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Cold Lightweight Imagers For Europa (C-LIFE)

Shane Byrne[1], Christian d'Aubigny[1], Bashar Rizk[1], Linda Powers[1], Michael Ward[1], Alyssa Baller[1], Steve Meyer[1], Elizabeth Turtle[2], and Alfred McEwen[1]

[1]University of Arizona
[2]JHU Applied Physics Lab.

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Abstract

C-LIFE is a landed camera suite, suitable for Ocean World surfaces, consisting of a color Context Reconnaissance Stereo Imager and an LED flashlight that can also identify biogenic material through fluorescence. The C-LIFE design leverages ongoing work (with industry partners Space Dynamics Lab, SRI International and Ball Aerospace) from our ICEE-2 and COLDTech awards in low-temperature detector qualification, radiation modeling and mechanical design. It takes advantage of our development work on the Descent Imager for Europa Hazard Avoidance and Radiation Durability (DIEHARD) and camera development on other missions. The C-LIFE camera head is mounted on the Europa Lander's high gain antenna, which provides tilt and pan capability. Minimal electronics in the camera head control and read out the detector and LEDs. Electronics in the lander vault perform most camera functions and image processing. C-LIFE contains no moving parts. In lieu of a focus mechanism, C-LIFE utilizes high F/number optics and a field of view elongated in the vertical direction with progressive focus from top (infinity e.g. imaging horizon) to bottom (close e.g. imaging sample delivery port). Strip filters (that match Europa Clipper's Europa Imaging System) on the detectors and partly-overlapping images provide color coverage. Heaters warm C-LIFE to operating temperatures, allowing self-heating to take over, but otherwise the camera is unheated in order to conserve energy. We combine two independent eyes into one mechanical housing (Figure 1) with a dual periscope design, which reduces the mechanical envelope, shielding mass, heating energy and total cabling distance. We use LEDs in three bands to illuminate and to excite fluorescence. Fluorescence excited by these three bands can identify the presence of key metabolic biomarkers and discriminate the quantities of live cells, dead cells and spores in a terrestrial setting. Figure 1. A dual-periscope design, with eyes 20 cm apart, folds optical trains (incoming rays in gray) to mutually shield focal planes. Fold mirrors locate LEDs inside the camera for shielding.

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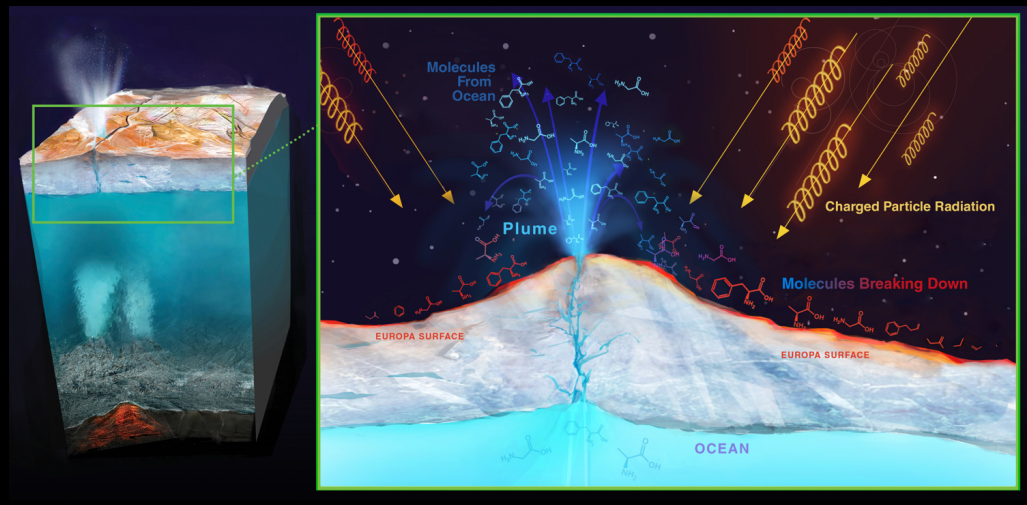
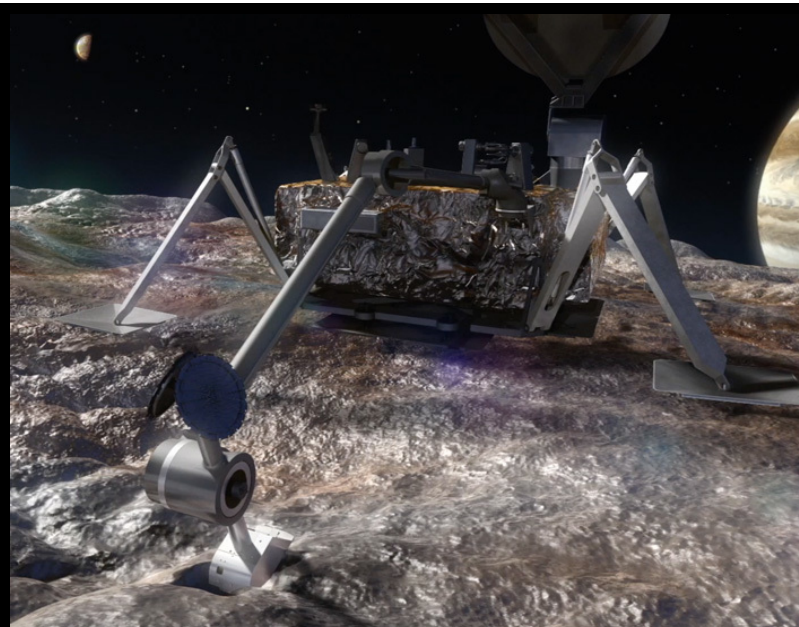
Due to observed plumes, the Europan surface is a means to investigate its ocean…

