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The Callisto Descent Probe

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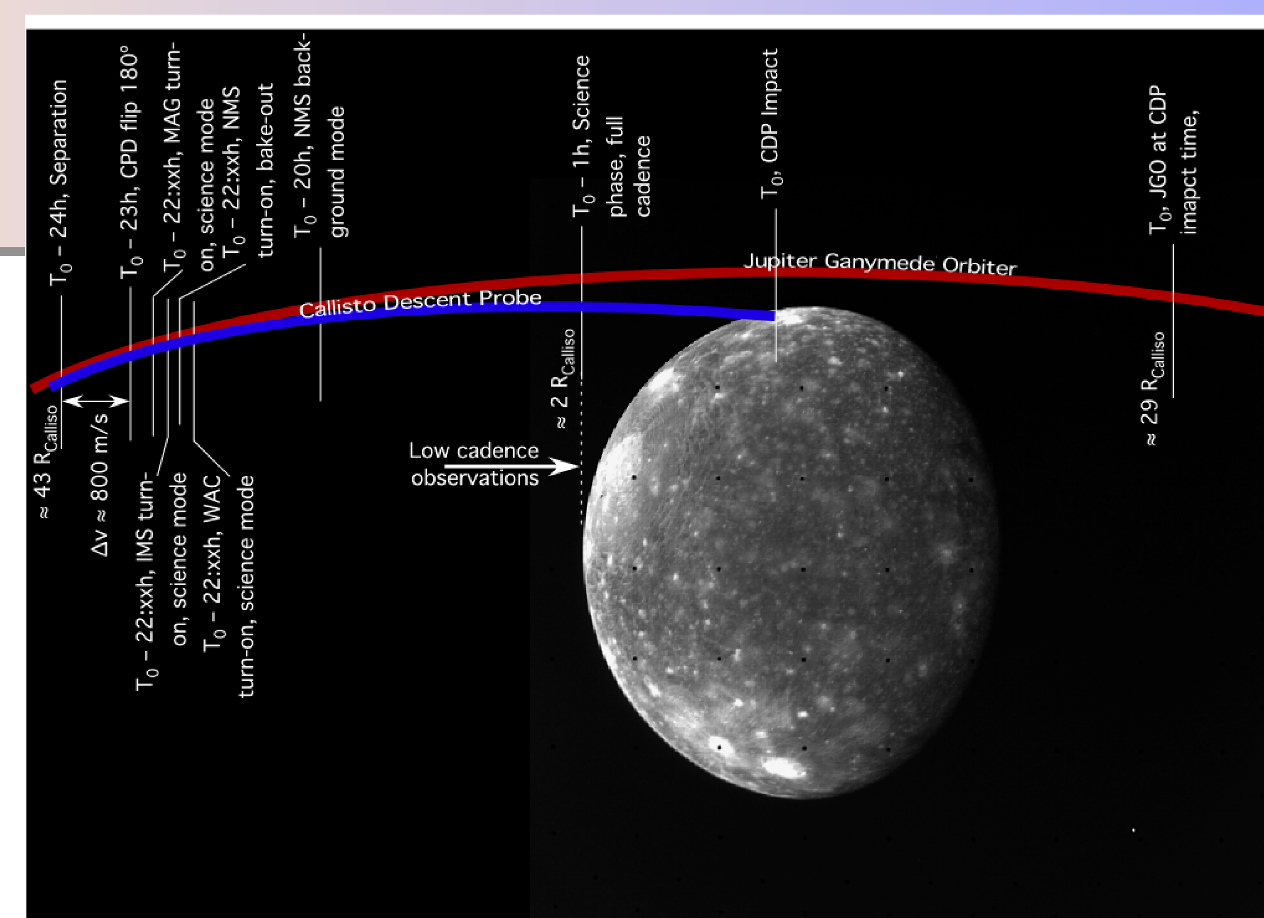


CONTEXT & OBJECTIVE

➢ Abstract

The Callisto Descent Probe (CDP) is a small spacecraft originally proposed to be part of the Jupiter Ganymede Orbiter (JGO) of the Europa-Jupiter System Mission (EJSM) of ESA and NASA. CDP shall be deployed during a dayside Callisto flyby of JGO. With the help of a de-orbit engine, the CDP's orbit will be adjusted to intersect the surface of Callisto. Scientific data will be recorded during the decent to the surface. The impact of CDP on the surface will end the science phase of CDP.

