EJSM/JGO Mission Overview

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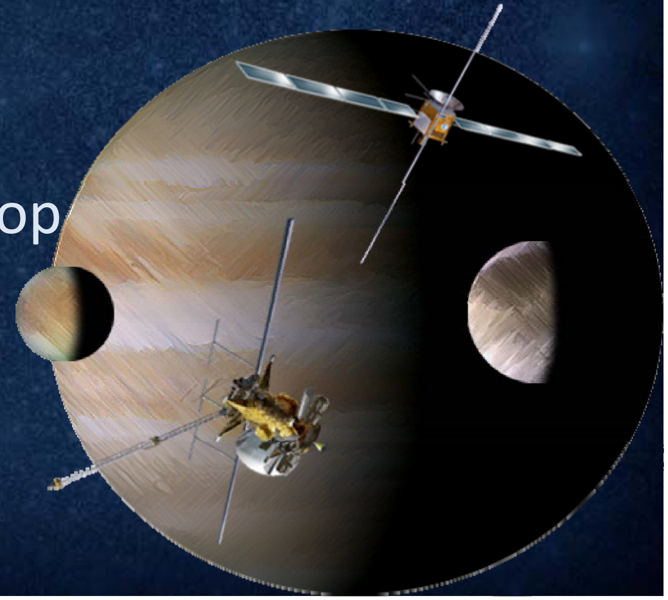
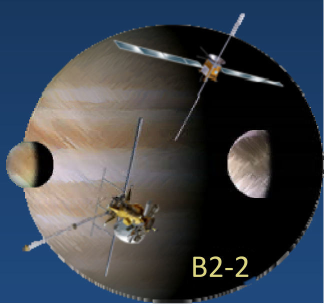
EJSM Instrument Workshop
July 27-29, 2010



JGO Spacecraft Key Properties

- Dry mass ~1690 kg, propellant mass ~2900 kg
- Planning payload 104 kg, ~120–150 W
- 3-axis stabilized s/c
- Power: GaAs LILT solar cells array (>60 m^2)
- HGA: >3 m, fixed to body; X/Ka-band, switching data rate
- High Δv requirement, high mass amplification, complex navigations
- Mission lifetime: 9 yrs; 6 yrs transfer
- Thermal: Venus flyby, Jovian system
- Challenges
  - Radiation environment; 150 krad (shielded)
  - Performance of GaAs LILT cells

Configuration ESA CDF, 2008



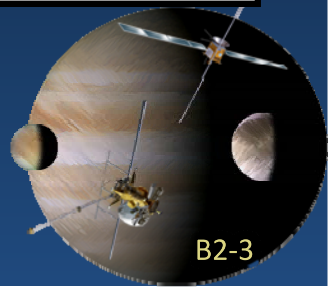
Launch Mass Constraints

Designing to maximum separated mass

Launch Date	Launch Mass	Dry Mass	Propellant Mass	Transfer Duration
March 2020	4172 kg	1687 kg	2425 kg	5.9 yrs
June 2021	3643 kg	1498 kg	2092 kg	6.9 yrs
May 2022	4641 kg	1701 kg	2872 kg	7.1 yrs
June 2023	3834 kg	1541 kg *)	2238 kg	6.6 yrs
August 2024	3871 kg	1520 kg *)	2295 kg	7.2 yrs

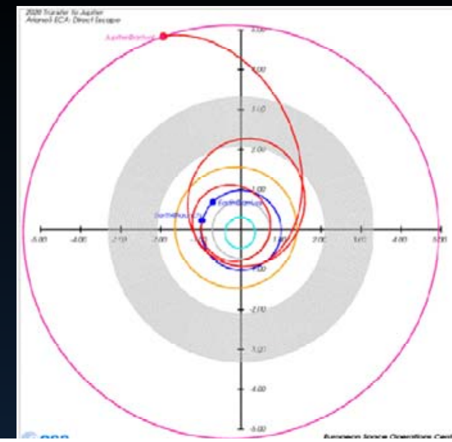
*) higher dry mass possible with longer interplanetary transfer times

