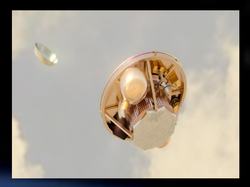
Seismic and Atmospheric Exploration of Venus (SAEVe) – A Revolutionary Long-Duration Lander for Venus

T. Kremic[1], M. Gilmore[2]

[1]NASA Glenn Research Center, 21000 Brookpark Road, Cleveland, OH 44135

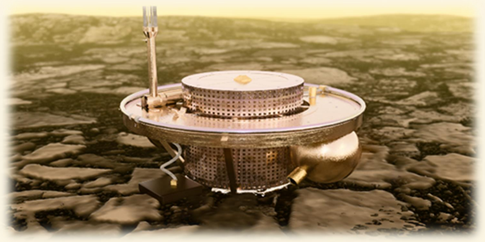
[2]Wesleyan University, Middletown, CT 06459

Kremic T., Ghail R., Gilmore M., Hunter G., Kiefer W., Limaye S., Pauken M. and Wilson C. (2020) Long-duration Venus Lander for Seismic and Atmospheric Science, *Plan. Space Sci.*, doi:10.1016/j.pss.2020.104961.



Introduction

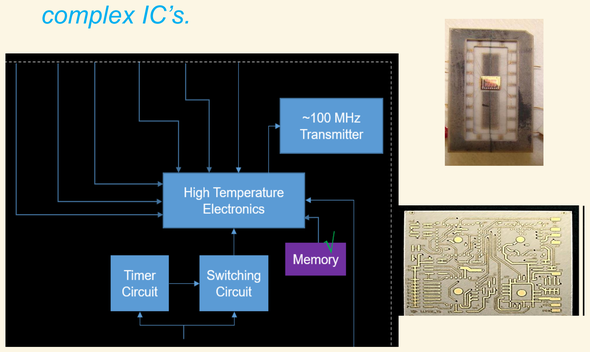
- Long-duration Insitu measurements on Venus are necessary
- The latest planetary decadal notes the need for in situ temporal measurements at the surface
- SAEVe is a small (<25kg, < 50cm) that returns the much-needed data
- Operates on the surface of Venus for >120 days taking seismic, meteorology, and other temporal data to:
  - Answer decadal science questions
  - Mature technology for future missions
- All lander systems are high-temperature and chemically compatible with Venus



Electronics and Comm Status / Need

- Currently demonstrating fabrication process for core required JFET devices.
- BJT device components successfully fabricated. Fabricating and testing full device for desired performance.
  - Last critical component for power switching and comm transmitter.

- *Further work –lower power sensors and instruments will enhance mission.*
- *Low power memory would be a key enhancement, especially for surface and interior science.*
- *Other enhancements could come from more complex IC's.*



High Temp board ready for addition of devices. Once populated board would be capable of executing LLISSE functions

Science Ladder

2 Landers

Science Objectives Tackled

1) Determine if Venus is seismically active and characterize the rate and style of activity,
2) Determine crust and lithosphere thickness and composition
3) Acquire temporal meteorological data to guide global circulation models
4) Estimate the momentum exchange between the planet and its atmosphere
5) Measure atmospheric chemistry variability
6) Determine current rate of heat loss from the Venus interior
7) Examine rock and soil distribution and morphology

One Lander

Science Objectives Tackled

1) Determine if Venus is seismically active and characterize the rate and style of activity,
2) Acquire temporal meteorological data to guide global circulation models
3) Estimate the momentum exchange between the planet and its atmosphere
4) Measure atmospheric chemistry variability
5) Determine current rate of heat loss from the Venus interior
6) Examine rock and soil distribution and morphology

De-Scoped Lander

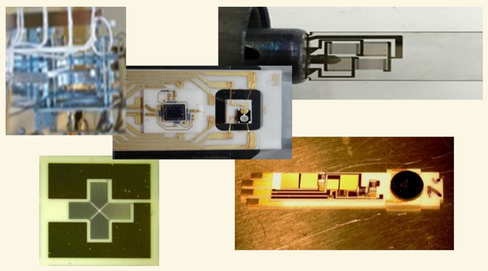
Science Objectives Tackled

1) Determine if Venus is seismically active and characterize the rate and style of activity,
2) Acquire temporal meteorological data to guide global circulation models
3) Estimate the momentum exchange between the planet and its atmosphere
4) Measure atmospheric chemistry variability,

SAEVe Science Ladder

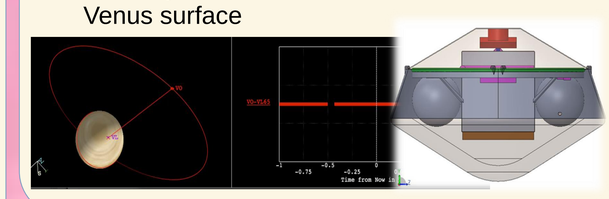
Sensors and Structure Status / Needs

- High-temperature instruments & sensors are at varying readiness levels – TRL 3 to 5+. Most at TRL 4 or >
- Development of a Venus seismometer under way as well (under HOTTech-2)
- *Heat flow, geology/ chemistry instruments and additional camera development would be enhancing and enabling for some science*



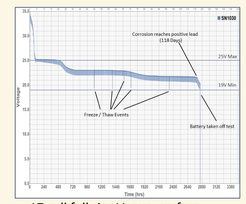
Concept of Operations

- SAEVe is delivered by a Venus orbiter that will relay data and do its own science
- Entry is via a small aeroshell
- SAEVe is dormant during launch and cruise and only becomes active as it nears the Venus surface

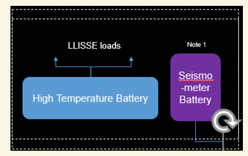


High-Temp Battery Status

- Currently performing sensitivity experiments to optimize battery packaging and mass for a flight-like 60-day battery.
- Trading packaging options to maximize robustness to off-nominal impacts, orientation, and operations.
- Developing detailed mission scenarios to assess housekeeping loads on battery life and verification testing for TRL-6.
- Test and demonstrate 1/3 scale thermal battery performance; investigate super critical CO2 exposure on electrochemical components.



17 cell full size Venus, surface temperature battery life test data



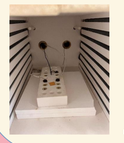
Power block diagram

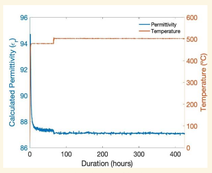
To Seismometer

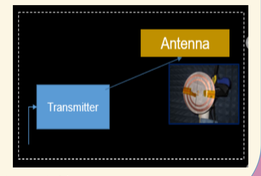
ATB 1/3 scale batteries delivered to GRC for testing

Communication System Status/Needs

- Recent BJT development progress is significant and is reduction risk and enhancing performance.
- Circuits have been designed and tested via simulations.
- Antenna and other component materials with appropriate properties at temperature and manufacturability at scales needed has been selected and tested.
- *Maturation of transmitter and antenna needs to be completed. High-temperature receiver would be highly desired and enhancing*







Oven testing and stability of high temperature antenna material

Conclusions and Acknowledgments

- A long-duration lander for Venus has been in development (LLISSE) and components/instruments are in development on other programs and making great progress
- Hardware exists for all sub-systems and various levels of testing have been completed
- Science enhancing projects have also been funded. E.g. Seismometer, memory, imaging

The resources for capabilities to achieve SAEVe have been generously provided by the Planetary Science Deep Space SmallSat Studies Program and NASA's Planetary Science Division.