EUROPA LANDER STEREO SPECTRAL IMAGING EXPERIMENT (ELSSIE). Scott L. Murchie1 (scott.murchie@jhuapl.edu), John Boldt1, Bethany L. Ehlmann2,3, Karl Hibbitts1, Russell S. Layman1, Joseph J. Linden1, Jorge I. Núñez1, Frank P. Seelos1, Kimberly D. Seelos1, and Calley L. Tinsman1. 1Johns Hopkins University Applied Physics Laboratory, 11101 Johns Hopkins Rd., MS 200-W230, Laurel MD 20723. 2California Institute of Technology, 1200 E. California Blvd., MC 150-21, Pasadena, CA 91125. 3Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109.

Introduction: Among the icy moons of the outer solar system, Europa provides an opportunity to answer some of the highest priority questions identified in the Planetary Science Decadal Survey: Beyond Earth, are there contemporary habitats elsewhere in the solar system? Do organisms live there now? Europa’s subsurface ocean is many times larger than Earth’s ocean, and sustained by tidal heating from Jupiter [e.g., 1]. Decades of research hypothesized that the ocean’s chemistry and sustained hydrothermal reactions at its floor could sustain extant life [e.g., 2-3]. Europa Lander will test this hypothesis by searching for biosignatures in situ on Europa’s ice crust.

In support of the search for biosignatures on Europa, determining habitability of Europa’s ocean, and understanding physical processes that modify Europa’s crust, we are prototyping ELSSIE under a ICEE-2 grant. ELSSIE would: 1) provide panoramic and workspace views to support sampling and geological analyses; 2) collect visible and infrared data to identify and map enrichments in organics and non-ice phases and determine which ice is least radiation-damaged, thus supporting selection of the best samples for detailed in situ analysis; and 3) survey the landscape for spectral evidence of active surface processes (Fig. 1).

Instrument Overview: ELSSIE’s sensor combines a 20-filter, 0.4–3.6 µm multispectral stereo imager based loosely on the Imager for Mars Pathfinder design [4] with a 0.8–3.6 µm point spectrometer, which all share a single radiation-shielded HgCdTe focal plane. ELSSIE would provide stereo and imaging/spectroscopic measurements of reflected light from visible to shortwave-infrared wavelengths. The Sensor is supported by a Data Processing Unit (DPU) based on that of the Mapping Imaging Spectrometer for Europa (MISE) on Europa Clipper [5]. Current work focuses on minimizing sensor mass and volume, qualifying mechanical designs for Europa’s cryogenic surface environment, demonstrating survival over the wide temperature range from cryogenic surface operation to heated microbial reduction, and demonstrating resiliency of the DPU data processing pipeline.

Sensor: The sensor would reside on the high-gain antenna and contains a stereo, multispectral camera and a single point spectrometer. The three optics would use fold mirrors to image onto different portions of a passively cooled 2048x2048 HgCdTe focal plane that resides within a radiation shield whose materials and thicknesses are patterned after those of MISE, which are designed to a radiation fluence that is worst-case at Europa’s surface.

Each of the 2 cameras (Fig. 2) has a slightly different refractive design with two 6-position filter wheels (providing 10 spectral filters plus a clear) positioned, and each subtends a 15°x15° field-of-view with 700x700 pixels on the HgCdTe detector. A set of five right-eye filters replicates those of Europa Imaging Sensor: System (EIS) [6] (designated “E” in Fig. 3); a second filter set covers 1.4–1.65-µm to detect hydrated salts (“S”). Two additional filter sets detect organic compounds based on absorptions at 3.3–3.4 µm (“O”), and characterize ice crystallinity and grain sizes using features at 1.25, 1.65, and 3.1 µm (“T”). Both eyes have adjustable focus from 50 cm to infinity.

The point spectrometer samples a 2-mrad spot at 8.5 nm/channel, augmenting multispectral imaging detections of compositional variations with higher spectral resolution assessment of the spectral signatures of phases that are present (Fig. 4).

All three optics include calibration lamps behind a partially silvered mirror to provide non-uniformity (flat-field) calibrations when pointing to space before and after each imaging campaign.

DPU: The DPU architecture adapts elements from flight and ground systems of both MISE and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) to mitigate radiation noise and return data within the budget of Europa Lander’s limited downlink. Adapting an approach developed for MISE, the DPU merges multiple short exposures within a single filter after first discarding the highest values at each pixel, which would be radiation hits (Fig. 5), with the resulting merged images having enhanced signal-to-noise ratio (SNR; Fig. 3). Onboard calibration uses background and lamp images taken while looking at space, plus ground-derived calibration matrices, and z-stacking merges same-filter images taken at different focus positions. The DPU co-registers calibrated images from different filters, and uses onboard image math to reduce 20-filter data to a few “summary product” images (a technique developed on CRISM [7]) that indicate strengths of absorption bands of interest. These products can be highly com-
pressed and downlinked for rapid identification of compositional heterogeneity and potential sampling sites. Additional DPU image compression (pixel-binning, sub-framing, and lossless or lossy compression) is applied to data from 9 imaging campaigns to enable broad science investigations and tactical support within constrained downlink. Downlinked data consist of stereo pairs, RGB color constructs from “E” filters, 2x2 or 4x4 pixel-binned summary products, and point spectra of regions of interest (ROIs). Unbinned, calibrated data are saved onboard using ~43 of ~189 Gb available storage space; 20-color images can be returned as needed.

**Concept of Operations:** The imaging campaigns use 160 of 600 Mb available downlink and include: (a) immediately after landing, stereo mosaics of lander hardware and the workspace, and an RGB panorama of the quadrant above the workspace; 3 hrs after landing, (b) a summary product mosaic of the workspace and (c) a stereo mosaic of the surrounding terrain. On subsequent sols there are (d) 330-channel point spectra of candidate sampling sites and ROIs; (e) early- and late-mission summary product mosaics of the 1.25- and 1.65-µm bands to detect changes in ice grain size or crystallinity; (f) post-sunset plume-search horizon mosaics; (g) before and after stereo/spectral imaging of the trench excavated for sample collection; (h) a stereo/RGB time series of excavation; and (i) stereo/spectral imaging of the sampled sites within the trench.