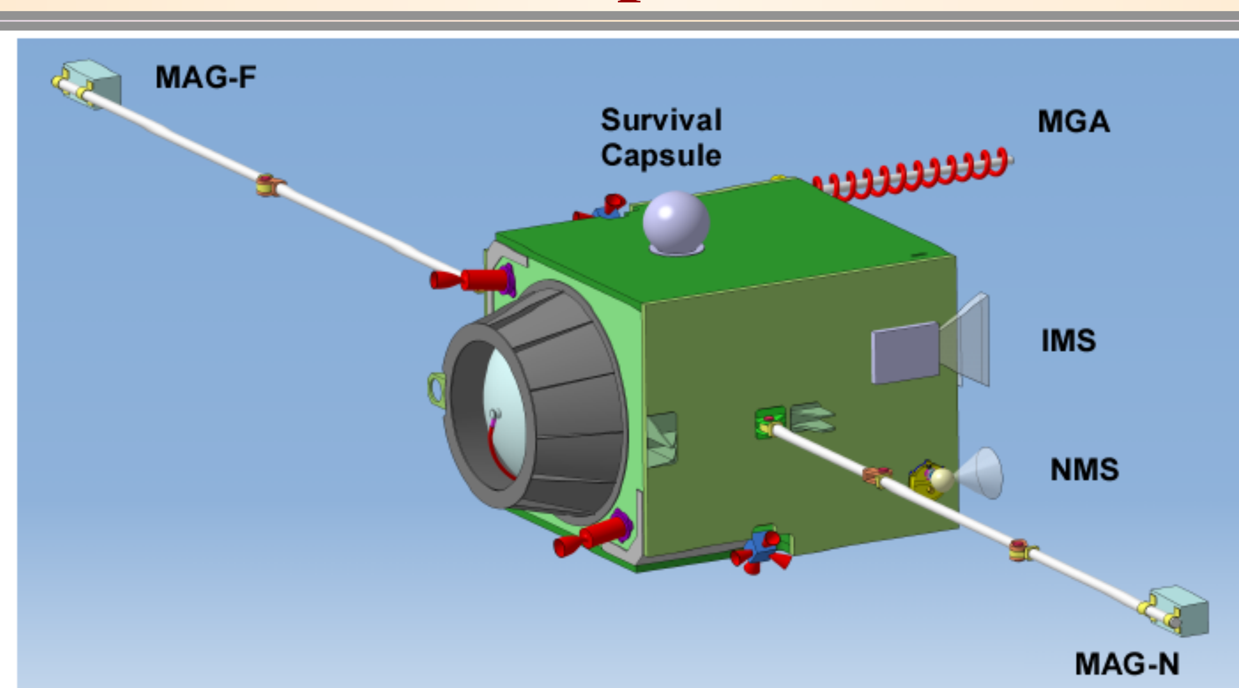
The scientific objective of CDP is to provide measurements during the descent phase, thus close to Callisto's surface that will enhance the total scientific return of the Callisto science investigation of EJSM. The areas of investigation of CDP instruments are the composition of neutrals and ions in the atmosphere, visible light imaging, magnetic field investigations, and radio science.

