THE JANUS CAMERA ONBOARD ESA's JUICE MISSION: FIRST OBSERVATIONS OF THE EARTH-MOON SYSTEM. Ganna Portyankina[1], Pasquale Palumbo[2], Thomas Roatsch[1], Luisa Lara[3], Manish Patel[4], Cecilia Tubiana[2], Alessio Aboudan[5], Livio Agostini[2], Luca Penasa[6], Alice Lucchetti[6], Klaus-Dieter Matz[1], Romolo Politi[2], Frank Trauthan[1], Angelo Zinzi[7], Jose Maria Castro[3], Vincezo Della Corte[8], Stubbe Hviid[1], Ralf Jaumann[9], Klaus-Michael Aye[9], Nicole Schmitz[1], Thomas Bilotta[10] and the JANUS team; [1]Institute of Planetary Research, DLR, Berlin, Germany (Ganna.Portyankina@dlr.de); [2]INAF-IAPS, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy; [3]Instituto de Astrofisica de Andalucia, Granada, Spain; [4]Open University, Milton Keynes, UK; [5]CISAS G. Colombo, Universita' di Padova, Italy; [6]INAF-OAPD Astronomical Observatory of Padova, Padova, Italy; [7]ASI HQ, Rome, Italy; [8]INAF-OAC, Osservatorio Astronomico di Capodimonte, Napoli, Italy; [9]Institute for Geosciences, Freie Universität Berlin, Berlin, Germany; [10]Leonardo SpA, Firenze, Italy.

Introduction: JANUS (Jovis, Amorum ac Natorum Undique Scrutator) [1, 2] is the imaging system aboard ESA's JUICE mission [3]. Following the successful launch of JUICE on April 14, 2023 from Europe's Spaceport in Kourou, French Guiana, the JANUS instrument completed commissioning activities and two scheduled checkouts to confirm its functionality and performance.

On August 19–20, 2024 JUICE performed first fly-by of Earth-Moon system or Lunar-Earth Gravity Assist (LEGA) maneuver. It has marked the first opportunity to operate JANUS under conditions closely resembling its primary science operations within the Jupiter system.

JANUS camera: The JANUS telescope is a modified Ritchey-Chrétien design with an effective entrance pupil diameter of 103.6 mm and a focal length of 467 mm. It offers a field of view (FoV) measuring 1.29° by 1.72° and uses a Teledyne-e2v CIS115 CMOS detector with a resolution of 1504 x 2000 pixels. The instrument has an instantaneous field of view (IFOV) of 15 microradians and a spatial sampling rate of 7.5 meters per pixel from a distance of 500 km. It is equipped with 13 filters that span the wavelength range from 340 to 1080 nm.

LEGA observational geometry and constrains: This flyby presented a unique opportunity to operate the instruments aboard JUICE with a primary focus on verifying operational capabilities, assessing performance, refining calibrations, evaluating data quality, and testing data processing strategies and tools. The main characteristics and constraints involve approaching the dayside from the nightside, crossing the dusk terminator for the Moon (Fig. 1) and the dawn terminator for Earth (Fig. 2). The Sun phase angle remained fixed at 90 degrees, causing incidence and emission angles to vary between 90 and 0 degrees and 0 and 90 degrees, respectively. Observations were not conducted on the Moon's nightside. On the dayside, the minimum elevation and relative speed over the Moon are approximately 900 km and 4.0 km/s, while for Earth, these values are about 8,400 km and 7.3 km/s. The kinematics of the flybys has restricted the potential for multi-filter imaging during different phases, primarily due to the time required for JANUS to switch filters, which is approximately 0.6 seconds, and the readout time of about 0.5 seconds. Additionally, there were operational limitations on the available data volume.

JANUS observations of the Moon: JANUS was thermally stabilized, powered on, and prepared for operation approximately 12 hours before the closest approach to the Moon. Image acquisition began around 30 seconds before the spacecraft crossed the terminator

Fig. 1*: Geometry of the Moon (left) and Earth (right) fly-by. JANUS field of view crossed the terminator from night to day side, its footprints outlined in white (basemaps from GoogleEarth).*

and continued until limb crossing, extending for an additional 15 minutes to capture stray light signals from the Moon outside the field of view. The coverage spans latitudes from 17°S to 16°N and longitudes from 107°E to 7°W (Fig. 1). The ground track passes over several notable features, including the LaPérouse and Langrenus craters, Mare Fecunditatis, Sinus Asperitatis, and the southern region of Mare Tranquillitatis.

