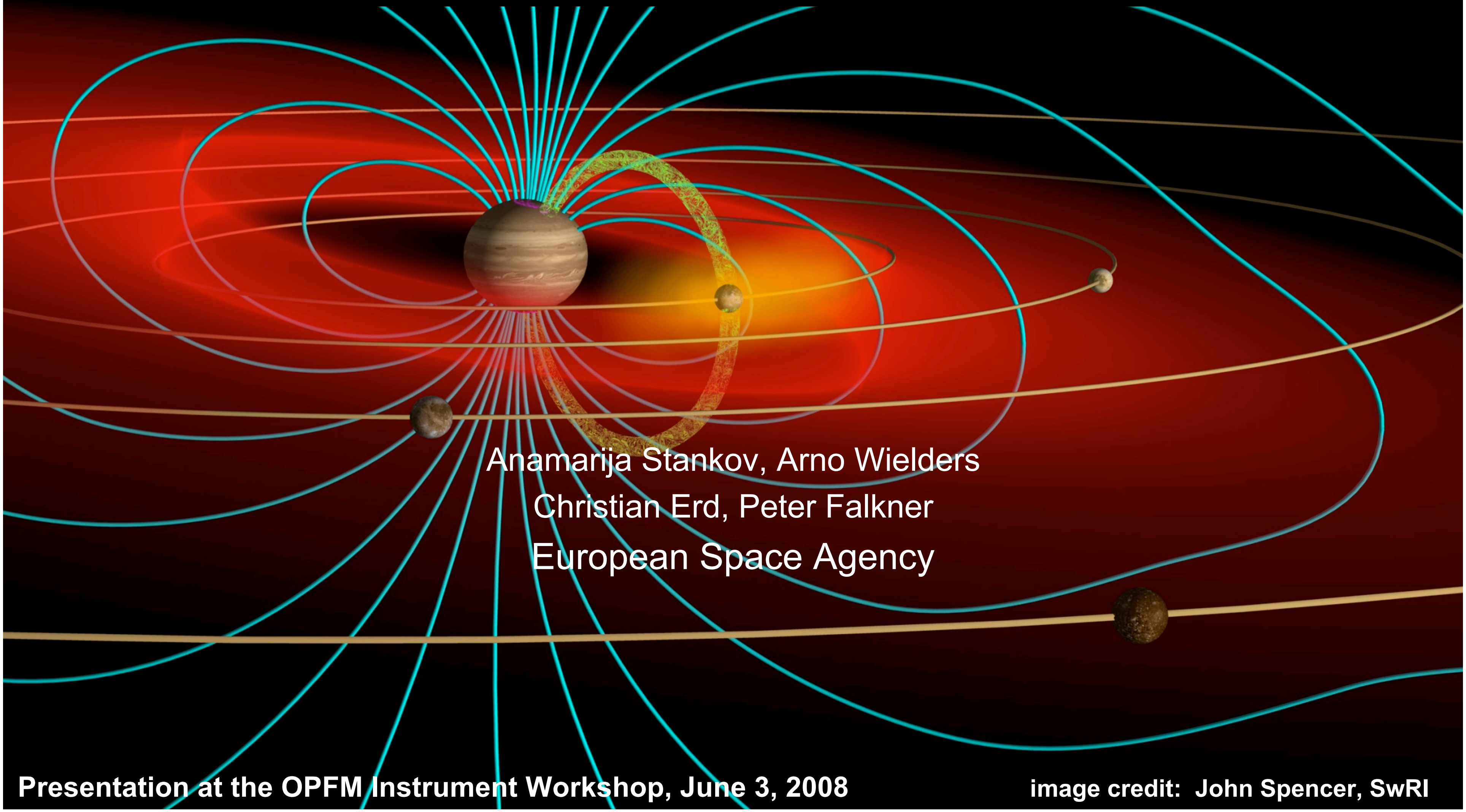
EJSM Jupiter Ganymede Orbiter
JGO



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Presentation at the OPFM Instrument Workshop, June 3, 2008

image credit: John Spencer, SwRI

Content

- Mission architecture and profile
- System engineering

- Payload constraints and summary description

- The JGO part of the EJSM is in a study phase and is designed using ESA's Concurrent Design Facility (CDF).

- The CDF study will finish June 16th, 2008.