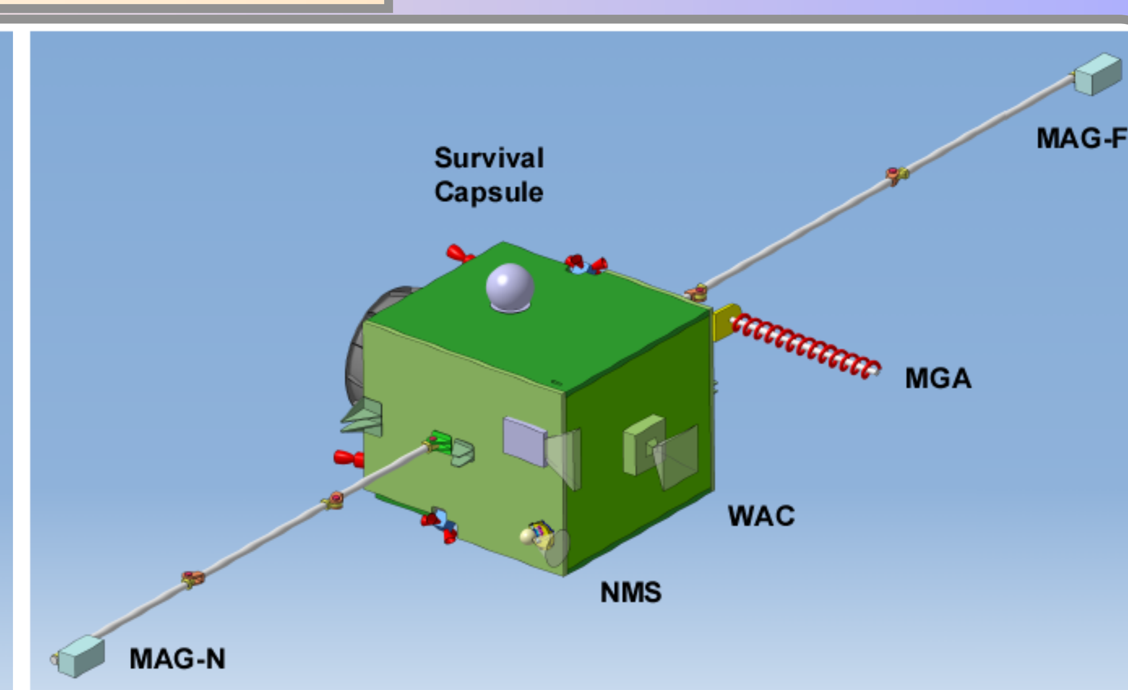
A possible addition to the payload is a survival capsule, which would survive the impact, and accommodates a radio beacon. The radio beacon will continue to transmit a radio signal from the surface for extended time periods.

