THE EUROPA IMAGING SYSTEM (EIS): HIGH-RESOLUTION IMAGING AND TOPOGRAPHY TO INVESTIGATE EUROPA'S GEOLOGY, ICE SHELL, AND POTENTIAL FOR CURRENT ACTIVITY.

E. P. Turtle[1], A. S. McEwen[2], G. C. Collins[3], L. Fletcher[4], C. J. Hansen[5], A. G. Hayes[6], T. A. Hurford[7], R. L. Kirk[8], A. C. Barr Mlinar[5], F. Nimmo[9], G. W. Patterson[1], L. C. Quick[5], J. M. Soderblom[10], N. Thomas[11], C. M. Ernst[1], [1]Johns Hopkins Univ. Applied Physics Lab., Laurel, MD; Elizabeth.Turtle@jhuapl.edu, [2]Univ. Arizona, Tucson, AZ, [3]Wheaton College, Norton, MA, [4]Univ. Leicester, Leicester, UK, [5]Planetary Science Institute, Tucson, AZ, [6]Cornell Univ., Ithaca, NY, [7]NASA Goddard Space Flight Center, Greenbelt, MD, [8]U.S. Geological Survey, Flagstaff, AZ, [9]Univ. California, Santa Cruz, CA, [10]Massachusetts Institute of Technology, Cambridge, MA, [11]Univ. Bern, Bern, Switzerland.

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 instrument payload [2] includes the Europa Imaging System (EIS), a camera suite designed to transform our understanding of Europa through global decameter-scale coverage, topographic and color mapping, and unprecedented submeter-scale imaging. EIS combines narrow-angle and wide-angle cameras to address science goals prioritized by the NRC decadal survey for planetary science, investigating Europa's geology, composition, ice shell and ocean. The cameras will:

• Constrain 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];

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

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

• Characterize 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, with a 2.3° x 1.2° field of view (FOV) and a 10-µrad instantaneous FOV (IFOV), achieves 0.5-m pixel scale over a 2-km-wide swath from 50-km altitude. A 2-axis gimbal enables independent targeting, allowing very high-resolution stereo imaging to generate digital topographic models (DTMs) with 4-m spatial scale and 0.5-m vertical precision over the 2-km swath from 50-km altitude. The gimbal also makes near-global (>95%; Fig. 1) 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 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 has a 48° x 24° FOV, with a 218-µrad IFOV, and is designed to acquire pushbroom stereo swaths along flyby ground-tracks (Fig. 2). From an altitude of 50 km, 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 rapid-readout, radiation-hard 4k x 2k CMOS detectors [7] and can image in both pushbroom and framing modes. Color observations are acquired by pushbroom imaging using six broadband filters (~300-1050 nm), allowing mapping of surface units for correlation with geologic structures, topography, and compositional units from other instruments. APL's radiation-hardened data processing unit (DPU) uses innovative real-time processing for pushbroom imaging, including WAC 3-line stereo, digital time delay integration (TDI), and collecting data to measure and correct pointing jitter, taking full advantage of the rapid, random-access readout of the CMOS arrays.

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] Janesick J. *et al.* (2014) *Proc. SPIE* **9211**, 921106.
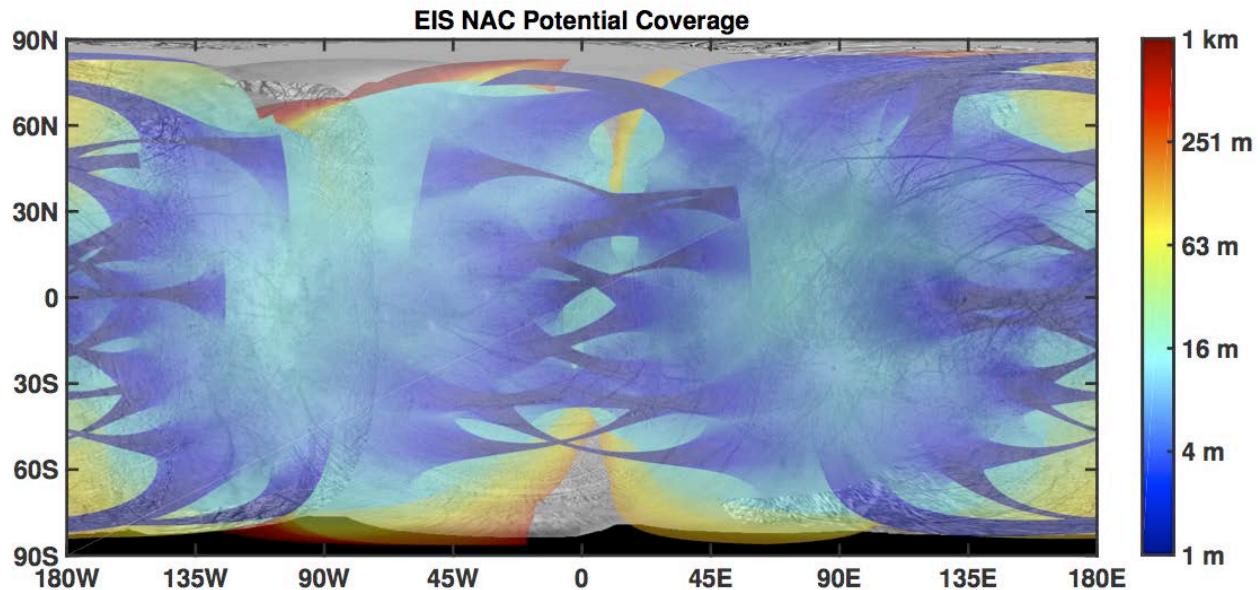