- The content is of this presentation reflects work in progress.
- disclaimer: all figures may change

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Mission architecture - overview

- The Jupiter Ganymede Observer (JGO) is part of the international Europa/Jupiter System Mission (EJSM), developed in collaboration with NASA, ESA and JAXA.
- The mission consists of the following elements:
  - A Jupiter Europa Orbiter (JEO), assumed to be developed and launched by NASA.
  - A Jupiter Ganymede Orbiter (JGO), assumed to be developed and launched by ESA.
  - A Jupiter Magnetospheric Orbiter (JMO), assumed to be developed by JAXA; launched either by JAXA or possibly carried by JGO (TBC).
  - Possibly a Europa lander provided by Roscosmos.

Mission architecture -1

- Launch of JGO with Soyuz Fregat 2-1B from Kourou in time frame 2018 (backup 2020)
  - Option: launch with Ariane 5 and direct escape (more mass, higher cost)
  - Option: launch of JGO and JMO together (only A5 case, tbc)
- Chemical propulsion for transfer as baseline

Mission architecture - 2

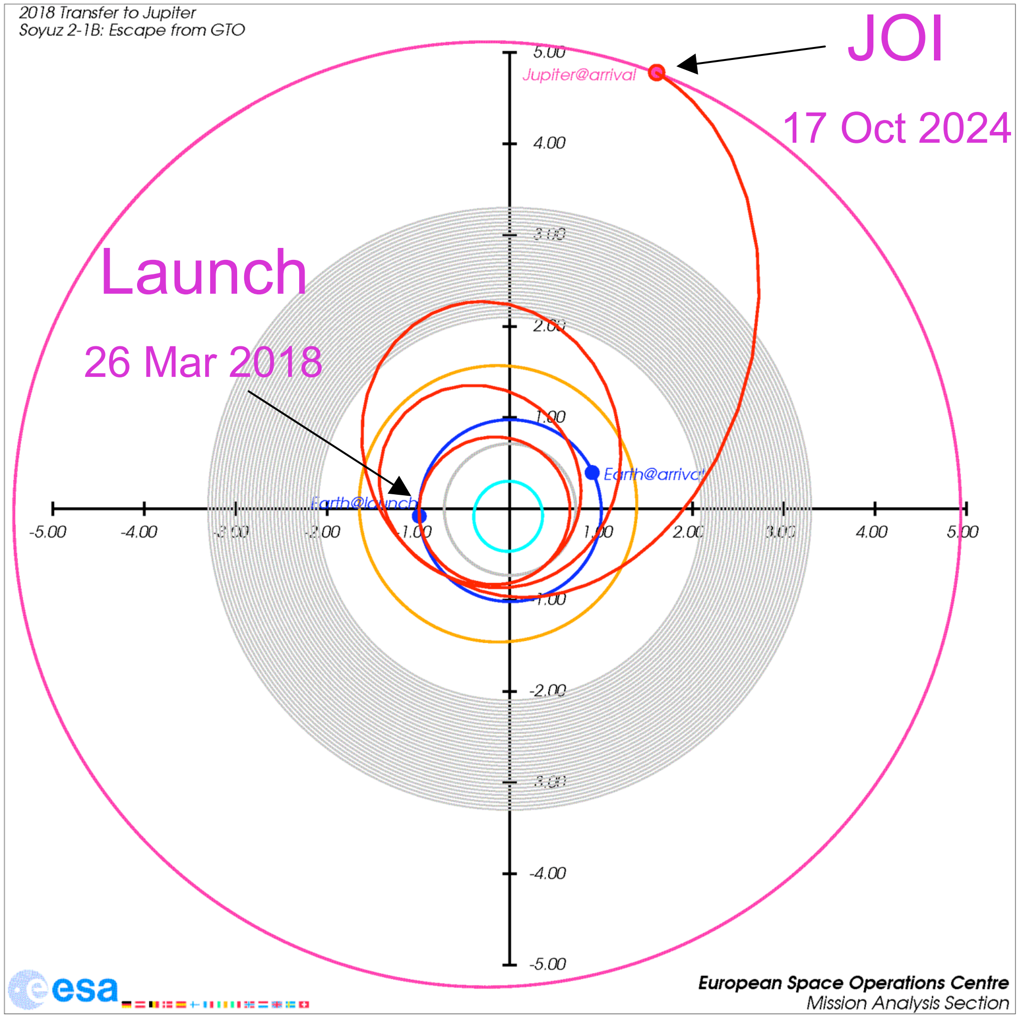
- VEEGA
  - SF-2B to GTO → escape to Venus
  - A5 direct to Venus
  - JOI via Ganymede (avoiding Io because of radiation)
- tour optimized for minimum radiation
- Jupiter tour with Callisto pseudo orbit
- Ganymede insertion followed by elliptical orbit (~200x2000 km) and circular orbit (200x200 km)