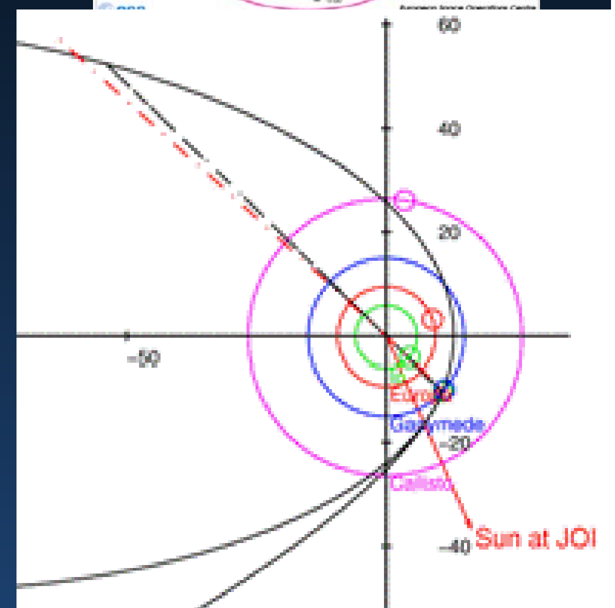
Design point

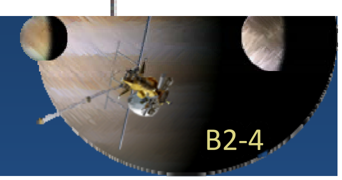


JGO Baseline Mission Profile

- Interplanetary transfer
  - Launch 2020
  - VEE Gravity Assist (Venus: 1 Jul 2020, Earth: 27 Apr 2021, Earth: 28 Jul 2023)
  - 5.9 years transfer, Δv = 195 m/s
  - Jupiter arrival: 4 Feb 2026
- Jupiter orbit insertion (230x13 RJ) and energy reduction (165 + 120 days; Δv = 990 m/s)
- Transfer to Callisto (57 days; Δv = 56 m/s)
- Callisto resonances: >9 swing-bys (240 days; Δv ≥ 90 m/s)
- Transfer to Ganymede polar orbit (85 days; Δv = 187 m/s)
- Ganymede elliptical phase 10,000x200 km & 5000 km circular (120 days; Δv = 397 m/s)
- Ganymede circular phase: 400 km (180 days; Δv = 530 m/s)
- Ganymede de-orbit (Δv = 40 m/s)
- Total mission duration: 9 years

