2017 Space Academy
NASA Glenn Research Center

Surface Analysis of Venus's Atmosphere and Geophysical Events (SAVAGE)

Santino Bianco, Callie Jakuszeit, Daniel Tiffin, Andre Antoine, Brad Sievers, Tibor Kremic, Jeff Balcerski, Gary Hunter
21000 Brookpark Rd, Cleveland, OH 44135

Introduction

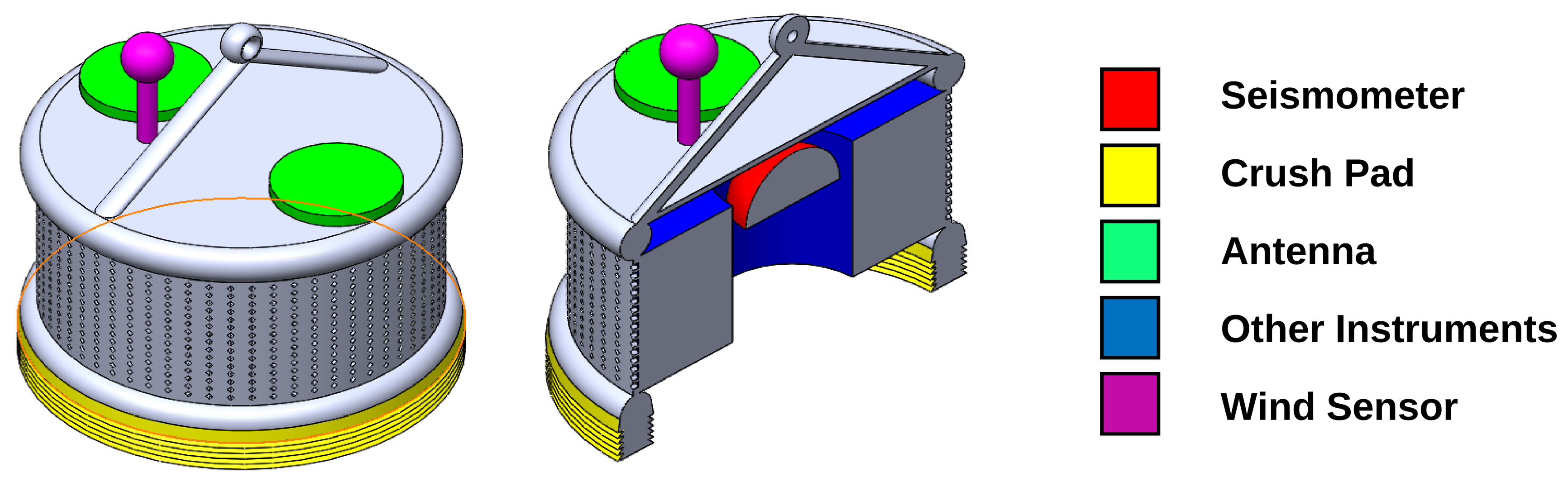
This "Pathfinder Class" lander/orbiter concept would demonstrate the capabilities of high temperature sensors and electronics and return the first in situ temporal data on the climate and geophysical activity of Venus. This concept builds on the Long-Life In-situ Solar System Explorer (LLISSE) probe. Assuming a ride-along launch and deployment, a cost limit of $250 million and a maximum system mass of 185 kg, preliminary analysis finds a mission consisting of up to five surface landers with two CubeSat relay orbiters for communication to be potentially feasible and worth future study.

Science Objectives

The science objectives of this mission concept were informed by the scientific questions published in the 2013-2022 Planetary Science Decadal Survey, the VEXAG 2014 Final Report, and the 2009 Venus Flagship Mission Study. The mission science objectives were then narrowed to those investigations which could be informed by a long-duration surface lander. Two overarching questions emerged: 1) What can be learned about the current climate of Venus, specifically the processes that control atmospheric super-rotation and the runaway greenhouse effect; 2) How active is Venus?

Lander Concept

Each probe weighs approximately 18 kg, is powered by a thermal battery, and is designed to last 120 days on the surface of Venus at ambient conditions. The probes are duplicates to minimize cost and provide redundancy. The probe will take initial measurements upon landing, two-minute periodic measurements every eight hours, and seismic event measurements given a stimulus. The maximum required data transmission was found to be 96 bits/s. The current lack of high temperature memory necessitates that seismic event data be transmitted immediately. Therefore, maximizing communication windows between the landers and orbiters is a high priority.