…but the Europan Surface is a hostile location



Our Camera Design Overcomes Five Major Challenges

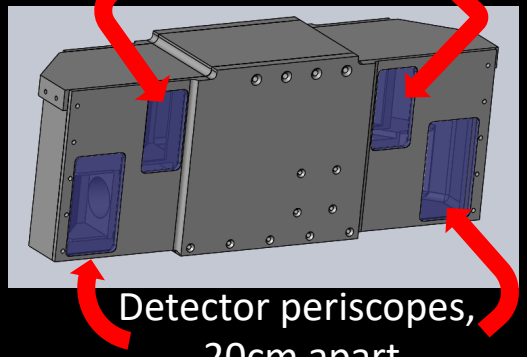
- Radiation
- Planetary Protection
- Low Ambient Temperature
- Low Available Energy
- Very Low Downlink

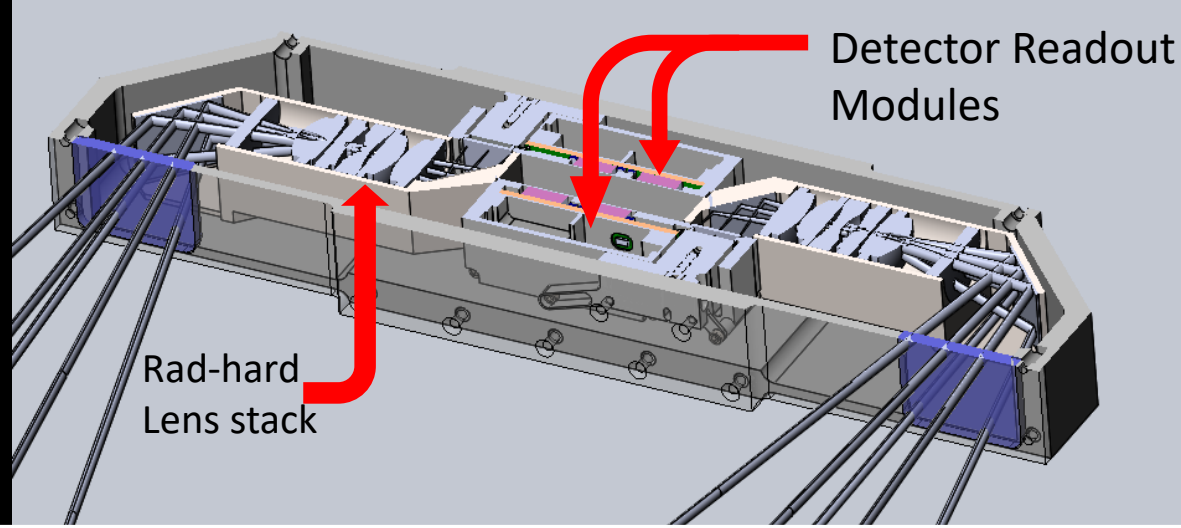


Radiation & Planetary Protection:

Dual-periscope design maximizes self-shielding

Parts survive required thermal sterilization and radiation doses



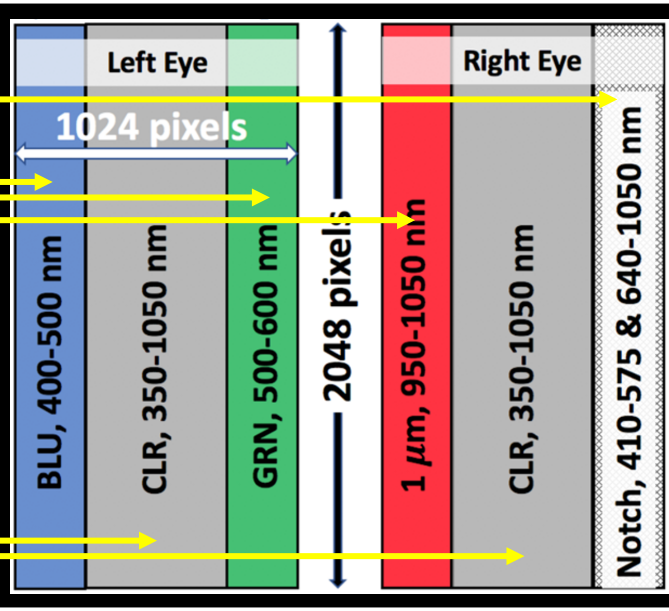


Low Temperatures & Energy:

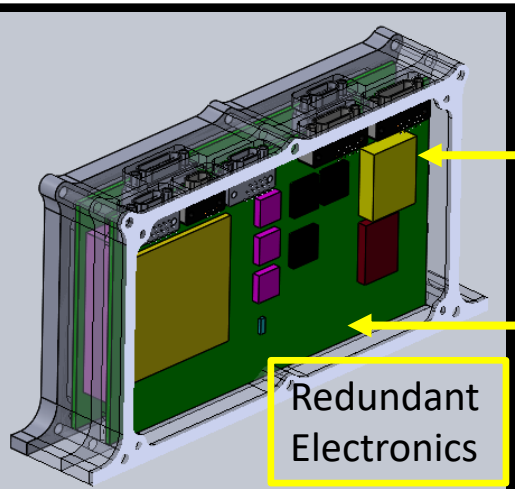
No moving parts or deployable covers with progressive focus and strip filters
Cryogenic storage and no survival heating between observing sessions

Fluorescence excited by three separate LEDs and detected by one notch filter

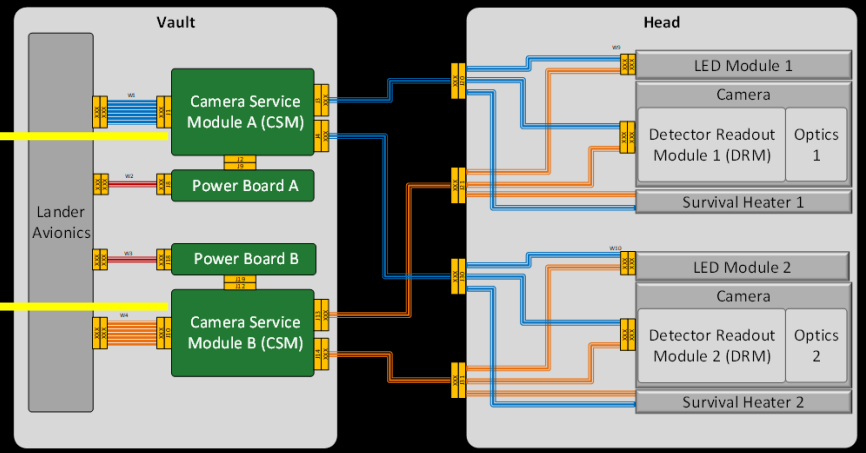
Color filters match the camera on Europa Clipper



Stereo in Pan



Redundant Electronics



Low Downlink:

Multi-image median filtering and wavelet compression. More-advanced tools in future work.

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C-LIFE has high impact on mission success and Europan science.

- Color stereo panorama
- Fluorescence of organic materials in three bands
- Plume detection through forward scattered light near east/west horizon
- Change detection at excavation site and through tidal effects
- Autonomous operation, higher-level product generation and smart algorithms to prioritize downlink