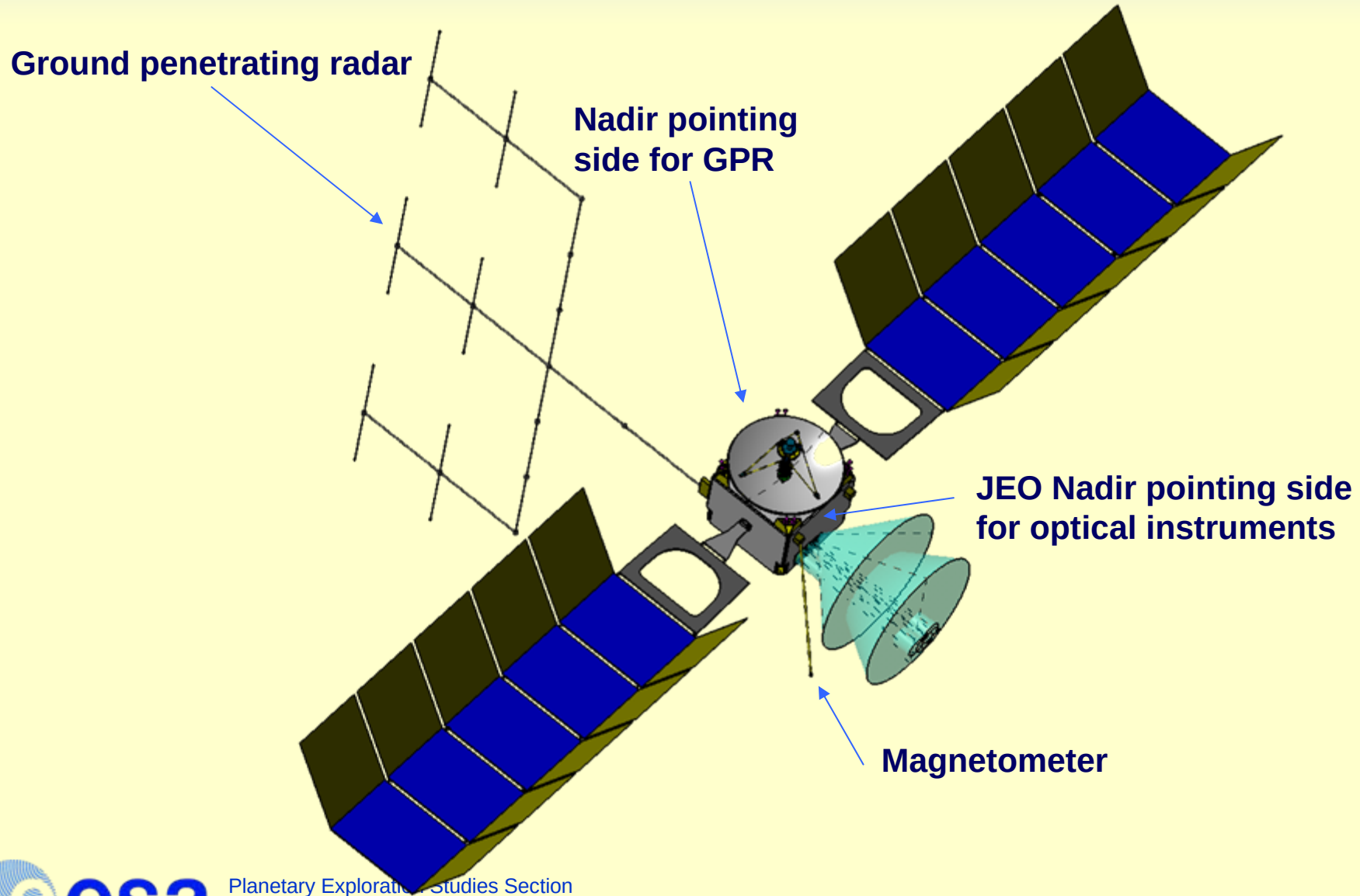
- 230 W required for JEO, 300 W required for JRS (EOL)
- JEO & JRS at 5 AU, solar array size~15 m^2 (each) (GaAs + concentrators)
- Rosetta at 5 AU, solar array size 2*32 m^2 (Si)
- Juno is baselining the use of Rosetta solar cell technology



