High-Temperature MEMS based Seismometer

PI: Tibor Kremic / NASA Glenn Research Center

Target: Venus, Mercury and on other high-temperature / harsh-environment solid surfaces

Science:

- Determine the rate and nature of the dynamics of the lithosphere of hot surfaces like Venus and Mercury
- Determine the structure and bulk composition of the interior of Venus and Mercury
- Insight into the geologic evolution of the surface

Objectives:

- Tailer MEMS seismic sensor from Insight mission heritage to enable operations at Mercury and Venus temperatures
- Develop electronics and data processing components and circuitry
- Integrate into a 1 axis seismometer and demonstrate in test at Venus conditions

Key Milestones Remaining:

- Field test in analogue seismic environment - 3/2025
- Seismometer demonstration in Venus conditions – late 2025

Cols: D. Spry/ NASA GRC, M. Krasowksi/NASA GRC, R. Herrick/University of Alaska, Fairbanks (UAF), B. Chow/UAF

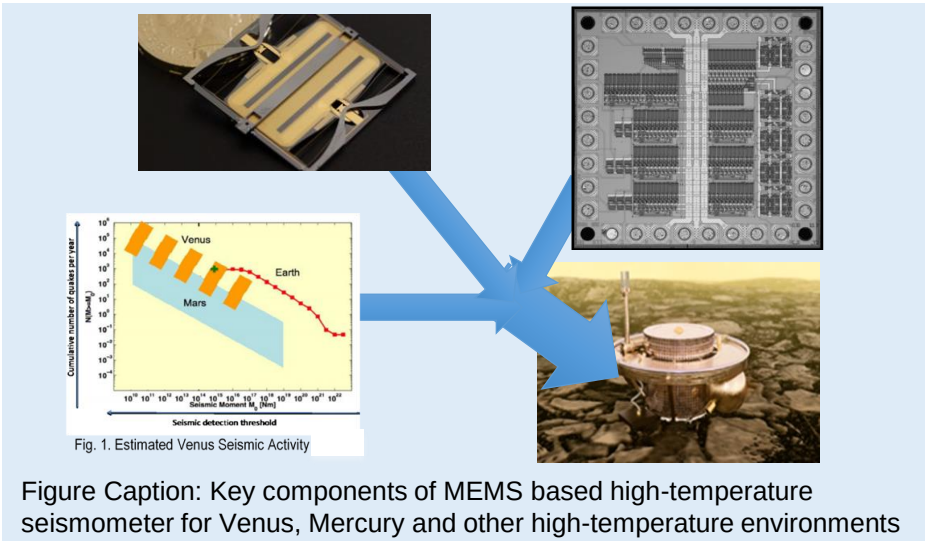


Fig. 1. Estimated Venus Seismic Activity

Figure Caption: Key components of MEMS based high-temperature seismometer for Venus, Mercury and other high-temperature environments

Technology Accomplishments:

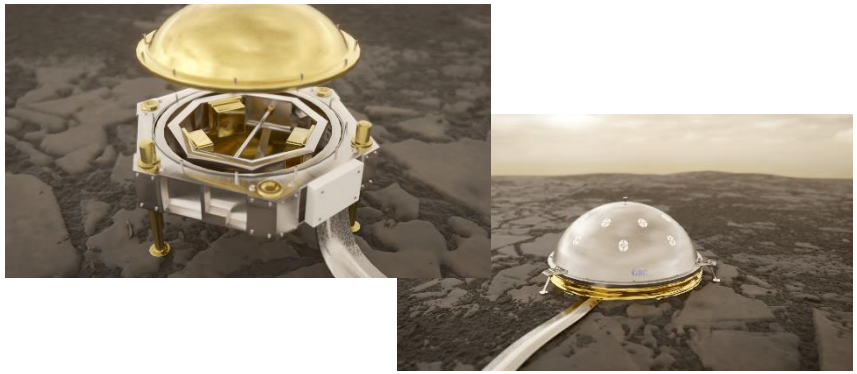
- Estimated Venus seismicity and determined required performance parameters
- Identified mods needed for heritage MEMS sensor – fabricated and tested at Venus conditions
- Designed and built driving circuitry including SI proxy version
- Designed and fabricating high-temp electronics to support sensor

Project start – Spring 2022
Project end – Fall 2025

TRL 2 to TRL 4

PSD Technology Development Specification Sheet

Title: High-Temperature MEMS based Seismometer
Technology Type: Sensor and supporting systems
PI: Tibor Kremic, Tibor.Kremic@nasa.gov, NASA Glenn
Program (21-HOTTCH21_2-0013)
TRL: Start= 2 Current= 2 Planned Exit= 4



Deployment: In-situ landed
Intended target(s): Venus, Mercury, and other hot surfaces

Current SWaP (at instrument level): (20cm/side, (mass), (100mW active mode)
Planned SWaP (Developed to TRL6): ~ ½ current size and weight, same or lower power level than current
Testing passed : Testing to date focused on highest risk - survival and operations at Venus conditions. Several rounds of testing at temperatures and in Venus conditions conducted of MEMS sensor and electronics components. Leveraging prior materials testing in Venus conditions for materials selection. Completed seismic characterization of environment to be used for analogue field and final performance testing.

Detailed specifications: Seismometer will be a 1 axis (readily expandable to 3 axis) based on a MEMS sensor. Seismometer will have indefinite life at Venus and Mercury surface conditions, assuming power availability. No seismometer exists today that can survive, let alone operate in these conditions. The target range is .1 to 5 Hz with a noise floor well below expected ambient noise levels. The seismometer will monitor vertical ground motion, conserving power, and when motion is detected, passing the filtering algorithm, data will be captured and immediately transmitted.
- Operating lifetime will be limited by the power source; requirement is a minimum of 120 days
- Performance capability is still being determined, driven by final electronics noise and sensor capability
- This instrument would be a compelling payload on a Mercury and Venus lander that carries long-duration operations capability as provided by a LLISSE or a like SAEVe platform. (E.g. Venus flagship, Mercury lander, Venera-D missions)
- Operating requirements: +/- 25V, tested for operations at 460C, 93 bar, and in reactive Venus like atmosphere