• Solar panels for power – LILT technology

Mission profile - phases

a) Phase 0: interplanetary phase ~6.5 years

1. Launch **26 March 2018**
2. Venus swing by on 14 Apr. 2019, altitude of 4992 km
3. Earth 1 swing by on 07 May 2020, altitude of 7148 km
4. Earth 2 swing by on 08 May 2022, altitude of 3985 km
5. JOI on **17 Oct. 2024**



PRE-DECISIONAL DRAFT— For planning and discussion purposes only

Mission profile - phases

b) Phase 1: from Jupiter arrival to first Ganymede gravity assist after Jupiter Orbit Insertion

c) Phase 2: orbit period reduction

d) Phase 3: from Ganymede to Callisto with low V-inf

e) Phase 4: pseudo-orbit around Callisto with science phase; different approaches for global coverage are studied

Mission profile - phases

f) Phase 5: from Callisto to Ganymede with low V-inf

g) Phase 6: Ganymede in-orbit science

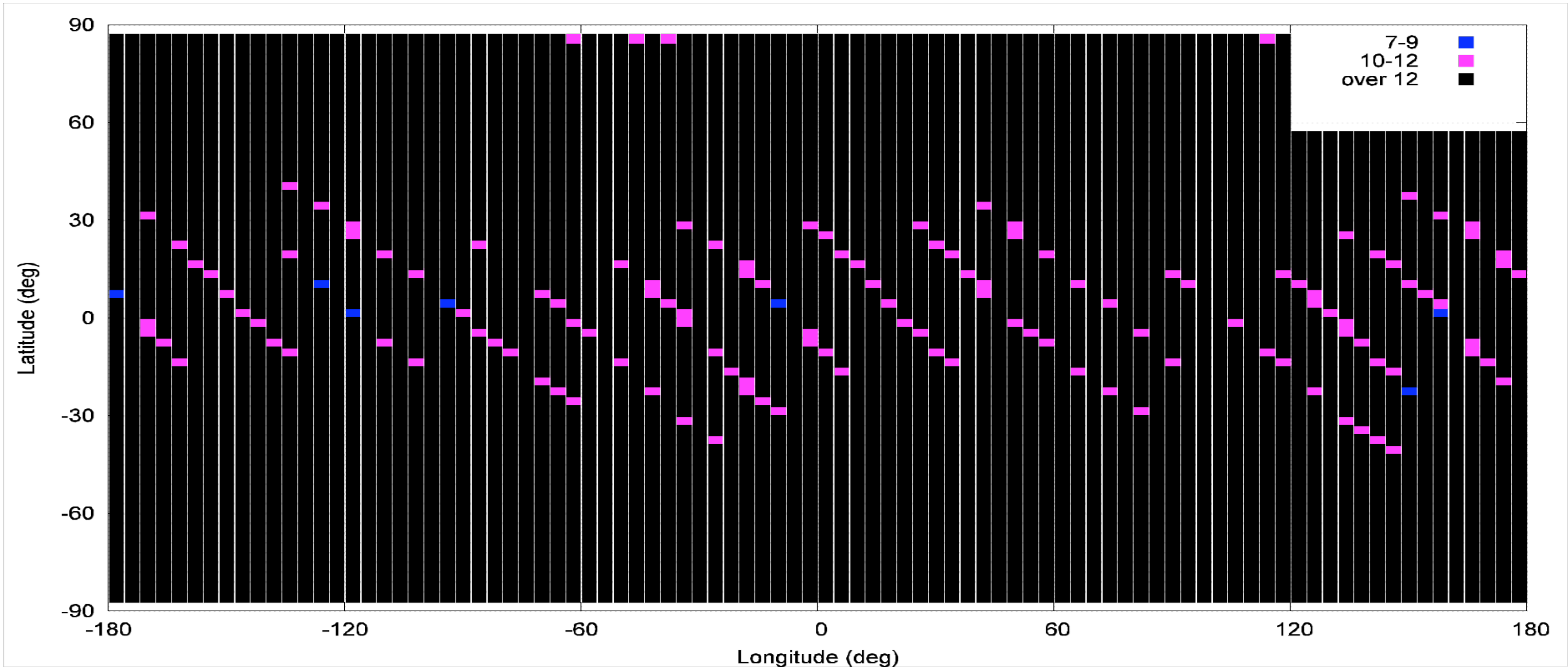
The **science phase at Ganymede** shall include:

– elliptical orbit (~200x2000 km) for mainly magnetic field analysis

– circular orbit (200x200 km) for remote sensing

Mission profile - phases

Global coverage of Ganymede during the elliptical orbit. Most regions are visited over 12 times. This figure refers to a 190 days observing phase.
Duration might be reduced due to radiation mitigation measures.



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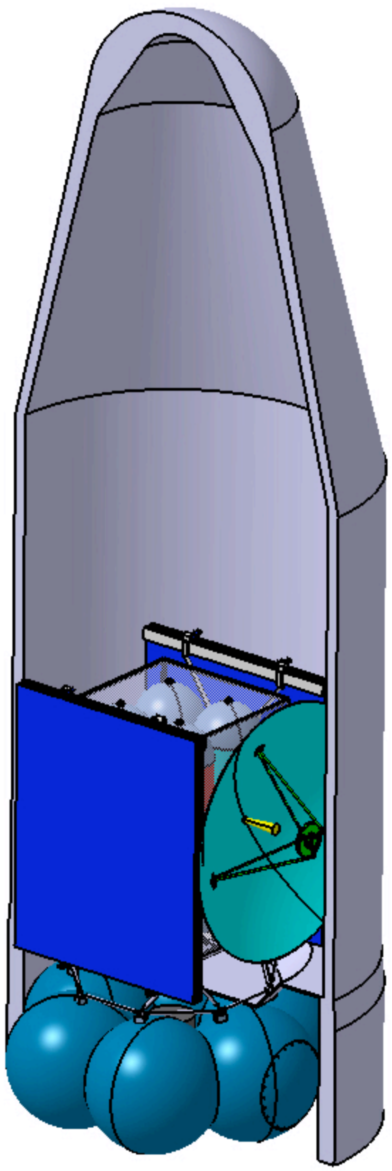
System engineering

- Launch configuration of JGO under Soyuz fairing
  - use Fregat for GTO insertion
  - transfer by S/C chemical engine to Venus
  - use of 4 large tanks
  - currently no further staging
  - folded solar panels
  - antenna (~2.6 m diam. tbc)



Currently identified key challenges

1. Power

    Solar power at Jupiter ~51 W/m^2; LILT technology:

    per 10 m^2 with assumption of 25% efficiency

    ➔ ~130 W available

    – goal: avoid concentrators

    – currently: panel sizing under discussion

2. Magnetic cleanliness

    for magnetic field measurements

Key challenges

3. Communication

- Current trade: necessary DoF for antenna pointing and size of the antenna
- Current figures (TBC): 65 W RF power, 2.8 m diam. antenna, and Cebreros station limited to ~40-50 kb/s.
- Alternatives to increase data volume:
  - use of more than one station for science phase (subject to availability)
  - Ka-band (some improvement, but also higher losses)
  - variable bit rate
- Ka band tentatively baselined

