NASA SBIR/STTR — Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2018 Phase I Solicitation

S1.11 In Situ Instruments/Technologies and Sample Processing for Ocean Worlds Life Detection

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC, MSFC

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

This subtopic solicits development of in-situ instrument technologies and components to advance the maturity of science instruments focused on the detection of evidence of life, especially extant of life, in the Ocean Worlds (e.g., Europa, Enceladus, Titan, Ganymede, Callisto, Ceres, etc.). These technologies must be capable of withstanding operation in space and planetary environments, including the expected pressures, radiation levels, launch and impact stresses, and range of survival and operational temperatures. Technologies that reduce mass, power, volume, and data rates for instruments and instrument components without loss of scientific capability are of particular importance. In addition, technologies that can increase instrument resolution and sensitivity or achieve new & innovative scientific measurements are solicited.

In addition, this subtopic solicits development of innovative sample processing technologies (methodologies and hardware) for the purposes of improving the resolution and sensitivity of life detection measurements and supporting habitability assessment of environmental samples from Ocean Worlds (e.g., Europa, Enceladus, Titan, etc.). Samples are expected to contain water, minerals, salts, etc. that may complicate measurements or interfere with interpretations. Thus, samples are expected to require separation of components as a preparatory step to analysis. Analytes of interest (e.g., organic molecules including biomolecules, cells, and inorganic solutes and particulates) in samples may also be too dilute and could escape detection unless concentration technologies are applied as a preparatory step. These technologies must be capable of operation under space and planetary conditions, including the extreme pressures, temperatures, radiation levels, stress from launch and impact. Technologies should be of low mass, power, volume; capable of radiation-hardening and sterilization; and require low data rates. Technologies that minimize biological and analytical contamination of the sample stream in order to meet planetary protection requirements and can maintain sample integrity for mission-science investigations and support integration of contamination and/or analyte monitoring are solicited.

For synergistic NASA technology solicitation, see ROSES 2016/C.20 Concepts for Ocean worlds Life Detection Technology (COLDTECH) call:

- https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId=%7B5C43865B-0C93-6ECA-BCD2-A3783CB1AAC8%7D&path=init.

Specifically, this subtopic solicits instrument technologies and components that provide significant advances in the following areas, broken out by planetary body:

- *Europa, Enceladus, Titan and other Ocean Worlds in general* - Technologies and components relevant to life detection instruments (e.g., microfluidic analyzer, MEMS chromatography/mass spectrometers, laser-ablation mass spectrometer, fluorescence microscopic imager, Raman spectrometer, tunable laser system, liquid chromatography/mass spectrometer, X-ray fluorescence, digital holographic microscope-fluoresce microscope, Antibody microarray biosensor, nanocantilever biodetector etc.) Technologies for high radiation environments, e.g., radiation mitigation strategies, radiation tolerant detectors, and readout electronic components, which enable orbiting instruments to be both radiation-hard and undergo the planetary protection requirements of sterilization (or equivalent).

- *Technologies and components relevant to sample processing of water and ice samples from plumes, surface ice, subsurface ice, or sub-ice waters* - Examples of such technologies include, but are not limited to: sonic processing; subcritical and critical solvent extraction; solid-phase extraction; cell isolation, concentration, and lysing; filtering, separation by osmosis and dialysis; chemical hydrolysis and derivatization; novel substrates or adaptives to enhance sensitivity or selectivity of target analytes; total organic carbon, pressure, temperature, pH, eH, dissolved ion monitoring and regulation components; miniaturized components such as microfluidic valves and pumps; and other fluid and solid handling systems following separation and concentration processing components).
- *Europa* - Life detection approaches optimized for evaluating and analyzing the composition of ice matrices with unknown pH and salt content. Instruments capable of detecting and identifying organic molecules (in particular biomolecules), salts and/or minerals important to understanding the present conditions of Europa’s ocean are sought (such as high-resolution gas chromatograph or laser desorption mass spectrometers, dust detectors, organic analysis instruments with chiral discrimination, etc.). These developments should be geared towards analyzing and handling very small sample sizes (mg to mg) and/or low column densities/abundances. Also of interest are imagers and spectrometers that provide high performance in low-light environments (visible and NIR imaging spectrometers, thermal imagers, etc.), as well as instruments capable of providing improving our understanding Europa’s habitability by characterizing the ice, ocean, and deeper interior and monitoring ongoing geological activity such as plumes, ice fractures, and fluid motion (e.g., seismometers, magnetometers). Improvements to instruments capable of gravity (or other) measurements that might constrain properties such as ocean and ice shell thickness will also be considered.
- *Sample-processing approaches optimized for particulate, inorganic chemicals, and organic molecules of possible biological origin in aerosols and surface materials* - Mechanical and electrical components and subsystems that work in cryogenic (95 K) and hydrocarbon-rich environments; sample extraction from liquid methane/ethane and/or hydrogen cyanide, sampling from organic 'dunes' at 95 K and robust sample preparation and handling mechanisms that feed into spectral and mass analyzers, as well as X-ray detection devices are solicited.
- *Enceladus* - Life detection approaches optimized for analyzing plume particles, as well as for determining the chemical state of Enceladus’ icy surface materials (particularly near plume sites). Instruments capable of detecting and identifying organic molecules (in particular biomolecules), salts and/or minerals important to understand the present conditions of the Enceladus ocean are sought (such as high resolution gas chromatograph or laser desorption mass spectrometers, dust detectors, organic analysis instruments with chiral discrimination, etc.). These developments should be geared towards analyzing and handling very small sample sizes (mg to mg) and/or low column densities/abundances. Also of interest are imagers and spectrometers that provide high performance in low-light environments (visible and NIR imaging spectrometers, thermal imagers, etc.), as well as instruments capable of monitoring the bulk chemical composition and physical characteristics of the plume (density, velocity, variation with time, etc.). Improvements to instruments capable of gravity (or other) measurements that might constrain properties such as ocean and ice shell thickness will also be considered.
- *Titan* - Life detection approaches optimized for searching for biosignatures and biologically relevant compounds in Titan’s lakes, including the presence of diagnostic trace organic species, and also for analyzing Titan’s complex aerosols and surface materials. Mechanical and electrical components and subsystems that work in cryogenic (95 K) environments; sample extraction from liquid methane/ethane, sampling from organic 'dunes' at 95 K and robust sample preparation and handling mechanisms that feed into mass analyzers are sought. Balloon instruments, such as IR spectrometers, imagers, meteorological instruments, radar sounders, solid, liquid, air sampling mechanisms for mass analyzers, and aerosol detectors are also solicited. Low mass and power sensors, mechanisms and concepts for converting terrestrial instruments such as turbidimeters and echo sounders for lake measurements, weather stations, surface (lake and solid) properties packages, etc. to cryogenic environments (95 K).

Other Ocean Worlds targets may include Ganymede, Callisto, Ceres, etc. Proposers are strongly encouraged to relate their proposed development to: NASA's future Ocean Worlds exploration goals. Existing flight instrument capability, to provide a comparison metric for assessing proposed improvements.

Proposed instrument architectures should be as simple, reliable, and low risk as possible while enabling compelling science. Novel instrument concepts are encouraged particularly if they enable a new class of scientific discovery. Technology developments relevant to multiple environments and platforms are also desired.

Proposers should show an understanding of relevant space science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.