JANUS: THE VISIBLE CAMERA ONBOARD THE ESA JUICE MISSION TO THE JOVIAN SYSTEM.

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Introduction: The JUICE (JUpiter ICy moons Explorer) mission [1] was selected in May 2012 as the first Large mission (L1) in the frame of the ESA Cosmic Vision 2015-2025 program. JUICE is now in phase A-B1 and its final adoption is planned by late 2014.The mission is aimed at an in-depth characterization of the Jovian system, with an operational phase of about 3.5 years. Targets for this mission will be Jupiter and its magnetosphere, its satellites and rings and the complex coupling processes within the system. The main focus will be on the detailed investigation of three of Jupiter's Galilean satellites (Ganymede, Europa, and Callisto), thanks to several fly-bys and 9 months in orbit around Ganymede.

JANUS (Jovis, Amorum ac Natorum Undique Scrutator) is the camera selected by ESA to fulfill the visible imaging scientific requirements of JUICE. It is being developed by a consortium of institutes in Italy, Germany, Spain and UK, supported by the respective Space Agencies (ASI, DLR, Ministerio de Ciencia e Innovación, UKSA), with contributions from Co-Investigators also from USA, France, Japan and Israel.

JANUS Science Objectives: The Galilean satellites Io, Europa, Ganymede and Callisto show an increase in geologic activity with decreasing distance to Jupiter [e.g., 2]. Io, nearest to Jupiter, is volcanically active. Europa could still be tectonically and volcanically active today, while Callisto, the outermost Galilean satellite, is geologically inactive but bears witness to past processes in the system through its surface features. Ganymede holds a key position in terms of geologic evolution because it features old, densely-cratered terrain, like most of Callisto, but also widespread resurfaced regions, similar to most of the surface of Europa. Ganymede observations from an orbiter are essential to investigate: (1) its wide range of surface ages which reveals a geologic record of several billions of years; (2) its great variety in geologic units and geomorphical features; (3) its active magnetic dynamo; (4) the possible presence of a subsurface ocean. The three icy Galilean satellites show tremendous diversity of surface features, witnesses of significantly different evolutionary paths. Each of these moons exhibits its own fascinating geologic history – formed by competition and also combination of external and internal processes. Their origins and evolutions are controlled by factors such as density, temperature, composition (volatile compounds), stage of differentiation, volcanism, tectonism, rheological behavior of ice and salts to stress, tidal effects and interactions with the Jovian magnetosphere and the space. These interactions are still recorded in the present surface geology wich displays also possible cryovolcanism, widespread tectonism, surface degradation and impact cratering.

Other important targets for JANUS observations are the Jupiter atmosphere, satellite's exospheres, Jupiter ring system and the minor satellites.

Instrument Architecture: In addition to the usual requirements for a planetary mission, resources constraints, S/C characteristics, mission design and the great variability of observing conditions for several objects place stringent constraints on JANUS architecture. Also, a high radiation environment in terms of total irradiation dose and flux in specific mission phases has to be considered. Finally, the design has to cope with a wide range of targets, from Jupiter atmosphere and lightning, to solid satellite surfaces, exosphere, rings, all to be observed in several color and narrowband filters (see preliminary spectral characteristics below) and from low to high ground resolution. A catoptric telescope with excellent optical quality is coupled with a CMOS detector; filter selection is done with a high heritage and redundant mechanism.

Narrowband filters centre/FWHM [nm]		***Broadband filters centre/FWHM [nm]***	
590/10	sodium D-lines	650/500	Panchromatic
656/10	Hα-line	410/80	violet, UV slope
727/10	methane	450/60	Blue
760/20	cont 1, geology	530/60	green, bkg Na
889/20	methane strong	656/60	red, bkg Hα
940/20	cont 2, Fe^{2+}	910/80	NIR 1, Fe^{2+}, Io obs.
		1000/150	NIR 2, Fe^{2+}, Io obs.

Instrument operations are flexible enough to optimize the acquisition parameters with respect to the many different observation conditions that JANUS will face. The instrument design will allow for adjustments in resolution, field of view, signal levels and SNR through binning, windowing and integration time. Updated calibration parameters can be applied for on-board data pre-processing. Cold redundancy is implemented for all critical electronic parts.

Capabilities and Performances: JANUS design optimizes the use of resources allocated for the JUICE imager in terms of performances and reliability. Analyses show that the JANUS design will allow good image quality and SNR>100 in almost all observing end-of-life conditions.

