VENUS LIFE FINDER MISSIONS: SAMPLE COLLECTION STRATEGY

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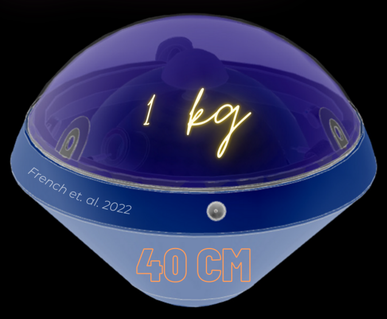
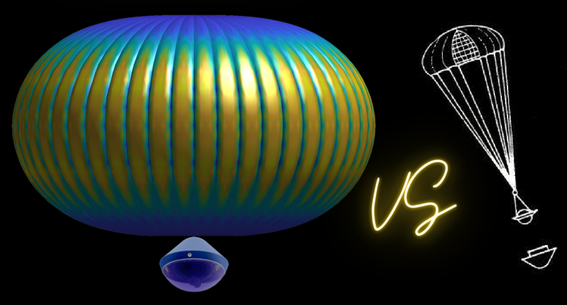
Early Venus, Earth, and Mars likely harbored similar conditions in their early history, but billions of years later, life as we know it was only detected on Earth. The relatively high deuterium-to-water ratio in Venus' atmosphere brings the possibility of a large proto-ocean presence on a potentially habitable surface. The surface of modern Venus is hostile to life; however, the possible migration of life to the cloud-deck biosphere has been discussed for a long time. Previous missions and ground-based observations revealed various unexplained phenomena associated with Venus' mysterious clouds: (i) the presence of large non-spherical particles in the lower cloud layer, (ii) unknown Ultraviolet absorber, (iii) uniformed water content in the cloud layers, (iv) the presence of biosignature phosphine gas, and (v) the presence of ammonia that can neutralize sulfuric acid. Now, the MIT-lead Venus Life Finder consortium is planning the astrobiological mission series to (a) search for organic compounds in the cloud particles, (b) measure the acidity and dryness of the cloud particles, and (c) sample return to search for cell-like structures and complex organic biopolymers. Only dedicated in-situ analysis of cloud particles, supported by a dedicated and selective cloud particle capture system (with potential sample return in the far future), would reveal either an unknown abiotic chemical process or the extraterrestrial life discovery. This presentation focuses on the preliminary strategy for Venusian cloud collection.

Q1 2025



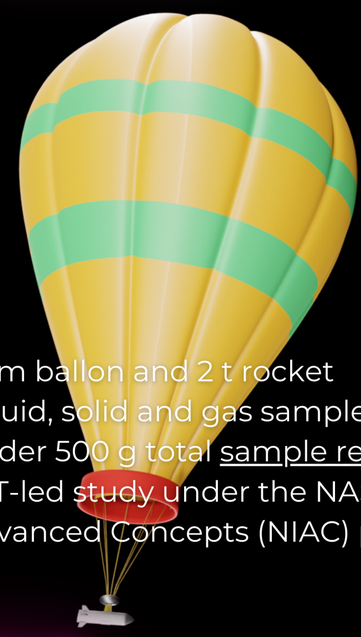
- Rocket Lab private planetary mission
- Encapsulated autofluorescence nephelometer
- 330 s fly-through the cloud deck
- Organic chemicals and habitability indicators
- MIT-led science case and data interpretation

2030S



- Multiday Venusian cloud sampling & analyses
- Mass spectrometry of collected clouds
- Dryness of the clouds
- Acidity of individual droplets (see poster by Kaasik and keynote talk by Pajusalu)

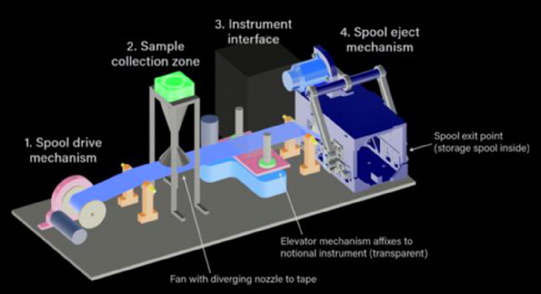
2050S



- 35 m ballon and 2 t rocket
- Liquid, solid and gas samples
- Under 500 g total sample return to Earth
- MIT-led study under the NASA Innovative Advanced Concepts (NIAC) program

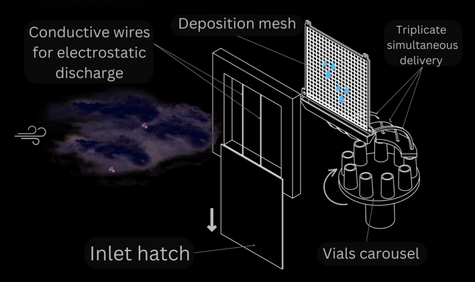
SOLID SAMPLE

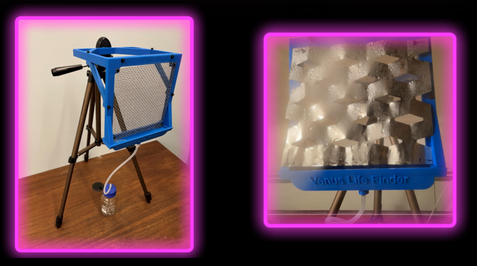
- Honebee Robotics leads the development of solid sample capture
- Gold tape with edge knife
- 1 g of solid material should contain in the order of three million particles



Credit: I.R. King , Honeybee Robotics

LIQUID SAMPLE





- Deposition surfaces: mesh, parallel lines, or Kirigami surface
- The collection efficiency is increased by electrostatic ionization of aerosols, which are deposited by Coulomb force
- Venusian clouds stretch from 48 to 66 km and are composed of the lower, middle, and upper layers
- 0.4 μm and 2 μm aerosols are present in all layers, 7 μm only in the middle and lower layers
- 1 mL of collected material represents ~10^9 to 10^{13} particles
- We target the daily collection of up to 10 mL in the lower clouds, 3 mL in the middle, 0.1 mL in the upper layer

AEROSOL HARP

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