ENCELADUS ORBILANDER: A MISSION CONCEPT STUDY TO SEARCH FOR SIGNS OF LIFE. S. M. MacKenzie[1], M. Neveu[2], A.F. Davila[3], J.I. Lunine[4], K.L. Craft[1], M.L. Cable[5], J.L. Eigenbrode[2], R. Gold[1], C.M. Phillips-Lander[6], J.D. Hofgartner[5], J.H. Waite[6], C.R. Glein[6], C.P. McKay[3] and the Orbilander Team [1]Johns Hopkins Applied Physics Lab, [2]NASA GSFC [3]NASA Ames [4]Cornell University [5]JPL Caltech [6]SwRI (shannon.mackenzie@jhuapl.edu)

Introduction: The search for signs of life elsewhere in our solar system is both timely and realistic, thanks to synergistic efforts from the planetary sciences and astrobiology communities, and advances in strategies to identify biosignatures and codify their interpretations. Critically, flight instruments that target a variety of biological traits—and, importantly, the systems to collect and prepare sample for those instruments—have reached increased levels of technical maturity thanks to NASA programs like MatISSE, PICASSO, ICEE2, COLDTech and SESAME.

Enceladus, a ~500 km diameter moon of Saturn, offers a unique opportunity to bring the fruits of these efforts to bear. Cassini's in situ exploration of the Saturn system revealed not only that a plume of ice and water vapor emanates from Enceladus' south pole, but that these materials are ultimately sourced from a subsurface ocean. Evidence of water-rock interactions and organic materials suggests that sources of metabolic energy and bio-essential compounds are present. Enceladus' plume enables sampling a habitable ocean without drilling through kilometers of rock or ice.

To demonstrate the feasibility of returning to Enceladus to search for signs of life in plume materials, we investigated four different mission architectures for the 2023-2032 Decadal Survey. All four concepts were capable of returning significant astrobiological science, but we found the best balance of resources and scientific return to be Orbilander (Figure 1), a single spacecraft that would first orbit Enceladus and then land on the surface. For a detailed discussion, see [1].

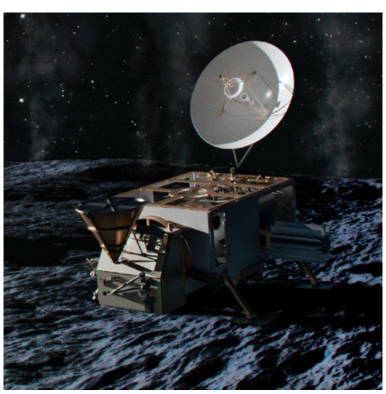

Figure 1: Artistic representation of the Orbilander concept during landed operations: HGA is deployed for sending data back to Earth and the funnel collects plume fallout.

Mission Overview: The notional design would launch in 2038 on a direct trajectory. After Saturn orbit insertion in 2045, a 4.5-year moon tour decelerates the spacecraft enough to get into Enceladus orbit. Science operations begin with at least 1.5 years in Enceladus orbit conducting both life detection and remote sensing science, as well as collecting the data necessary to identify a safe landing site. Landing occurs as early as 2051 but can be delayed if more time is needed in orbit. Descent and landing are enabled by terrain-relative navigation and hazard avoidance. Landed operations include characterizing the landing site for suitable sample excavation areas, life detection analyses, and seismic monitoring of the moon's interior and would continue for 2 years. Two Next-Generation RTGs power the spacecraft. Ka-band downlink over the course of the science mission returns 1.1 Tbits of data.

Science Objectives and Payload: Orbilander's primary goal is to search for evidence of life. A positive result requires multiple lines of evidence. We therefore defined five objectives that map to seven potential biosignatures: 1. Amino acid abundance distributions and enantiomeric excess, 2. Lipid abundance distributions and structures, 3. Molecular Assembly Number, 4. Genetic biopolymer, 5. Cell characterization. Objectives 1-3 discriminate between biotic and abiotic sources of organic matter, and therefore deliver impactful science whether life is present or not. Objectives 4 & 5 provide insights into the nature of Enceladean life, if present. The instrument types needed to meet these objectives are largely at high TRL, and include a high-resolution mass spectrometer (HRMS), a separation-capable mass spectrometer (SMS), an electrochemical sensor array (ESA), microcapillary electrophoresis and laser-induced fluorescence (µCE-LIF), microscope, and a solid-state nanopore sequencer.

Orbilander would also advance fundamental planetary science. The secondary science goals are to characterize the interior, determine plume ejection mechanics and assess ocean habitability. A combination of in situ (HRMS, SMS, µCE-LIF & seismometer) and remote sensing instruments (narrow- and wide-angle cameras, a radar sounder, a thermal emission spectrometer, a laser altimeter, & a context imager) meet these goals using in orbit and surface data.

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References: [1] MacKenzie et al. 2021 *PSJ* 2 77 https://doi.org/10.3847/PSJ/abe4da