Figure 1. Areas of Europa's surface accessible for imaging by EIS NAC, color-coded by pixel scale and shown for a potential mission trajectory (15F10) at altitudes below 1000 km. Using the gimbal, the NAC can image a swath 2.3° wide, up to 30° from the nadir position. In this way, mapping of >95% of Europa at ≤50 m/pixel is possible (with data volume being the limiting factor).
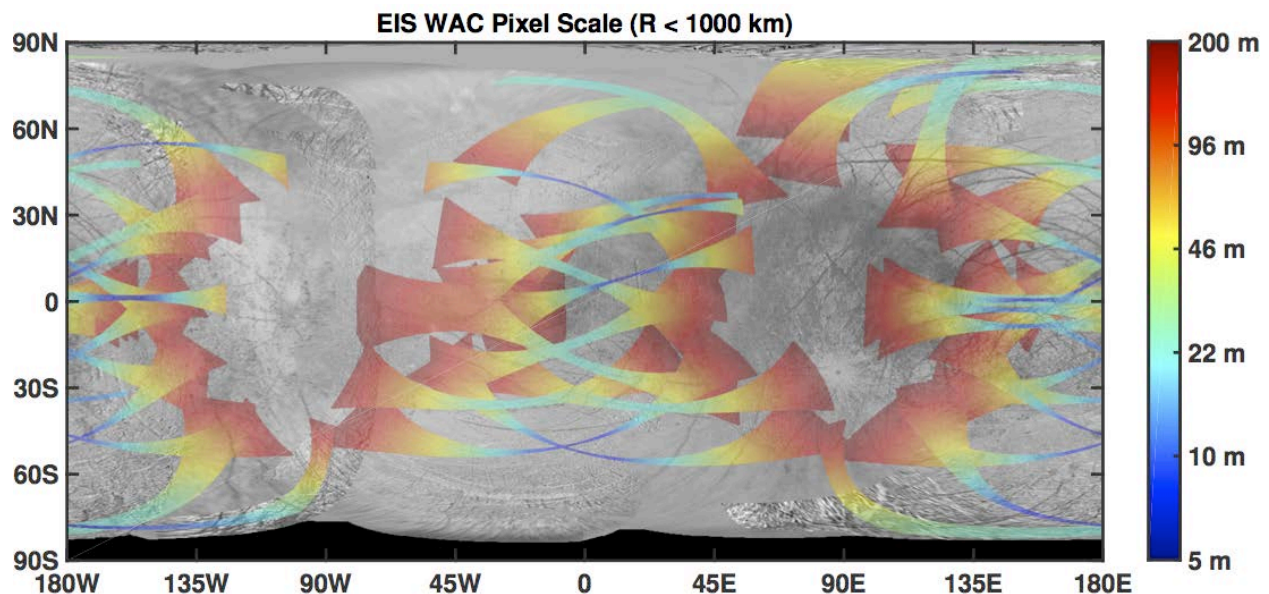

Figure 2. EIS WAC coverage, including 3-line stereo and color imaging, color-coded by pixel scale, shown for imaging at altitudes below 1000 km for the same mission trajectory (15F10) as in Fig. 1.