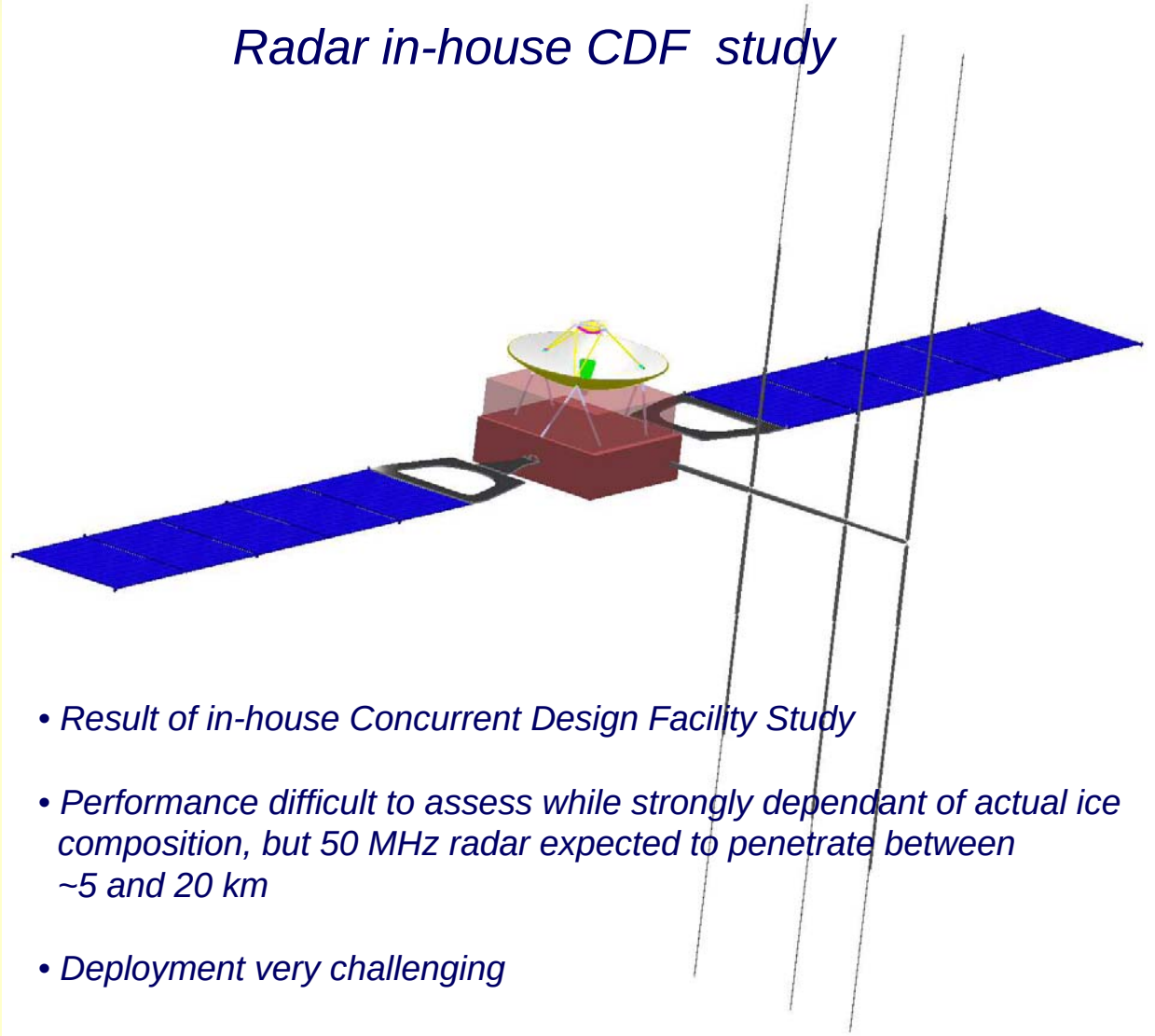
S/C Configuration (3): Relay Satellite propulsion system