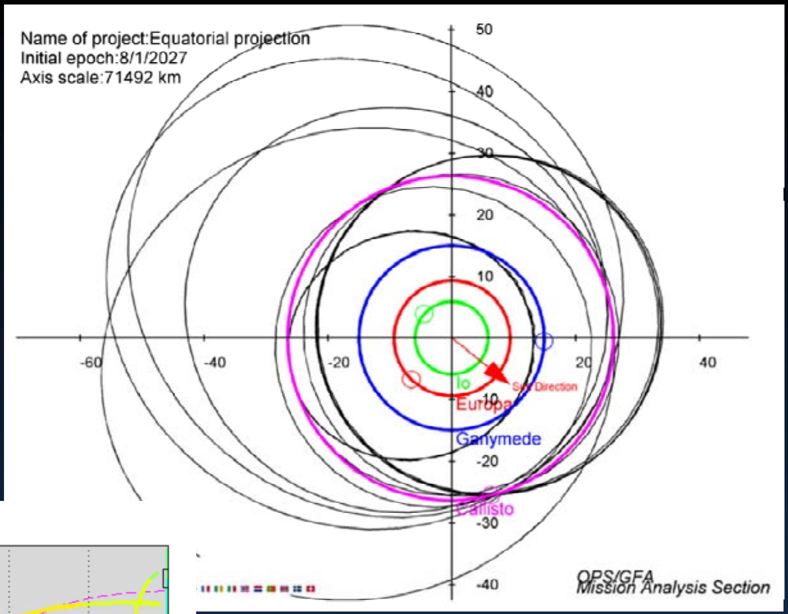


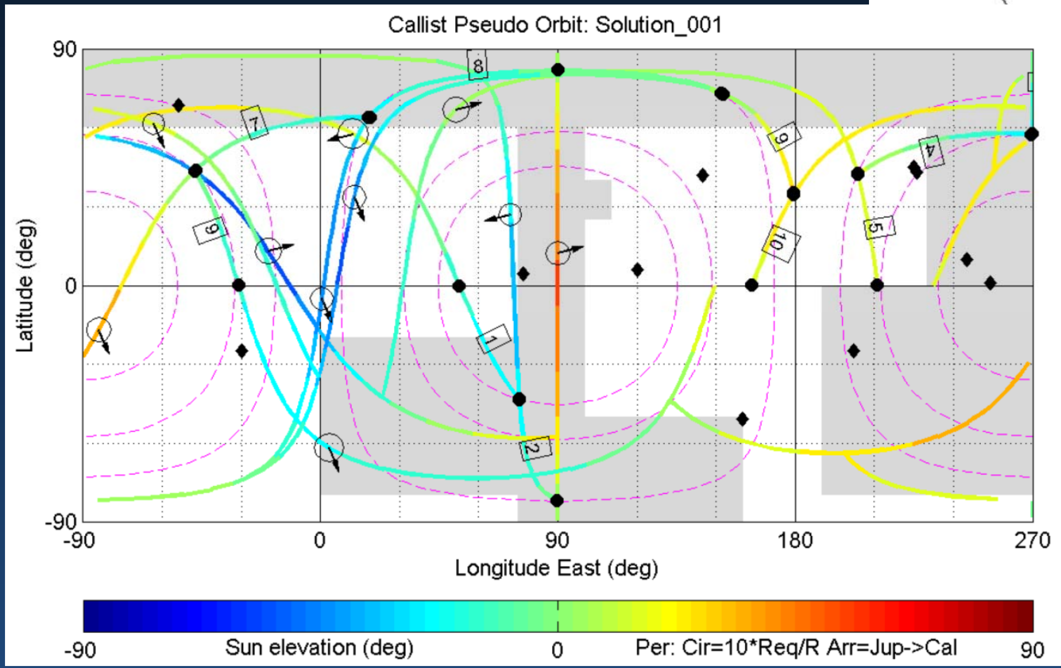


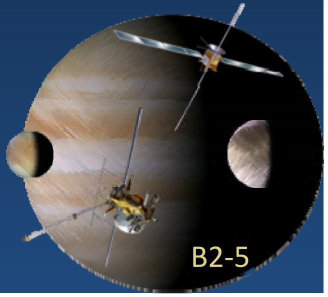


Callisto Flyby Phase

- Resonant orbit with Callisto (1:1)
- 9 flybys, each 200 km altitude

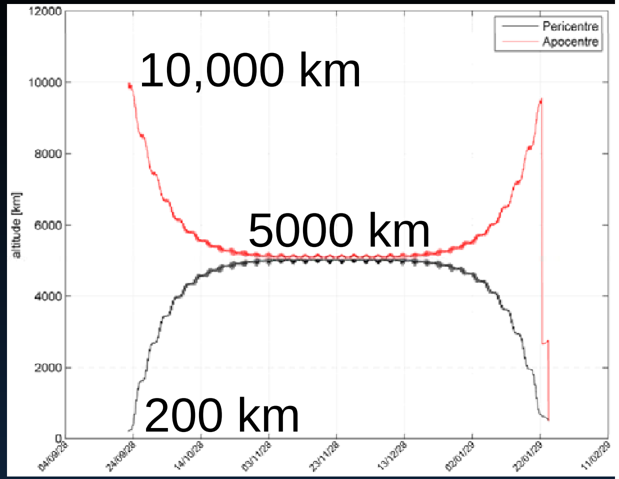




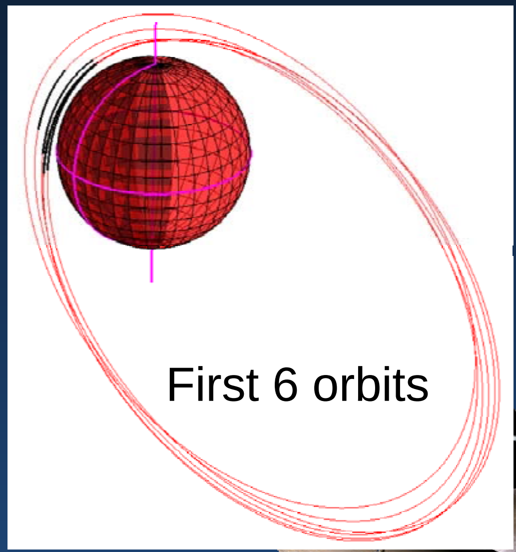


Ganymede Orbit Phases

- Driven by
  - Avoiding sun eclipses
  - Low altitude
  - Declination of the sun to orbital plane (β angle) is drifting towards higher values

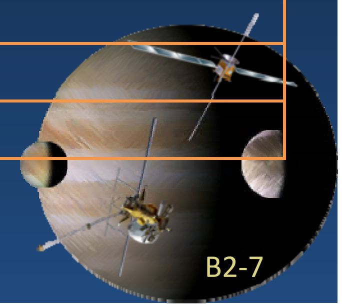


Phase	Pericente Altitude [km]	Apocenter Altitude [km]	β Angle [deg]	Duration [days]
Elliptical	200	10,000	30	120
High Circular	500	500	60	120
Low Circular	200	200	76	60
End	200	200	84	n/a