CDP Spacecraft

The CDP Spacecraft

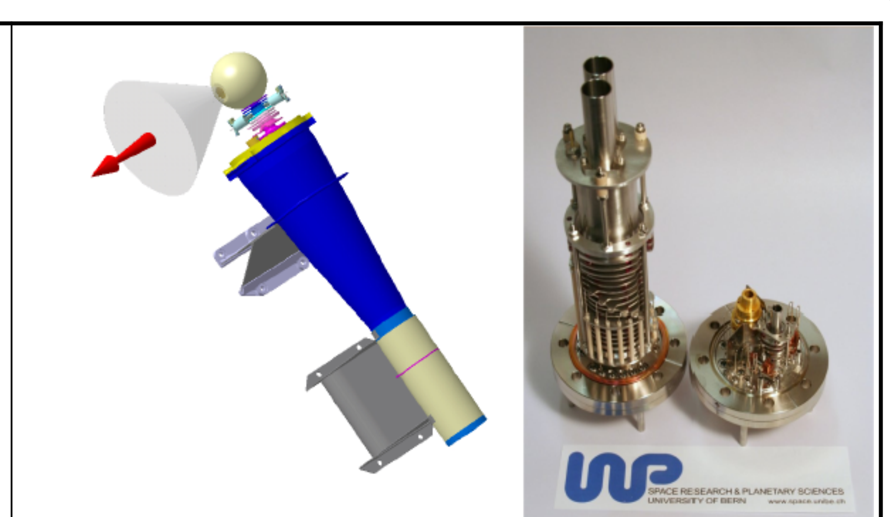
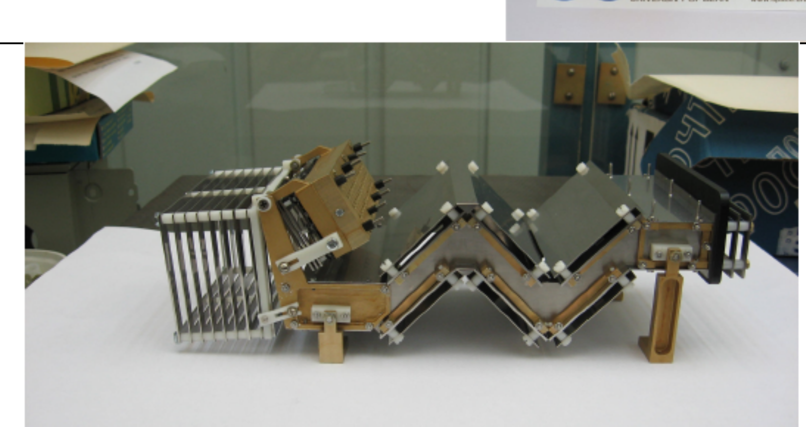
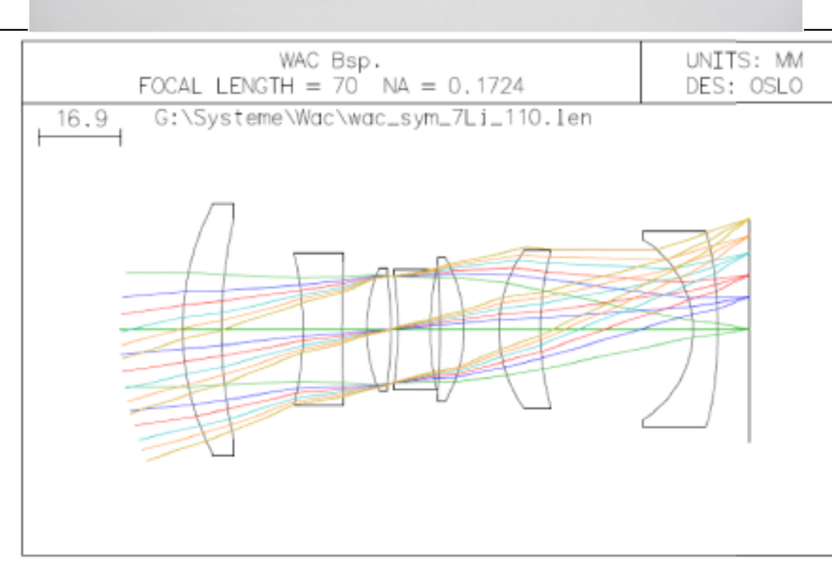
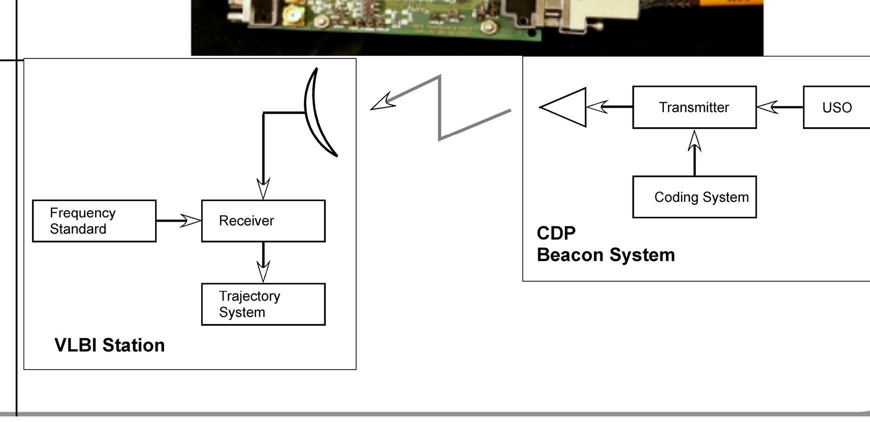
The CDP will be a small spacecraft travelling as passenger of the JGO spacecraft to its final destination Callisto. CDP weight is about 91 kg total mass including the separation mechanism. The present design is based on the ALP-SAT spacecraft design, thus it is not optimised for JGO. Significant mass reductions are likely possible.
Release of CDP from the JGO spacecraft and its spin-up will be accomplished with a spring separation system. CDP has a de-orbit engine to change its trajectory to a collision trajectory with Callisto. CDP will also have small thrusters for spin adjustment and stabilisation, as well as attitude control.