S/C Configuration (3): JEO operational configuration

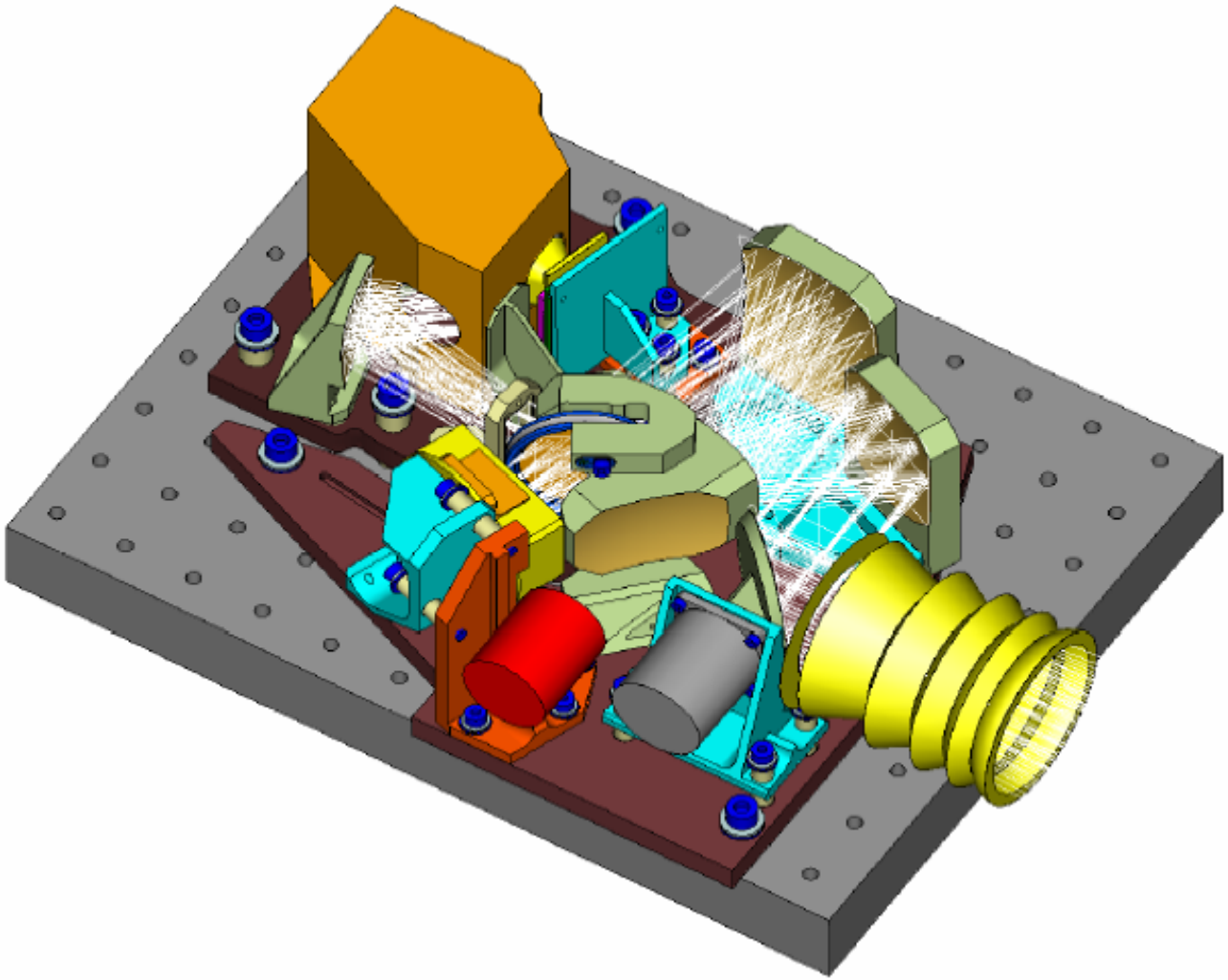


S/C Configuration (3): JEO operational configuration



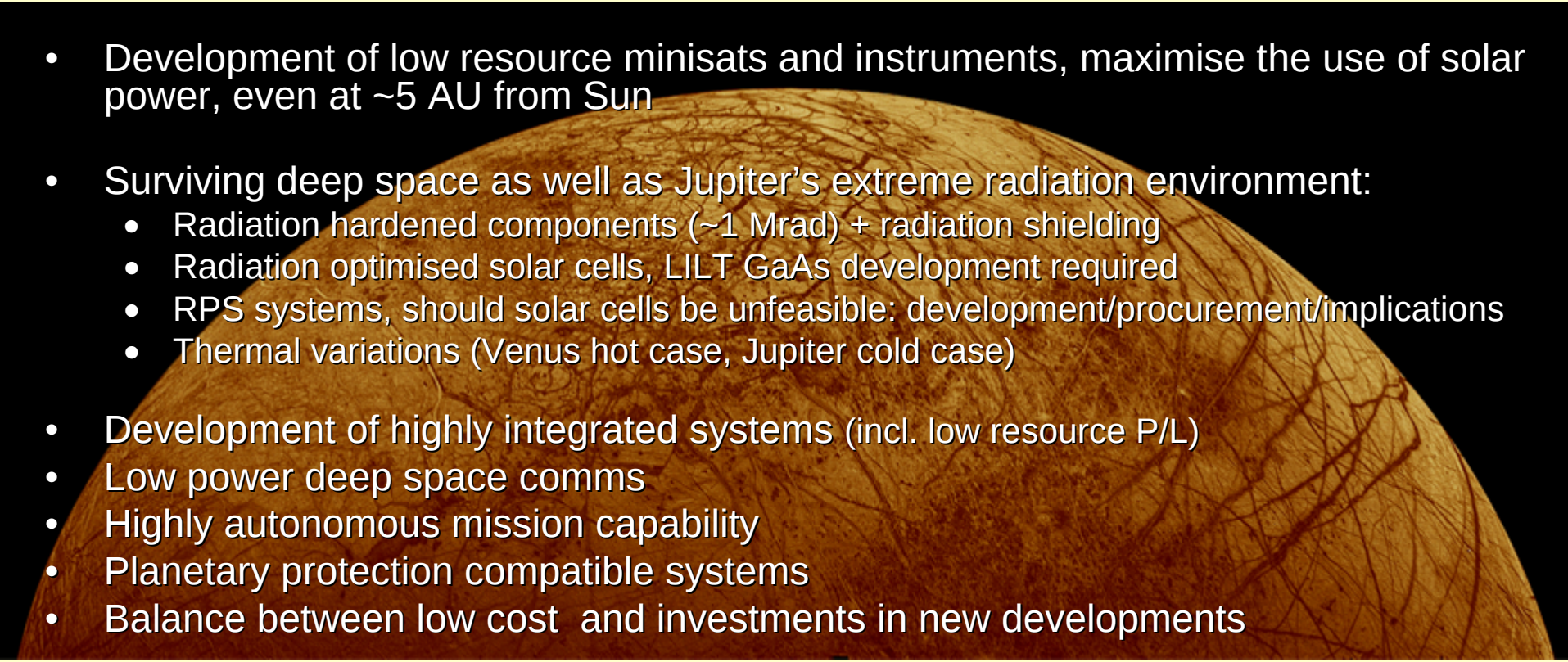
- *Result of in-house Concurrent Design Facility Study*
- *Performance difficult to assess while strongly dependant of actual ice composition, but 50 MHz radar expected to penetrate between ~5 and 20 km*
- *Deployment very challenging*

Highly Integrated Strawman Payload used in the study



Highly Integrated P/L Suite – Design Study and Bread Boarding

Main challenges for JME



- Development of low resource minisats and instruments, maximise the use of solar power, even at ~5 AU from Sun
- Surviving deep space as well as Jupiter's extreme radiation environment:
  - Radiation hardened components (~1 Mrad) + radiation shielding