JANUS will allow orders-of-magnitude steps ahead in terms of coverage and/or resolution and/or time evolution on many targets in the Jupiter system. JANUS spatial resolution ranges from 400 m/pxl to < 3 m/pxl for the three main Galilean satellites, and from few to few tens of km/pxl for Jupiter and the other targets in the Jovian system (see figure 1).

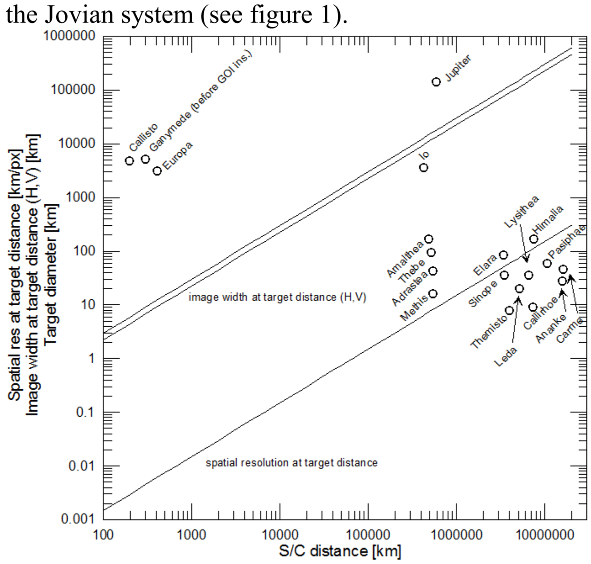

Figure 1: ground sampling in km/pxl and image width in km are compared with the size of different targets at the minimum distance foreseen by JUICE mission design. Only few targets are not resolved.

Assuming the available scientific data volume (about 20% allocated to JANUS out of 1.4 Gb/day), JANUS observation will cover about a 100% of Ganymede surface in 4 filters at 400 m/pxl sampling. About 3% of the surface of Ganymede will be covered at <24 m/pxl and 60 targeted areas will be observed at about 3 m/pxl. This will represent a dramatic improvement with respect to Galileo coverage (figure 2).

Stereo imaging at Ganymede is doable at sampling between 5 and 25 m/pxl and will be obtained by combining nadir and S/C tilted observations.

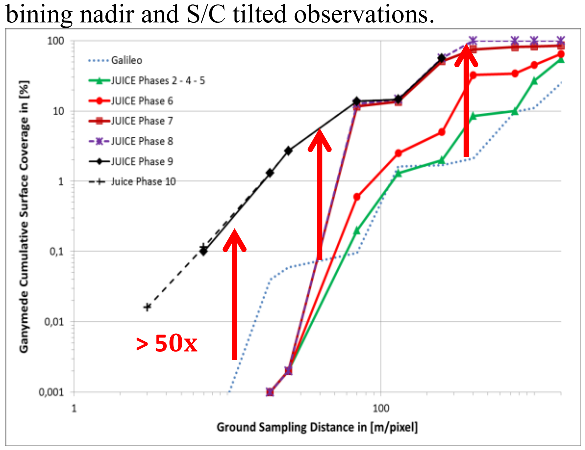

Figure 2: JANUS ground sampling distance and surface coverage for Ganymede in different mission phases (2 to 7: fly-bys during Jupiter orbits; 8 to 10: orbits around Ganymede) compared to Galileo.

For Callisto, assuming only nadir pointing, JANUS will cover 100% of the surface at ≤ 2 km/pxl, 41 % at ≤ 1 km/pxl, 14 % at ≤ 400 m/pxl, 6.5% at ≤ 200 m/pxl, and some targets with 4 colors imaging at medium resolutions (i.e., ~10 m/pxl).

55% of Europa's surface can be covered at ≤ 3 km/pxl, 42 % at ≤ 2 km/pxl, 25 % at ≤ 1 km/pxl, 11 % at ≤ 700 m/pxl, 3.2% at ≤ 400 m/pxl, 1.1% at ≤ 200 m/pxl and some targets at resolutions ~ 10 m/pixel. Low to medium-resolution imaging (i.e. km to ~100 m – range) is obtained in four filters. Note that all given numbers are worst case estimations, as raster pointing strategy is under study during the fly-bys in order to increase coverage at higher resolution.

Ground sampling at Io will gain 6 to 20 km/pixel with long monitoring time also at NIR wavelengths. The rings and minor satellites can be observed at ~7 km/pxl, while Jupiter's atmosphere will be observed down to 9 km/pxl.

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