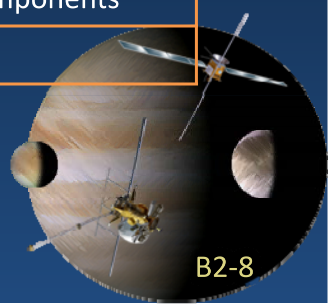
JGO Model Payload

Instrument	Acronym	High level description
High Resolution Camera	HRC	Spectral range: 350–1050 nm, 12 filters, IFOV: 0.005 mrad
Wide Angle Camera	WAC	Wide: 12 filters Framing, IFOV: 2 mrad
Plasma Package (includes part of INMS)	PLP	Plasma Analyzer Electrons: 1 eV – 20 keV, Ions: 1 eV – 50 keV Particle Analyzer: Electrons: 15 keV – 1 MeV Ions: 3 keV – 5 MeV, ENA: 10 eV – 10 keV Thermal plasma number density (Te < 10 eV)
Radio and Plasma Wave Instrument	RPWI	Plasma Wave: electrons, ions Electric & magnetic field vector, QTNS
Magnetometer	MAG	Dual tri-axial fluxgate sensors
Visible and infrared Hyperspectral Imaging spectrometer	VIRHIS	Pushbroom imaging spectrometer with two channels with scan system, Spec. range: 400–5200 nm, Spec. res: 2.8 - 5 nm
Submillimeter Wave Sounder	SWI	2 channels: Spec. range: 550–230 µm FOV: 0.15° – 0.065°
Radio Science Instrument	JRST	2-way Doppler with Ka-Band transponder
Ultrastable Oscillator	USO	Ultra-stable Oscillator
Ultraviolet Imaging Spectrometer	UVIS	EUV and FUV + MUV grating spectrometers Spectral range: 50–320 nm
Laser Altimeter	LA	Single Beam @ 1064 nm, 10 m spot @ 200 km 175 Hz pulse rate
Subsurface Radar	SSR	Single frequency: 20–50 MHz, Dipole antenna: 10 m



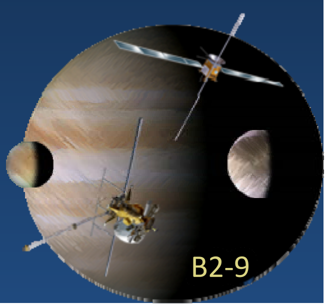
JGO Additional Items

Instrument	High level description
X-band tranceiver	Ranging & occultation applications in close collaboration with JEO
Radiation Monitor	Verification of radiation environment models (during complete mission) & potential warning system for intense radiation events
Mechanisms	**High level description**
Radar Antenna (1)	10 meter long antenna for Subsurface radar potentially accommodating RA-PWI (electric component of high frequency plasma waves) of RPWI
MAG boom (1)	~ 5 m boom accommodating two MAG sensors and SCM of RPWI
RPWI-LP-PWI Langmuir probe booms (4)	~ 2-3 m long booms accommodating Langmuir probes
RPWI-RWI booms (3)	~ 2 m long booms acting as electric monopoles measuring radio waves
Shielding	**High Level description**
Spacecraft	Standard spacecraft structure acts as shielding (highly dependent on location on or inside S/C)
Equipment level	Box shielding; overall box shielding to reduce dose within
Component level	Dedicated component shielding for specific medium radiation sensitive components
Part level	Spot shielding application; highly specific shielding (e.g., bi-polar)



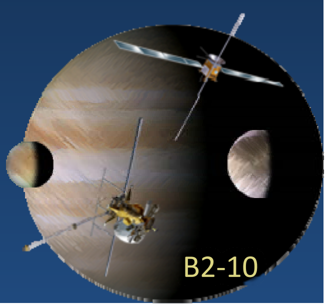
JGO Model Payload Driving Requirements and Critical Issues

- Field of View accommodation & large amount of appendages
- Large number of booms – it is recommended to consider combined sensor accommodations
  - Accommodation of booms on s/c body is the baseline
  - Accommodation of part of RPWI on SA is under study
- Electromagnetic Compatibility:
  - Electric charging few Volt over spacecraft
  - 2 nT DC magnetic field
  - < 50 dBμV/m below 45 MHz



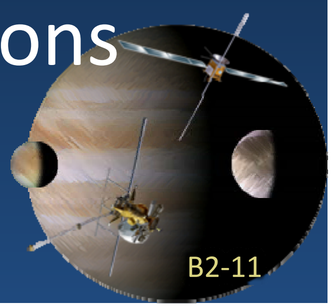
JGO Model Payload Driving Requirements and Critical Issues

- Radiation shielding & radiation sensitivity of scientific measurements in high radiation environment
- Potential distortions of radar antenna beam patterns and effects on scientific measurements
- Resources limited (mass, power, data volume)
- Thermal demands for cooling of detectors



Model Instrument Operations

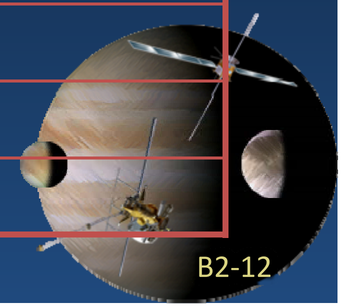
- A preliminary instrument operation scenario was defined together with the science team
  - Showed that all science objectives could be met
  - Showed that all data fit into available telemetry volume (1 Gb/day)
- Operations of remote sensing and in situ separated in time
  - Instrument power during stand-by/switch off important
- No (or much reduced) instrument operations during telemetry downlink periods