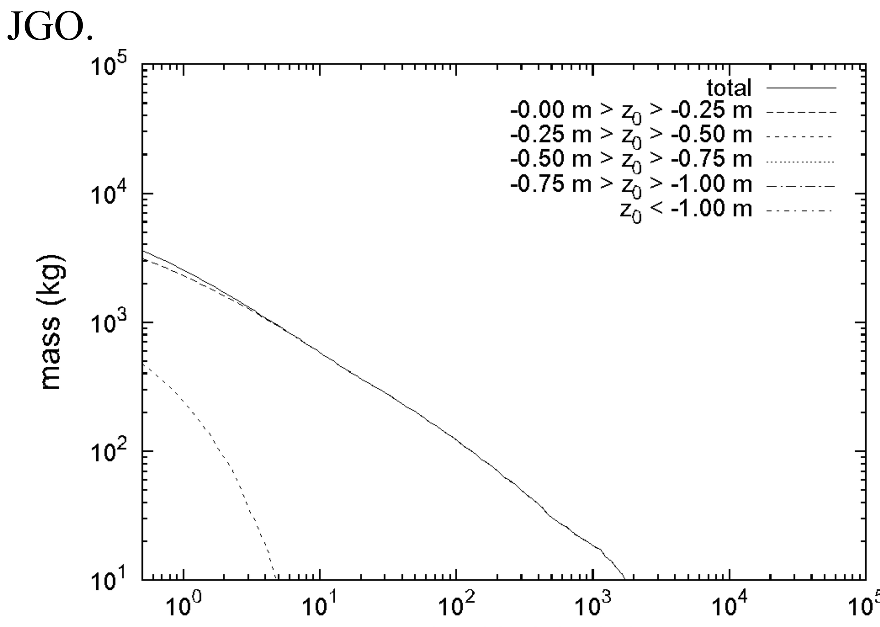
Main thrusters: 2 x 20 N	Hydrazine: 28 kg Cold gas: 0.405 kg	Scientific payload: 18 kg Survival capsule: 5 kg
Total wet mass: 91 kg		