The JANUS observation plan featured various instrument settings and data types for different segments of the orbit. Initially, continuous imaging was performed using the panchromatic filter with lossless compression as the Sun incidence angle shifted from 90 to 69 degrees. Image timing allowed each area to be observed two to four times. Subsequently, continuous multi-filter coverage was conducted, utilizing 4, 5, 8, or all 13 filters depending on the region, also with lossless compression. During this phase, Sun incidence angles ranged from 68 to 47 degrees and 41 to 29 degrees.

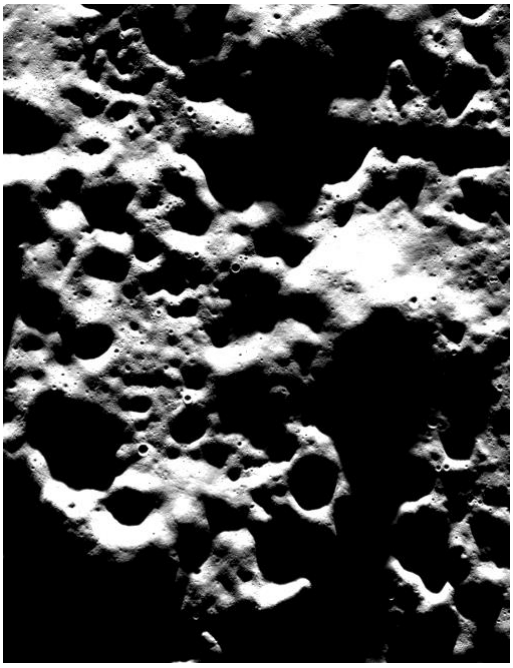

Fig. 2*: An example of JANUS image from Moon observatio taken in panchromatic filter with lossless compression and under low solar incidence.*

JANUS observations of the Earth: Image acquisition began about 37 minutes before closest approach, capturing nighttime views over the Indian Ocean. Observations continued through the terminator crossing until limb crossing, followed by an additional 11 minutes of imaging to measure stray light from the Moon outside the field of view. With the exception of two frames taken over Luzon Island and Hawai'i, all daytime images were captured over the Pacific Ocean. Unlike the observations of the Moon, reference data for Earth imaging were planned by coordinating acquisitions over the same footprints, as closely timed as possible, with other Earth-observing satellites, specifically PRISMA and EnMAP.

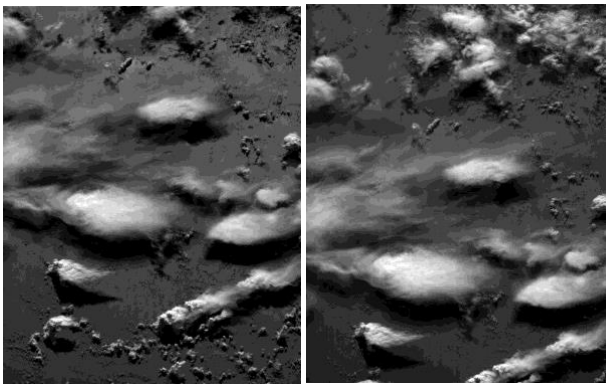

Fig. 3*: JANUS images of clouds and sea surface at 650 and 380 nm.*

Future work: At this stage, the JANUS team has implemented a pipeline for geometry corrections, including optical and rolling shutter distortions, as well as projection. Radiometric calibration is being finalized.

Acknowledgments: The Italian team has been supported through the ASI-INAF contract 2023-6-HH.0. JANUS was developed by an international team lead by an Italian Principal Investigator in collaboration with German Co-PI and Institutes from Italy, Germany, Spain and UK. JANUS team acknowledges funding from the respective Space Agencies: ASI, DLR, Spanish Research Ministry and UKSA.

References: [1] Palumbo, P., et al., (2014), LPSC Vol. 45, p. 2094; [2] Palumbo, P., et al., 2024, SSR, under review [3] Grasset, O., et al., (2013). PSS, 78, 1-21.

Fig. 4*: Farewell image of the Earth-Moon system was taken from > 5e10^6 km to characterize a specific detector behavior and perform additional radiometric checks.*