THE EUROPA IMAGING SYSTEM (EIS), A CAMERA SUITE TO INVESTIGATE EUROPA'S GEOLOGY, ICE SHELL, AND POTENTIAL FOR CURRENT ACTIVITY. E. P. Turtle[1], A. S. McEwen[2], S. N. Osterman[1], J. D. Boldt[1], K. Strohbehn[1], and the EIS Science Team, [1]Johns Hopkins Univ. Applied Physics Lab., Laurel, MD; Elizabeth.Turtle@jhuapl.edu, [2]Univ. Arizona, Tucson, AZ.

Introduction: Based on the Europa Clipper mission concept [1], NASA's Europa Multiple Flyby Mission, planned for launch in 2022, will perform more than 40 flybys of Europa with altitudes at closest approach as low as 25 km. The science payload [2] includes the Europa Imaging System (EIS), a camera suite designed to provide global decameter-scale coverage, topographic and color mapping, and unprecedented sub-meter-scale imaging. EIS combines narrow-angle and wide-angle cameras (Fig. 1) to address Europa Mission science goals of investigating Europa's geology, composition, ice shell and ocean.

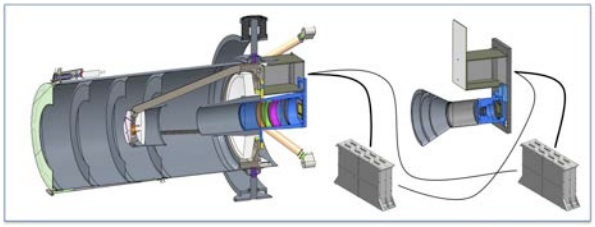

Figure 1: (Left) EIS NAC, (right) EIS WAC, and identical, cross-strapped DPUs (in spacecraft vault).

EIS science objectives include:

• constraining the formation processes of surface features by characterizing endogenic geologic structures, surface units, global cross-cutting relationships, and relationships to Europa's subsurface structure and potential near-surface water [*e.g.*, 3];

• searching for evidence of recent or current activity, including potential plumes [4];

• characterizing the ice shell by constraining its thickness and correlating surface features with subsurface structures detected by ice penetrating radar [5];

• characterizing scientifically compelling landing sites and hazards by determining the nature of the surface at scales relevant to a potential lander [6].

EIS Narrow-angle Camera (NAC): The NAC is derived from *New Horizons* LORRI [7] heritage and has a 2.3° cross-track x 1.2° along-track field of view (FOV) and a 10-µrad instantaneous FOV (IFOV) to achieve 0.5-m pixel scale over a 2-km-wide swath from 50-km altitude. It is mounted on a 2-axis ±30° gimbal to enable NAC targeting independent of S/C pointing. Use of a gimbal makes near-global (>95%; Fig. 2) mapping of Europa possible at ≤50-m pixel scale (to date, only ~14% of Europa has been imaged at ≤500 m/pixel), as well as regional stereo imaging. The gimbal slew rate is specifically designed to be able to perform very high-resolution stereo imaging from as close as 50-km altitude during high-speed (~4.5 m/s) flybys. These observations will generate digital topographic models (DTMs) with 2-m spatial scale and 0.25-m vertical precision over the 2-km swath.

The NAC will also perform high-phase-angle observations to search for potential plumes; a pixel scale of 10 km from 1E6 km range means that the NAC can take advantage of good illumination geometry for forward scattering by potential plumes even when the spacecraft is distant from Europa.

EIS Wide-angle Camera (WAC): The WAC, derived from *MESSENGER* MDIS [8] heritage, has a 48° cross-track x 24° along-track FOV, with a 218-µrad IFOV. The along-track FOV is designed provide sufficient convergence angle to acquire pushbroom stereo swaths along flyby ground-tracks (Fig. 3). From 50-km altitude, the WAC achieves 11-m pixel scale over a 44-km-wide swath, generating DTMs with 32-m spatial scale and 4-m vertical precision. These data also support characterization of surface clutter for interpretation of radar deep and shallow sounding modes.

Detectors and electronics: The cameras have identical radiation-hard 4k x 2k CMOS detectors [9] which function in both pushbroom and framing modes and have rapid readout for imaging during fast flybys and to minimize radiation-induced noise. Color observations are acquired by pushbroom imaging with six broadband filters on a substrate in front of the detector.

APL's radiation-hardened data processing unit (DPU) uses innovative real-time processing for pushbroom imaging [10], including WAC 3-line stereo, digital time delay integration (TDI) to enhance signal-to-noise ratio (SNR), and collecting data to measure and correct pointing jitter [11], taking full advantage of the rapid, random-access readout of the CMOS arrays. The cameras have identical DPUs, which are cross-strapped for redundancy.

Summary: EIS will provide comprehensive data sets essential to fulfilling the goal of exploring Europa to investigate its habitability and will perform collaborative science with other investigations, including cartographic and geologic mapping, regional and high-resolution digital topography, GIS products, color and photometric data products, a database of plume-search observations, and a geodetic control network tied to radar altimetry [5].

References: [1] Pappalardo R. T. *et al.* (2015) *AGU Fall Meeting*, Abstract #P13E-01. [2] Pappalardo R. T. *et al.* (2015) *LPSC* **46**, Abstract #2673. [3] Schmidt B. E. *et al.* (2015) *Nature* **479**, 502-505. [4] Roth L. *et al.* (2014) *Science* **343**, 171-174. [5] Moussessian A. *et al.* (2015) *AGU Fall Meeting*, Abstract #P13E-05. [6] Pappalardo R. T. *et al.* (2013) *Astrobiology* **13**, 740-773. [7] Cheng A.F. et al. (2008) Space Sci. Rev. 140, 189-215. [8] Hawkins S.E. et al. (2007) Space Sci. Rev. 131, 247-338. [9] Janesick J. *et al.* (2014) *Proc. SPIE* **9211**, 921106. [10] McEwen A.S. et al. (2012) Intl. Wkshp. Instr. Planet. 1, 1041. [11] Mattson S.M. et al. (2009) EPSC 4, 604-1.