Payload Operations Scenario

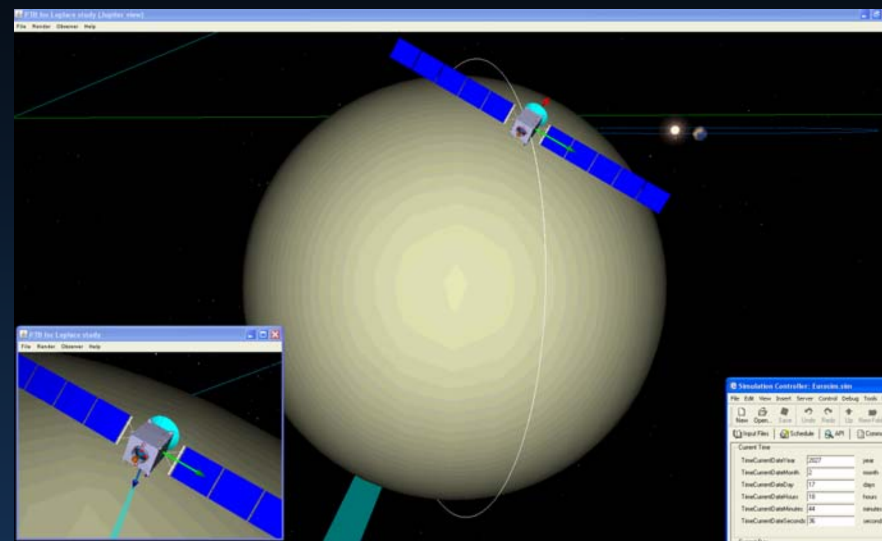
- Instruments operations were defined per Ganymede orbit
- Verification of observations and measurements made, data return, science return
- S/c sizing: Power, accommodation

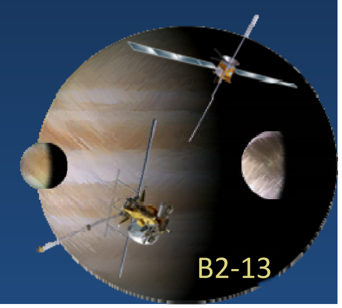
Obs1 Remote Sensing	Obs2 In situ + WAC & LA	Obs3 Radar + in situ	Obs4 Radio Science & downlink	Obs5 Jupiter Monitoring, etc
VIRHIS	**WAC**	**SSR**	**JSRT**	**SWI**
HRC	**LA**	**RPWI**	**USO**	**VIRHIS**
UVIS	**MAG**	**MAG**		**HRC**
MAG	**RPWI**	**PP**		**WAC**
LA	**PP**			**UVIS**



Instrument Operations Spacecraft Pointing

- During flybys unconstrained pointing capability
- During Ganymede orbit phases
  - Baseline is continuous rotation of s/c around yaw
  - Exceptionally stable pointing will be performed, with recovery period
- Stable Earth pointing will be performed (TM download)

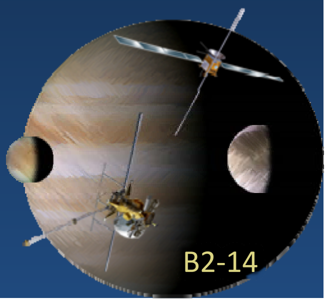




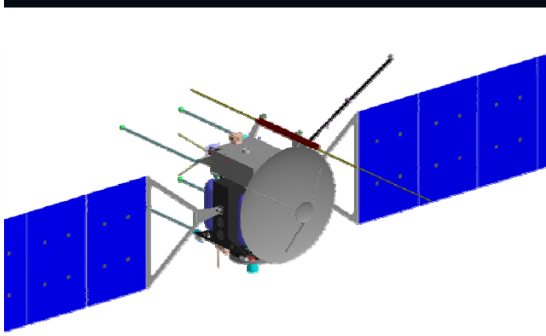
JGO Status

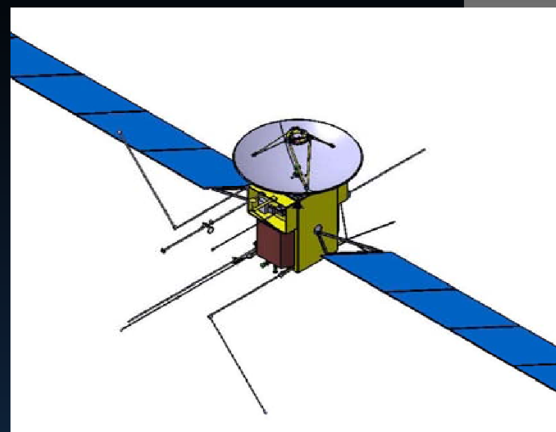
- ESA finished a Phase 0/A level study with 3 industrial consortia (led by Astrium, OHB, TAS)
  - KO in July 2009
  - Completion by July 2010