Key challenges

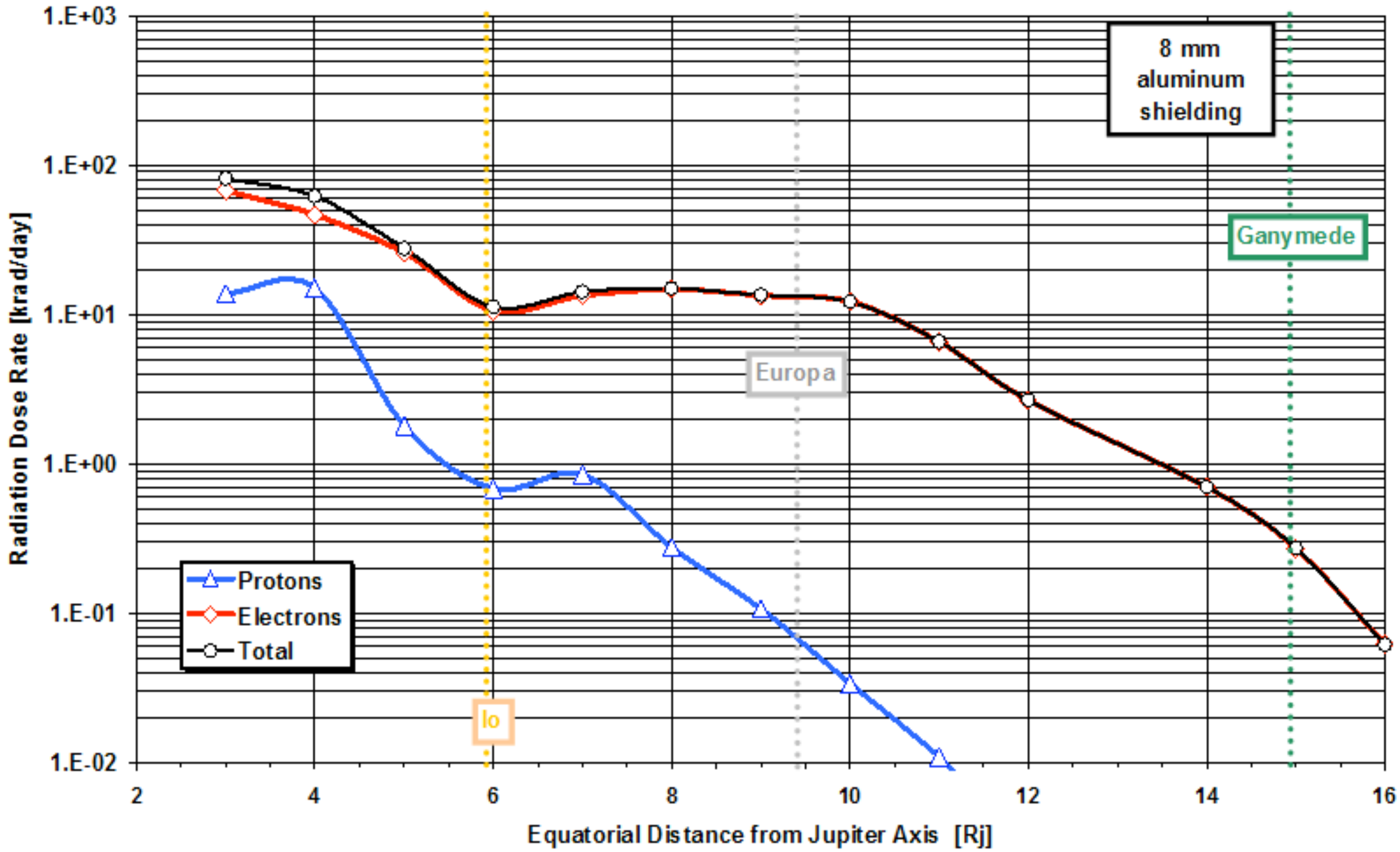
4. Radiation

Current total radiation dose estimate (w/o transfer) is ~152 krad. Goal is <50 krad (radiation margin 100% -> 100 krad max. dose).

<u>Mitigation strategies:</u>

- Reduce time in orbit around Ganymede
- Increase shielding
- Take shielding of Ganymede (body and magnetosphere) into account

Key challenges - radiation



Divine & Garret model used for calculation; note: 8mm Al shielding and dose calculated for a S/C at Ganymede distance; shielding by moon itself not taken into account.

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Planning Payload

- different options discussed
- 40 kg, 60 kg, 80 kg P/L with and w/o Ganymede orbit options
- sizing case for CDF study: 60 kg with Ganymede orbit
- goal to accommodate maximum P/L

Planning Payload - description

Camera package:
- two instruments: Wide Angle Camera and Medium Resolution Camera

Goal: imaging of Jupiter, large irregular moons and Ganymede/Callisto

MRC: Nadir pointing camera plus potential identical copy slightly looking forwards for stereo imaging FoV 14.7 degrees (along track)
Pointing stability: 1/3 of pixel IFOV is ~17 arcsec
Cross calibration with possibly NAC, spectrometers and laser altimeter

WAC: Nadir pointing, FoV: 117 degrees, 12 filters
Pointing stability: 1/3 of pixel IFOV is 2/3 mrad (~ 150 arcsec)
Cross calibration: NAC, spectrometers and laser altimeter

Planning Payload - description

Radio Science Package

- two instruments: transponder and ultra-stable oscillator (latter TBC)

Goal: measure gravity field of moons and determine possible existence of subsurface oceans through tidal response. With USO also atmospheric science can be done

Transponder:

- BepiColombo heritage; ranging in competition with data transfer.