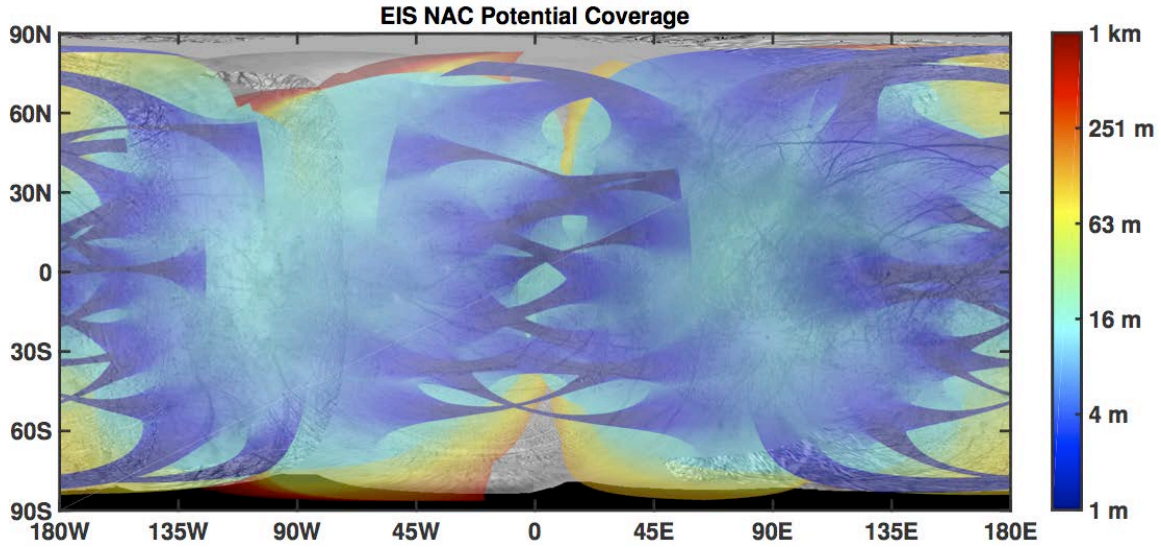

Figure 2. Areas of Europa's surface accessible for imaging by EIS NAC using the 2-axis ±30° gimbal. The NAC can image a swath 2.3° wide (2-km wide, with 0.5-m pixel scale from 50-km altitude), up to 30° from the nadir ground-track. In this way, mapping of >95% of Europa at ≤50 m/pixel is possible (with data volume being the limiting factor). Imaging coverage is color-coded by pixel scale and shown for a potential mission trajectory (15F10) when the spacecraft altitude is below 1000 km.

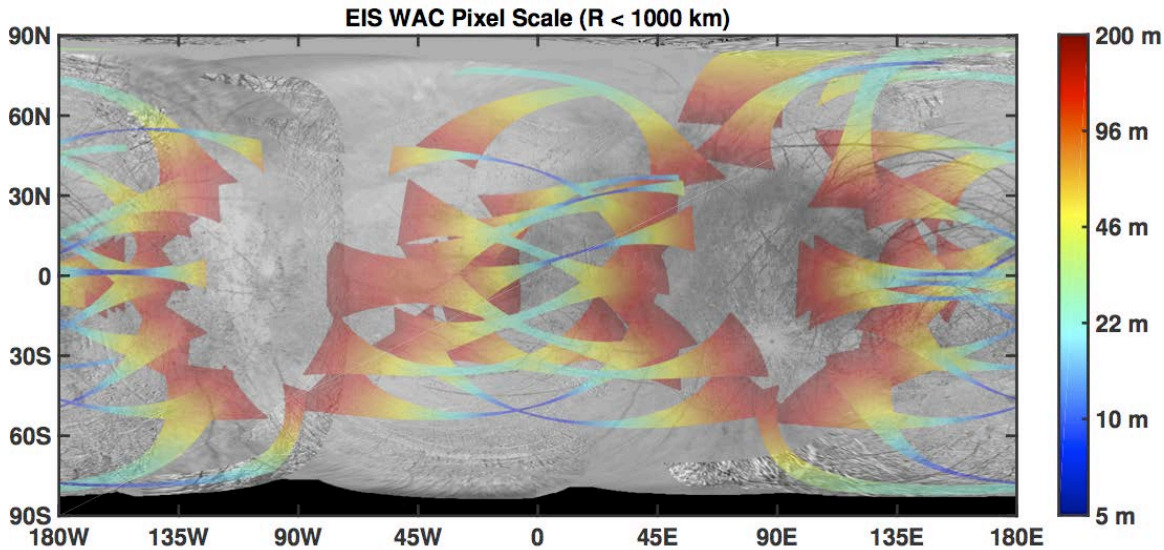

Figure 3. EIS WAC imaging coverage includes 3-line stereo and 6-color imaging, color-coded by pixel scale. The WAC images a swath 48° wide (45-km wide, with 11-m pixel scale from 50-km altitude). Imaging coverage is color-coded by pixel scale and shown for a potential mission trajectory (15F10) when the spacecraft altitude is below 1000 km.