A Mission Concept for Investigating Habitability on Enceladus

Silenus (Spectrometer Investigating the Livability of Enceladus with a Network of Underground Seismometers) is a New Frontiers mission to study Enceladus and determine its habitability potential. The spacecraft system consists of an orbiter and a network of penetrators that will reach the surface. Building on the discoveries of the Cassini mission, Silenus is the next step in increasing our understanding of the interplay of chemistry and geophysics in the support of life. The spacecraft will peer into the icy plumes of Enceladus, identifying specific life-critical gases, molecules, and ions. Simultaneously, it will scan the planet to measure topography, exceeding the standard set by Cassini. Finally, the mission will place four seismometers to directly study the ice sheet and core.

A World Awaiting

A tiny icy-world with water-plumes, Enceladus is one of the most geologically active bodies of the solar system. It harbours a subsurface ocean few kilometers below its icy surface. The ocean feeds water-plumes that emanate from long parallel fractures in the South pole reaching hundreds of kilometers altitude. Cassini detected the simple building blocks of life but it was not equipped to address life itself or habitability. Silenus will assess whether Enceladus provides the necessary conditions to sustain biotic or prebiotic activity.

Science Goals and Objectives

Silenus will look for present or past habitable environments in Enceladus, and understand these aspects by addressing the following research questions:

1. Understand the biologically-relevant chemistry of the Enceladus plume by:
   a. Determining the abundance, provenance and distribution of plume organic constituents.
   b. Determining salts, pH , and salinity of the ocean.
2. Understand the geophysical context and history of Enceladus.
   a. Characterise Enceladus' interior.
   b. Understand the exchange pathways between the ocean, ice shell and core.

Voyage to Enceladus

Launching in 2028, Silenus will take 13 years to reach Enceladus. Of that time, the journey to the Saturnian system will take 10 years by looping four times around the sun, executing a sequence of gravity assists with Earth and Venus. Silenus then transitions into Enceladus orbit using another gravity assistance over three years. Upon arrival the spacecraft will fly in a HALO polar orbit to fly 15 times through the plume at an altitude of 30 kilometers and drop off three of the four penetrators in SPT. Finally, Silenus settles into a nominal science orbit of altitude 250 kilometers and deploy the remaining penetrator at Samarkand Sulcus.
Mission Design

Silenus will be the first solar-powered spacecraft to operate in the Saturnian system, using solar panels in a way analogous to Juno. The orbiter will fly through the plume, taking detailed measurements of organic molecules. The penetrators consist of a seismometer and a context camera dropped sequentially on the surface and perform operations for two weeks while communicating with the orbiter. The orbiter will relay this data to Earth and simultaneously perform altimetry observation. At the conclusion of the mission, the orbiter will be disposed by deorbiting into the uninhabitable moon Tethys, thus protecting Enceladus from potential contamination.

Instruments

Silenus is equipped with a set of instruments to perform chemical and geophysical measurements. Silenus will fly through the plumes to collect uplifted ocean material for organic and inorganic chemical analysis, while scanning the surface topography and characterizing the gravity field in concert with a seismic network to determine Enceladus interior structure.

Illustration of Orbiter and Penetrator with instruments indicated:

- Capillary electrophoresis
- Mass spectrometer
- Capillary Electrophoresis
- Ion-selective Electrodes
- Context Imager
- Seismometers
- Altimeter
- Transponder