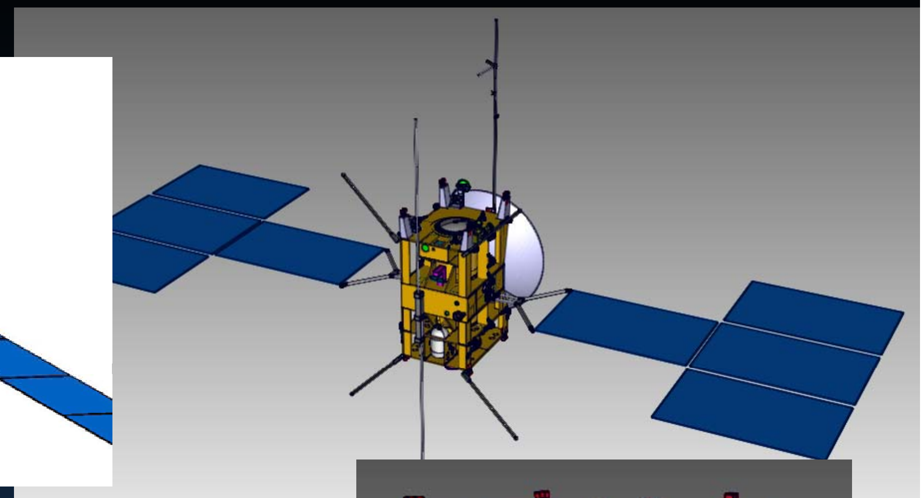
- Currently preparing for ESA internal technical review in preparations of the L-class downselection