  - Radiation optimised solar cells, LILT GaAs development required
  - RPS systems, should solar cells be unfeasible: development/procurement/implications
  - Thermal variations (Venus hot case, Jupiter cold case)
- Development of highly integrated systems (incl. low resource P/L)
- Low power deep space comms
- Highly autonomous mission capability
- Planetary protection compatible systems
- Balance between low cost and investments in new developments

➢ The technology development activities that are identified in these studies will have to be started soon should similar mission concepts be selected for the CV 1525

Current activities

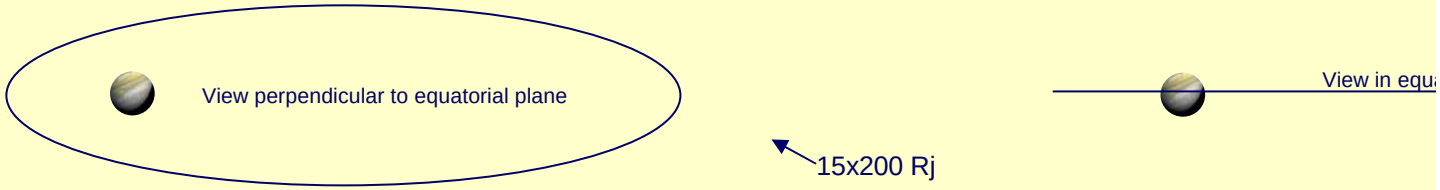
- Studying **additional Jovian study scenario's** in view of CV 2015-25 recommendations, e.g.:

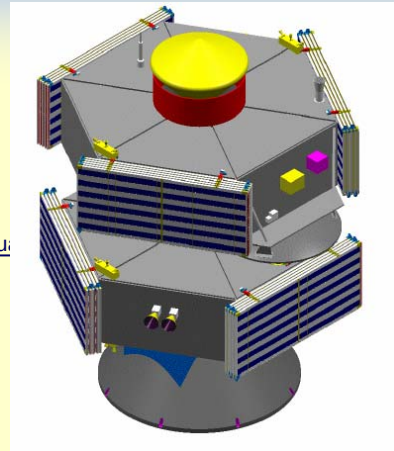
➢ **Jovian Magnetospheric S/C**
  - ➢ Magnetopause
  - ➢ Magnetotail
  - ➢ Poles (aurorae)

➢ **Jupiter Atmospheric Probes**
  - ➢ Up to 100 bar
  - ➢ Assess minimum configuration for relevant science
  - ➢ Assess feasibility of combining atmospheric probe with magnetospheric mission (EMC, stabilisation, etc.)

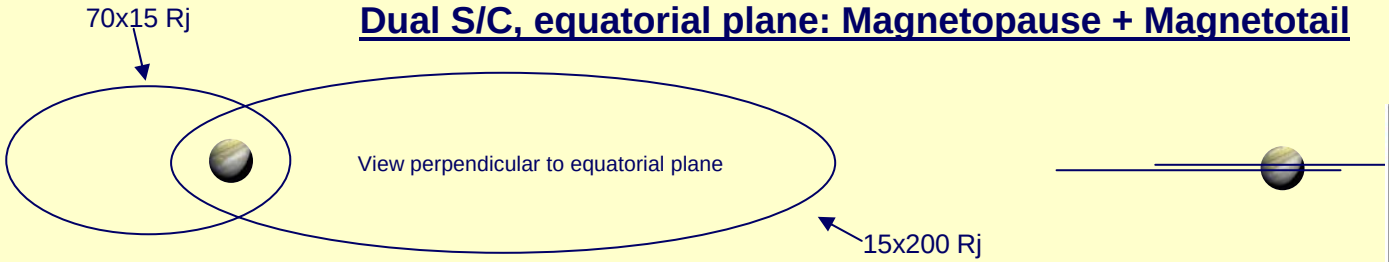
Considered magnetospheric mission scenarios

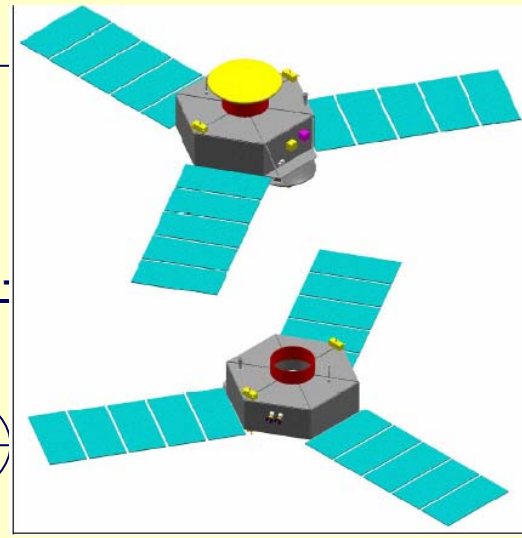
Single S/C, equatorial plane: Magnetotail