USO:

- Venus Express heritage, extreme phase stability for measuring range to Earth. Needed for atmospheric sounding (TBC).

Planning Payload - description

Magnetometer

Goal: measure magnetic field of moons and Jupiter

- tri-axial fluxgate design
- residual magnetic field at sensor below 0.2 nT (tbc)
- boom length 2-3 times dimension of S/C (tbc)
- two sensors on boom

Thermal mapper:

Goal: map thermal emission and thermal inertia of moons, Io's total heat-flow and Jupiter atmospheric sounding

- 5-25 micron imager, bolometer array, pixel IFOV: 0.5 mrad (100 m ground resolution), nadir pointing total FoV: 6.9 degrees, 50 mm aperture
- absolute pointing: 80 arcmin, pointing stability of 10 arcsec/sec

Planning Payload - description

V/NIR imaging spectrometer

Goal: geologic mapping of the moons, composition, exosphere. Jupiter atmospheric composition and general circulation.

0.4–5.2 micron spectrometer, 3.4 degrees FoV, absolute pointing error: 0.5 arcmin, pointing stability: 6.5 arcsec/0.5 sec, co-alignment mounting knowledge 13 arcsec w.r.t reference, nadir pointing

Submm wave sounder

Goal: sounding of Jupiter's stratosphere

Heterodyne spectrometer: 2 bands around 557 and 1200 Ghz, movable mirror for limb and nadir sounding, cooling to 150 k needed, 27 cm telescope (goal 60 cm), nadir/limb viewing, total power 50 Watts (TBC); Herschel heritage

Planning Payload - description

Plasma Package
Combination of:

Sensor	**Name**	**Particle to measure**
Ion Mass Analyzer	IMA-1&2	Ions, 10 eV – 15 keV (mass resolution)
Electron spectrometer	ELS	Electrons, 10 eV – 15 keV
ENA imager (ENA)	ENS	ENAs, 10 eV – 3 keV
Energetic charge particle spectrometer	EPS	Ions, 10 – 1500 keV (mass resolution) ENAs, 10 – 1500 keV
Langmuir probe (LAP)	LAP	Cold (Te < 10 eV) plasma

Preferred location: Main unit: nadir plane; IMA-1 anti-nadir plane.
Power 25 W; mass 7.7 kg; pointing stability and knowledge better than 1 degree FoV : 90 by 360 degrees
Langmuir probe on a 50 cm (min) length boom (TBC).

Planning Payload - description

Micro laser altimeter

Goal: measure topography of the moons; digital elevation maps

- range accuracy 1 m, laser spot footprint: 20 m, nadir pointing, high frequency low power system, cross-calibration receiver/emitter. New development; low TRL.

UVIS UV spectrometer

Goal: Jupiter aurora measurement; identification of key elements on surface of moons.

-heritage from BepiColombo PHEBUS instrument, spectral range; 50-320 nm with two detectors; EUV: 50-130 nm and FUV: 130-320 nm

Ion Neutral Mass Spectrometer

- mainly to measure isotopic ratios of elements of Europa atmosphere

Planning Payload - description

Radar

Goal: measure subsurface structures of the moons

- SHARAD like design; dipole tip-to-tip length of 9 meters, active radar sounding; FoV 1km by 10 km; spectral range: 20 to 50 Mhz; 12 kg and 20 W power. Data-rate ~220 kbps (tbc); penetration depth < 5 km with 10 m vertical resolution

Narrow Angle Camera

Goal: high-resolution mapping of the surface of moons, monitoring of Io and Jupiter

- 20 cm aperture, pointing stability of 1/3 pixel over 0.5 sec: 1/3 arcsec over 0.5 sec (stringent), spectral range: 350-1050 nm, FoV: 0.29 degree, large focal length of 3 meters, nadir pointing, TE cooler of 2 W

Payload constraints

- Thermal constraint

  Venus fly-by hot case - science phase at Jupiter cold case

- Radiation constraint

  Radiation tolerance of P/L components needs to be ensured; goal: 100-150 krad incl. margin

- Power constraint
  - eclipse cases
  - operational timeline

- Pointing constraint for NAC <1 arcsec