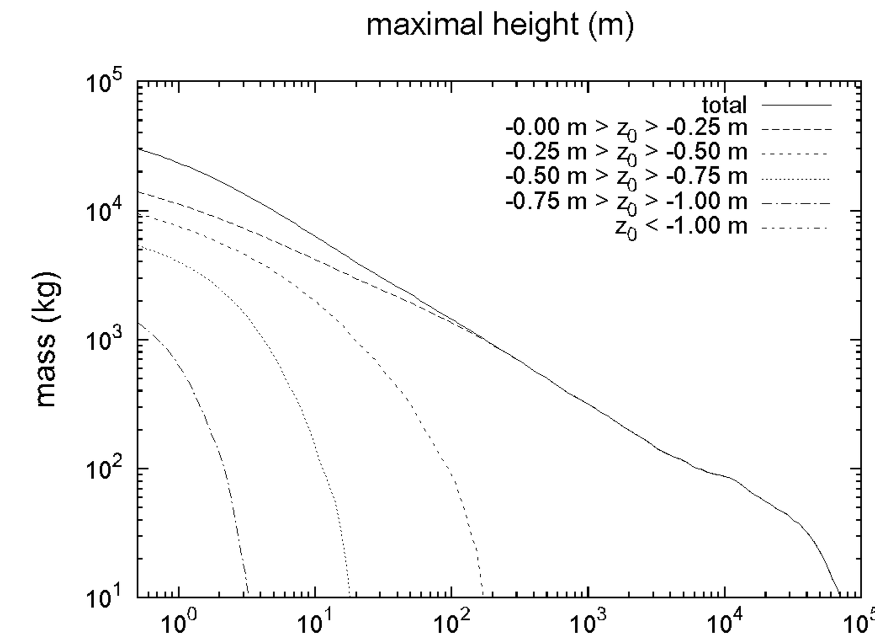
Scientific Instrumentation

Neutral Gas Mass Spectrometer (NMS): to measure the atmospheric neutral gas composition. Much more sensitive mass spectroscopic measurements will be performed during decent than during flyby because the atmospheric density increases dramatically closer to the surface. Moreover, since the atmosphere is in direct contact with the surface it thus provides information of the surface composition.	o Thermal neutral gas measurement, o Mass resolution: M/ΔM = 1000 o Mass range: 1–1000 amu o Field-of-View: cone 60° half-angle (centered in ram direction) o Sampling time: 1 – 100s (full mass spectrum, 6 decades dynamic range in 5 s) o Sensitivity: 10^{-16} mbar in 5 s. o Geometric factor: 0.71 [cm² sr]	
Ion Mass Spectrometer (IMS): to measure the composition of low-energy ions arriving mainly from Callisto. These ions result from sputtering of ions from the surface from Callisto by energetic particles from Jupiter's magnetosphere, and thus also provide information about Callisto's surface composition.	o Low-energy ion measurement: < 20 eV o Mass resolution: M/ΔM = 200 o Mass range: 1–300 amu or 500–1000 amu o Field-of-View: 60°x10° (centred in ram direction) o Sampling time: 5s (full mass spectrum) o 8 decades dynamic range o Geometric factor: 0.69 [cm² sr]	
Wide Angle Camera (WAC): for surface imaging in visible light at high cadence to contribute to the characterization of the surface. In particular, WAC it will provide close up images of Callisto's surface at spatial resolutions much better than can be achieved from the JGO spacecraft. WAC optical design combines very low distortion with a wide field-of-view, using materials for high radiation environment	o Aperture = 24.0 mm o Focal length = 70 mm o 114 µrad/px for 8 µm (0.25 m/px at 2 km altitude) o Exposure time around 1.4 ms o Focal plane dimension: 32.5 x 32.5 mm square o 2k x 4k detector with 8 µm pitch gives 16.4 mm x 32.8 mm. o 1/e² encircled energy = 10–14 µm o Transmittance at 600 nm > 80% o Transmittance: 250 nm –1150 nm > 50% o Operational temperature = –100ºC to +30ºC o Optics to withstand 300 kRads with < 2% degradation	
Magnetometer (MAG): will measure the altitude profile of the induced magnetic field variations generated due to varying Jovian magnetic field induced in Callisto's interior. The actual altitude profile allows drawing conclusions on the strength and structure of the induced field, thus providing information about the inducing layers such as a possible subsurface ocean.	o Two flux-gate magnetometers, magnetic field vector o MAGs on deployable booms of different length o Dynamic range ± 1000 nT o Noise level < 10 pT/√Hz @ 1 Hz o Sampling frequency: 2 – 128 Hz	
Radio Beacon: allows the reconstruction of the probe's state-vector (coordinates and their time derivatives) by means of VLBI and Doppler measurements. The radio beacon in the survival capsule will contribute to research in celestial mechanics, planetary dynamics, seismology, and geodesy.		

Post-Impact Science

Impact Plume: Observation of the impact plume by remote sensing instrumentation on board of the JGO spacecraft by looking back to Callisto. Simulations show the impact of a 50 kg aluminium projectile on Callisto for an impact angle of 5º (top panel) and 20º (bottom panel). Since CDP will be approaching Callisto from the day side, back illumination of the plume should give good visibility for observations from JGO.





Radio Beacon (RB): The Radio Beacon inside the survival capsule shall survive the impact of the CDP spacecraft and stay operational on the surface by at least two weeks running on battery power. Unfortunately, the feasibility of a survival capsule still has to be demonstrated.
RB will continue to send the beacon signal that will be recorded by VLBI, thus allowing continuous tracing of its position on Callisto's surface and will contribute to research in celestial mechanics, planetary dynamics, seismology, and geodesy.