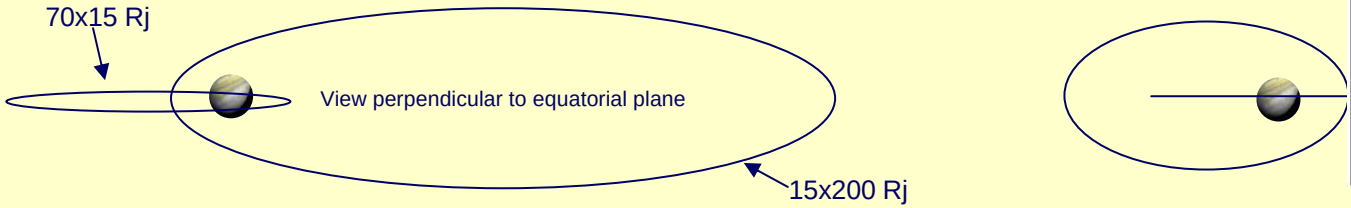


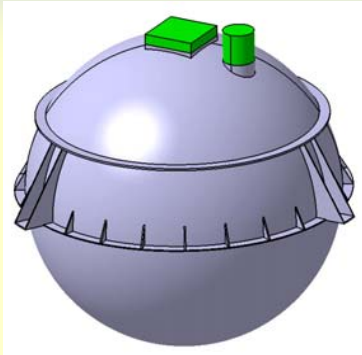
Dual S/C, equatorial plane: Magnetopause + Magnetotail





Dual S/C, equatorial and polar plane: Magnetopause + Magnetotail



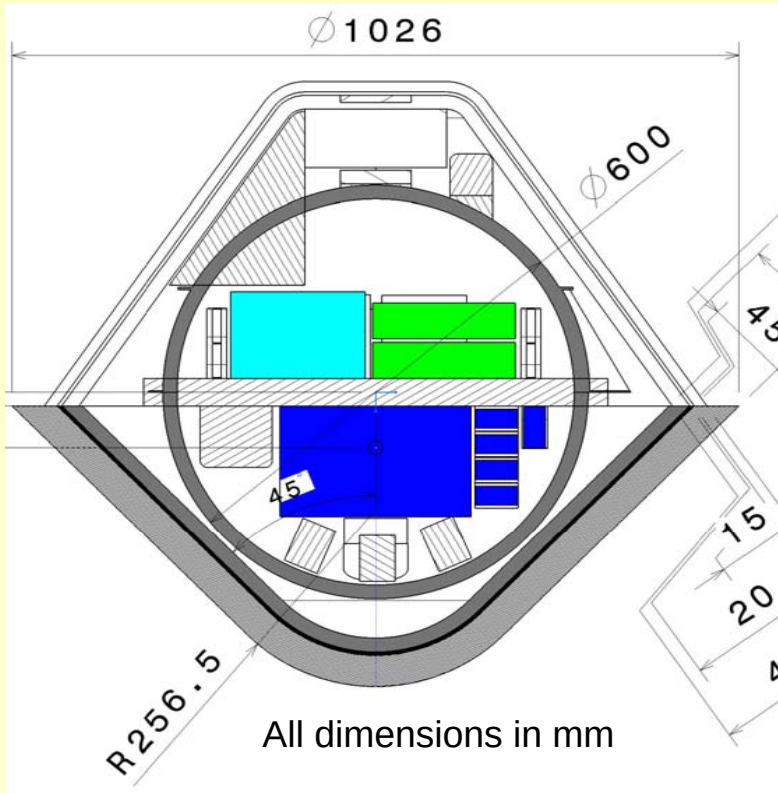


40 bar probe:

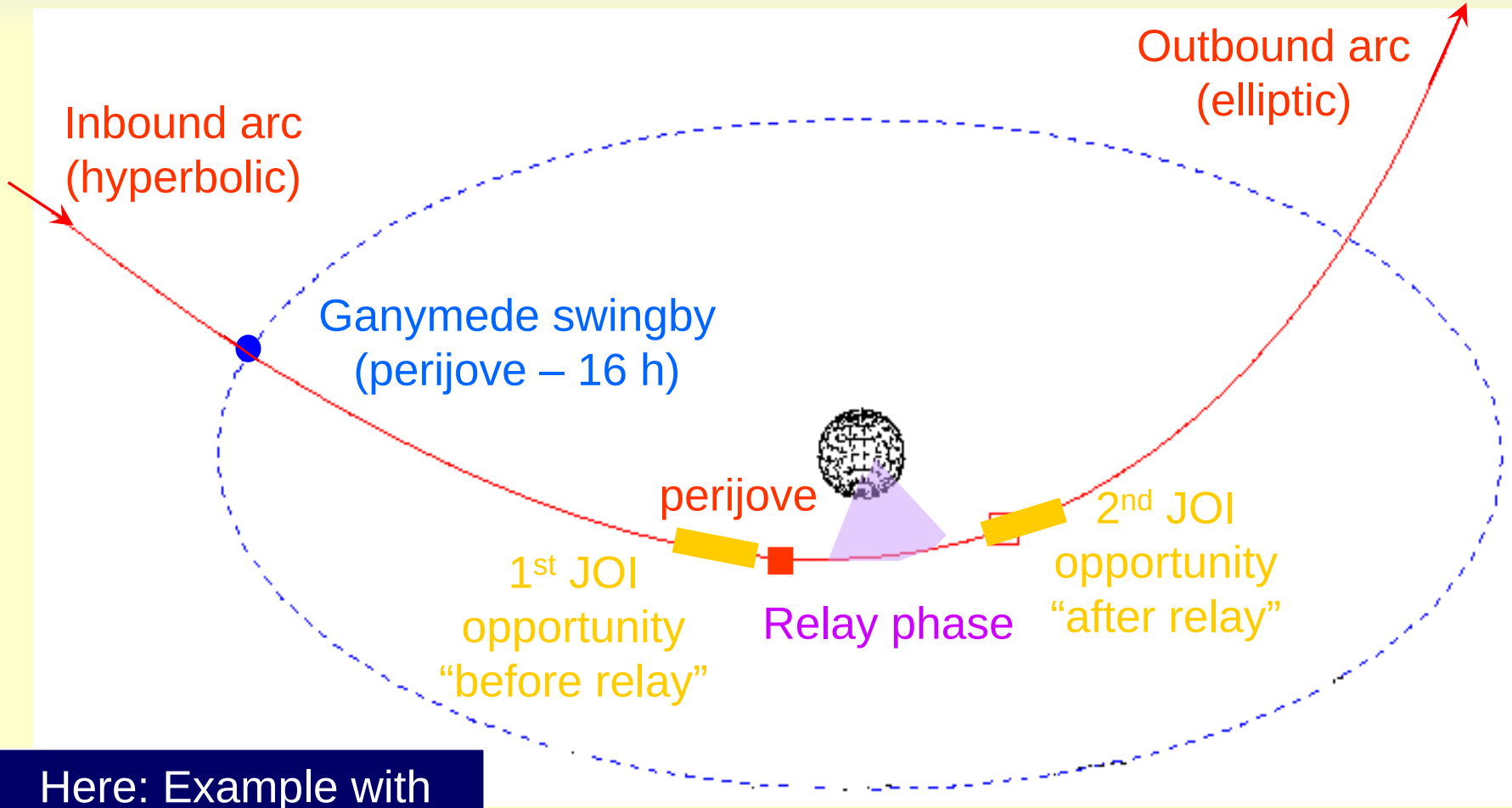
- Mass ~ 270 kg
- P/L resource ~ 12 kg, ~30 W (peak), ~350 bps
- Entry latitude between -7 and +3 deg
- Two probes + one orbiter
- Descent time = 1 hour
- Comms scenario complicated but should be feasible

100 bar probe:

- Mass > 320 kg
- P/L resource ~ 12 kg, ~30 W (peak), ~350 bps
- Entry latitude +3 deg
- One probe + one orbiter
- Descent time = 1 hour
- Variable power comms system to cope with very strong atmospheric attenuation (~23 dB)