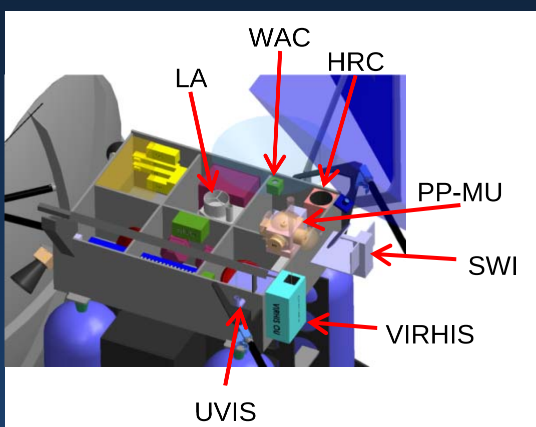


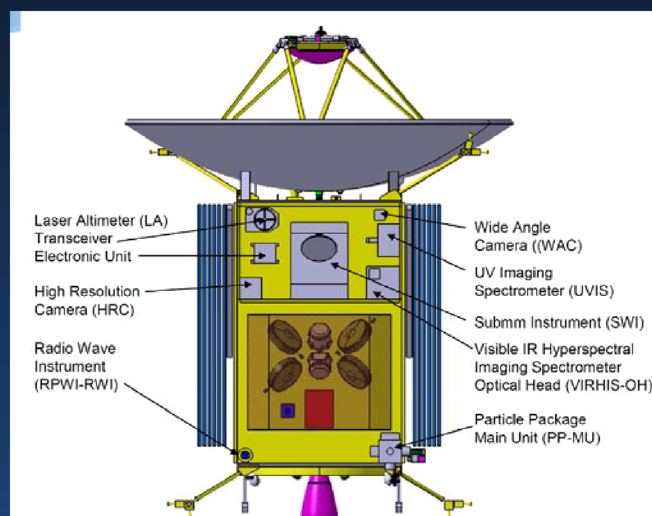
Spacecraft Configurations

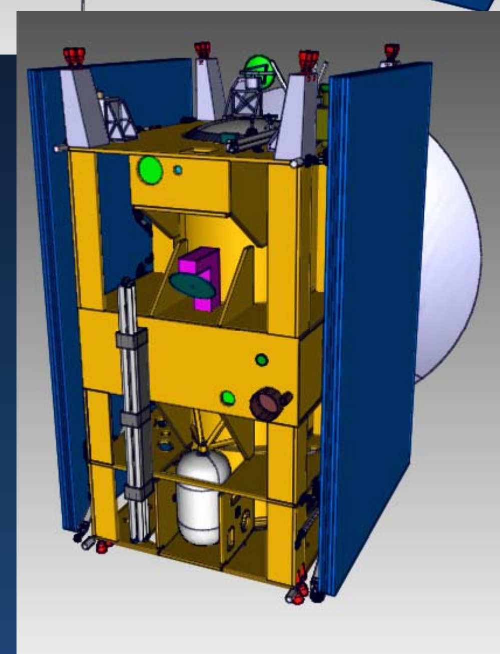








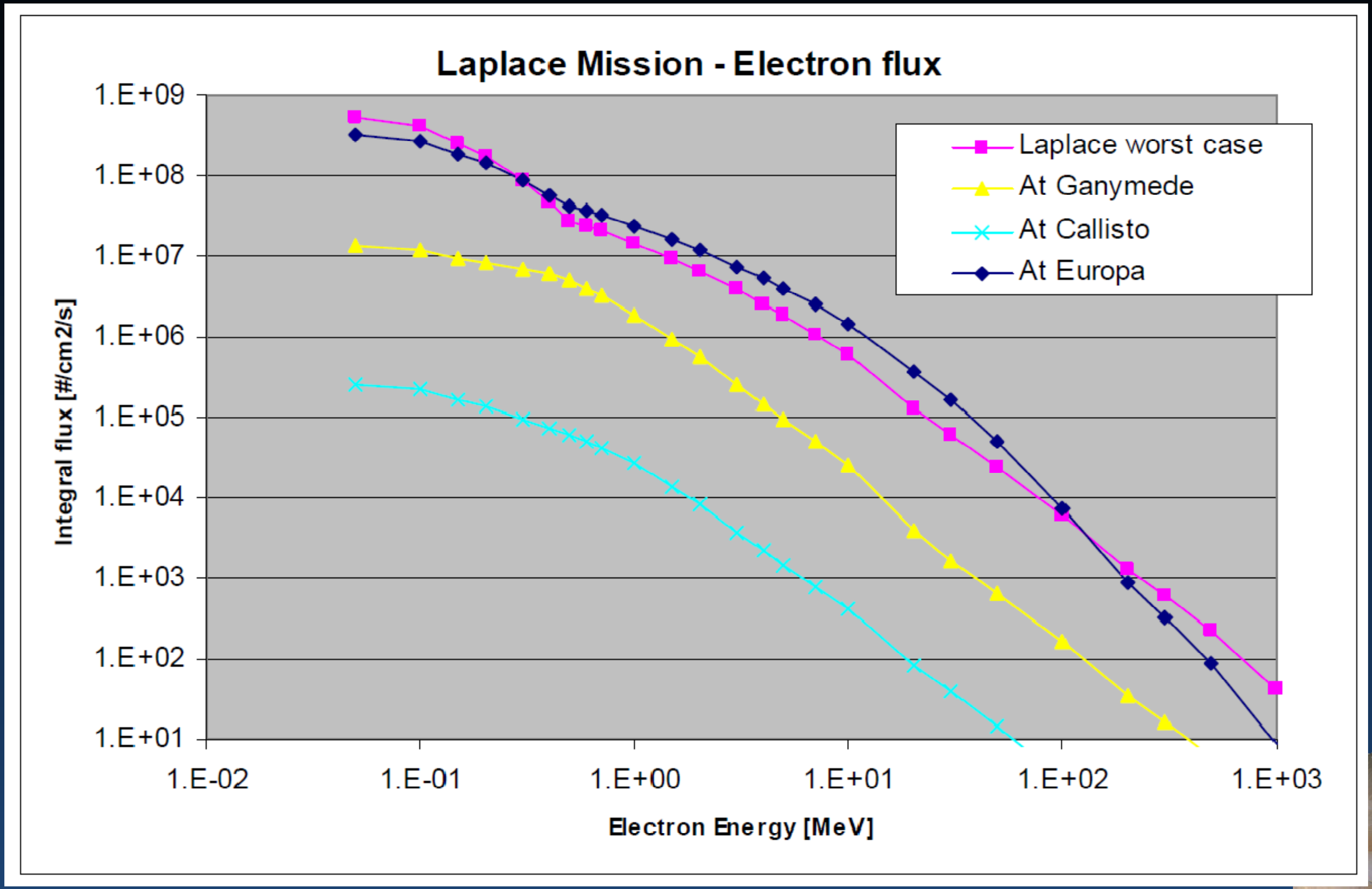




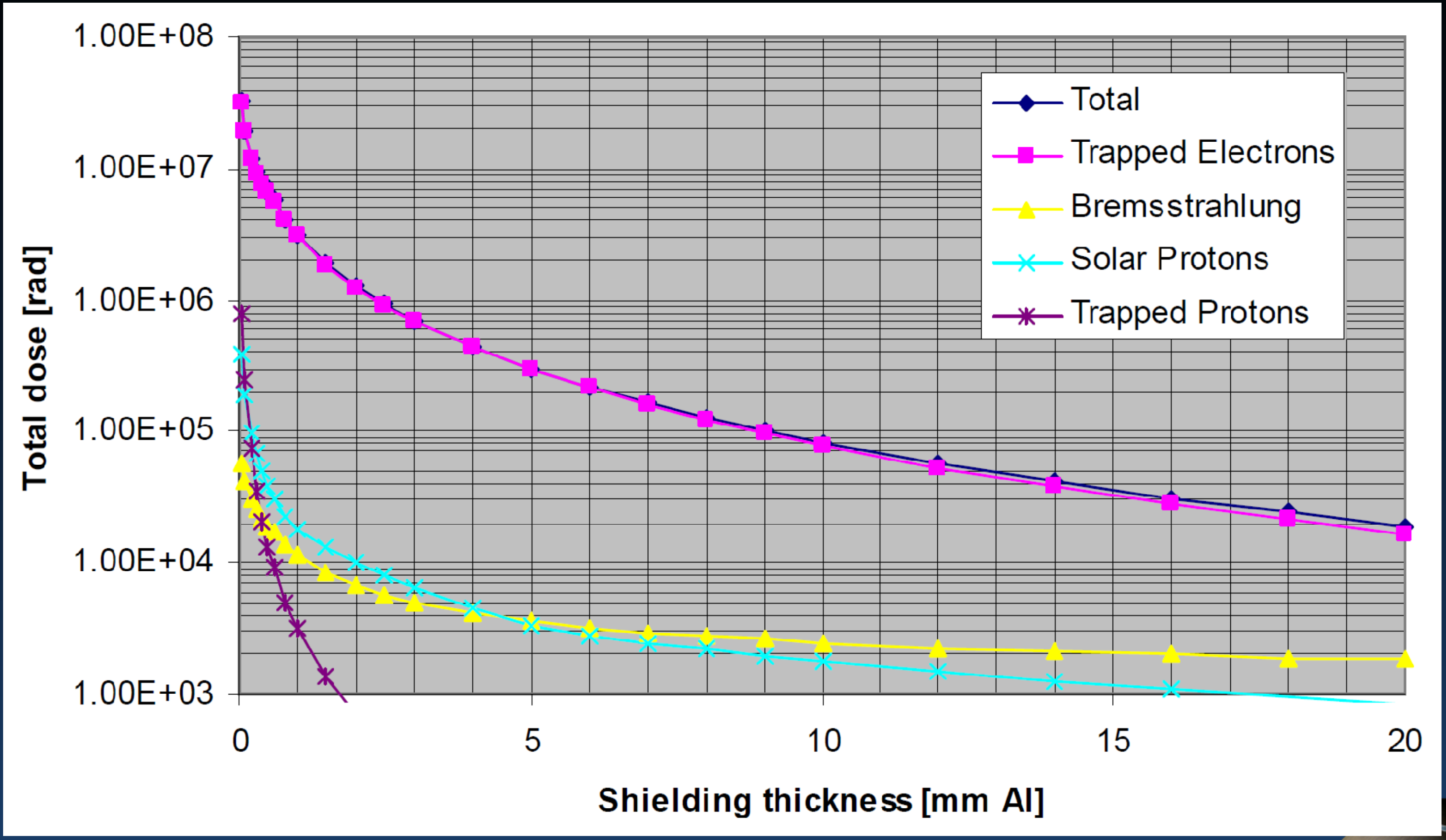
JGO Radiation Mitigation

- Total ionizing dose ~85 krad behind 10 mm Al
- Additional shielding with alternative materials (Ta, W) should be investigated
- Design shall aim for 150 krad tolerance
- Shielding
  - Mostly box shielding, some spot shielding
  - 10 mm Al is conservative approach; tailored shielding material may be used
  - Studies are estimating ~80 kg shielding for 104 kg payload and avionics
  - Solar cell arrays currently designed to be covered with 70 µm cover glass
- Combined mitigation approach: shielding and radiation hardened components

Radiation Environment



Radiation Environment



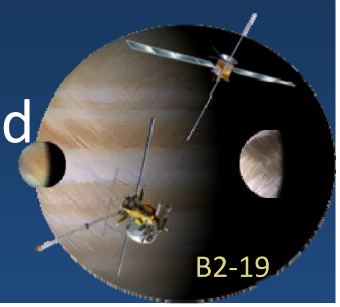
Environment is dominated by electrons

Planetary Protection Requirements

- Category II + additional requirements
  - Significant interest in processes of chemical evolution
  - Remote probability of contaminating future exploration

- Demonstrate probability of contaminating the Ganymede subsurface ocean $\leq 10^{-4}$
  - Investigating timescales and transport properties of surface processes
- Contamination of Europa ocean $\leq 10^{-4}$
  - Probability of accidental impact on Europa (reliability)
- Probability of impact launch vehicle on Mars $\leq 10^{-4}$ for 50 years after launch
  - Probability of accidental impact as a consequence of failure

- Planetary protection plan will be compiled and reviewed



Outlook & Programmatics

- L-Class down selection process starting in October 2010 and will be finished by the SPC decision in June 2011
  - Evaluation process will closely follow that of M-missions
  - Independent reviews on science, technical and programmatics
  - Review on ESA elements and overall readiness of the EJSM mission
- Expecting instrument contributions from US on JGO and from Europe on JEO