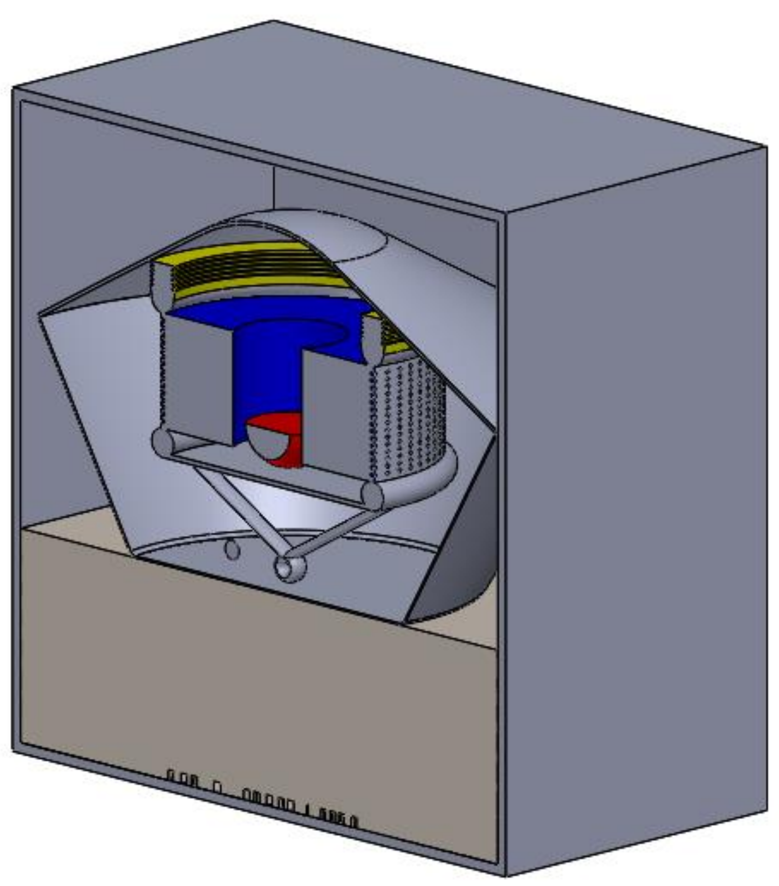
Scientific Instrument Suite

Instruments	Description	Science Goals
Seismometer	Measure amplitude and frequency of seismic and volcanic activity	• Characterize contemporary and model historic rates of seismic and volcanic activity • Determine composition and size of the core, mantle, and crust
MEMS Chemical Sensor Array	Measure PPM of CO, SO_x, OCS, H_2, HF, HCl, NO, O_2, and H_2O	• Characterize atmospheric chemistry at the surface • Determine the effects of outgassing fluxes on the climate balance
Atmospheric Science Instrument	Measure temperature, pressure, and wind velocity	• Characterize the dynamics and variability of Venus's weather below 10 km, specifically the day to night transition
Heat Flux Plate	Measure heat flow from the surface to the atmopshere	• Determine how Venus is releasing its heat now and how this is related to resurfacing and outgassing • Pair with seismic measurements to search for evidence of modern volcanism
Net Flux Radiometer	Measure upwelling and down welling radiation	• Determine the atmospheric radiative balance • Relate radiative driving forces to measured atmospheric circulation
Magnetometer	Measure static and dynamic magnetic fields	• Characterize magnetic flux at the surface

Orbiter Concept

The first ever interplanetary CubeSat orbiter was proposed. Trades were conducted in orbiter size, propellant selection, delta-v versus orbit eccentricity, and lander view time versus transmission power requirements. The individual orbiters will have 86% with the probes. 100% visibility is possible with multiple orbiters. A 9U CubeSat, green monopropellant, and a 10-day orbit were found to be most feasible.

Potential Delivery Configuration



Probe, aeroshell, and CubeSat packaged in a 27 U P-POD

Conclusion

This concept builds on the LLISSE probe to expand the potential science return of a long-duration lander. With high-temperature technology development, a lander surviving 2 orders of magnitude longer than the current record is feasible. An expanded instrument suite and a preliminary CubeSat communication system were proposed to greatly enhance ability to address high priority science questions. The relatively small size of the duplicate landers and orbiters makes the mission scalable, and therefore flexible for ride-along with a fly-by or Venus-aimed mission. Improvements in high temperature memory and batteries with higher energy densities and or recharging capabilities would greatly increase science return. Further analyses into the delivery methods as well as instrument development are needed.

Contact: djt60@case.edu
636-675-6409