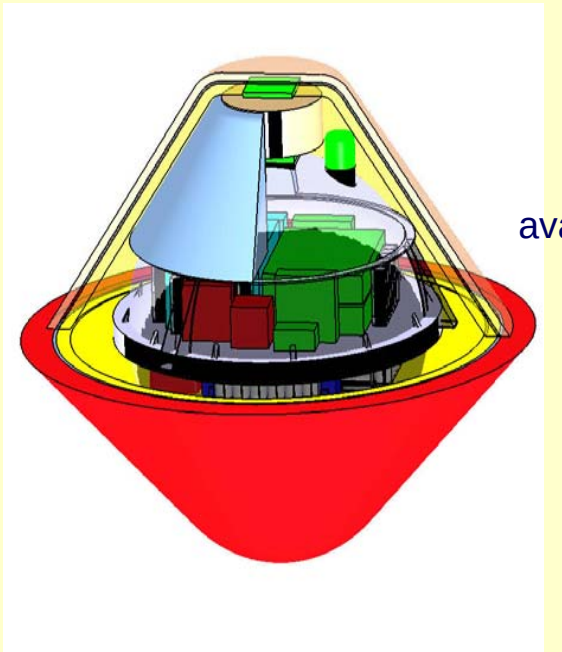


Swingby-Augmented JOI

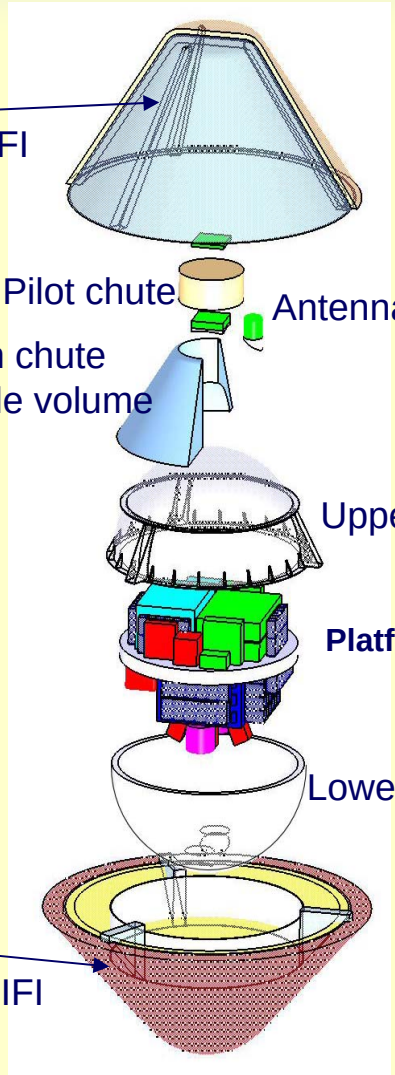


Here: Example with Ganymede swing-by

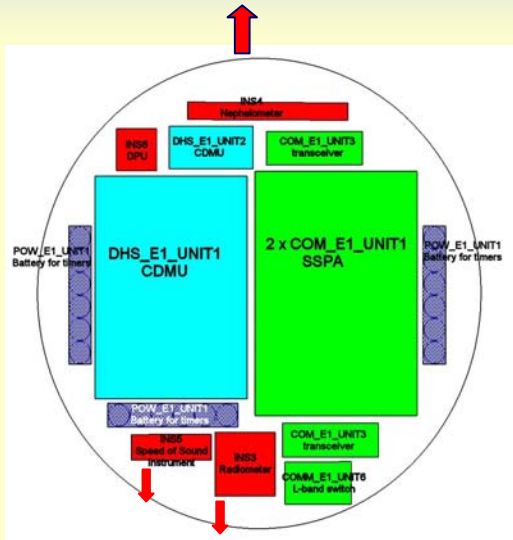
Accommodation

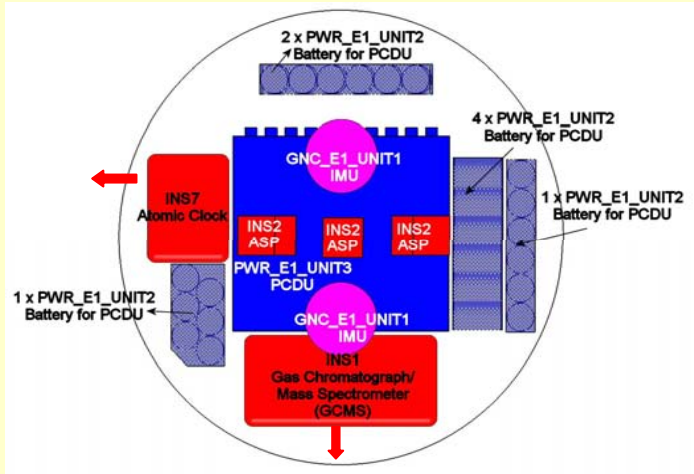


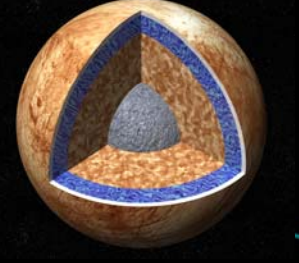
Back cover
3 layers: ablator, structure, IFI



Front shield
3 layers: ablator, structure, IFI







Thank You

Any Questions ?