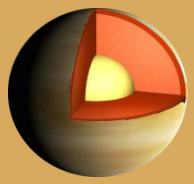


# Perspectives on the Future of Venus Exploration

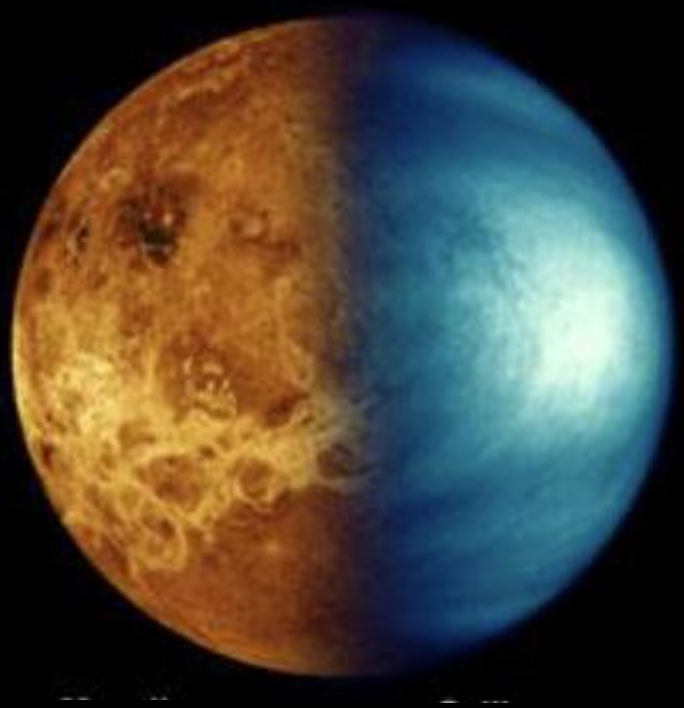
**James Cutts[1], Robert Grimm[2], Noam Izenberg and Paul Steffes and members of the VEXAG Executive Committee**

**Third International Conference on Instruments for Planetary Missions, 2016**

**Oct 24, 2016**

1. Jet Propulsion Lab, California Institute of Technology, Pasadena, California
2. Southwest Reseach Institute, Boulder Colorado
3. Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland
4. Georgia Tech, Atlanta, Georgia

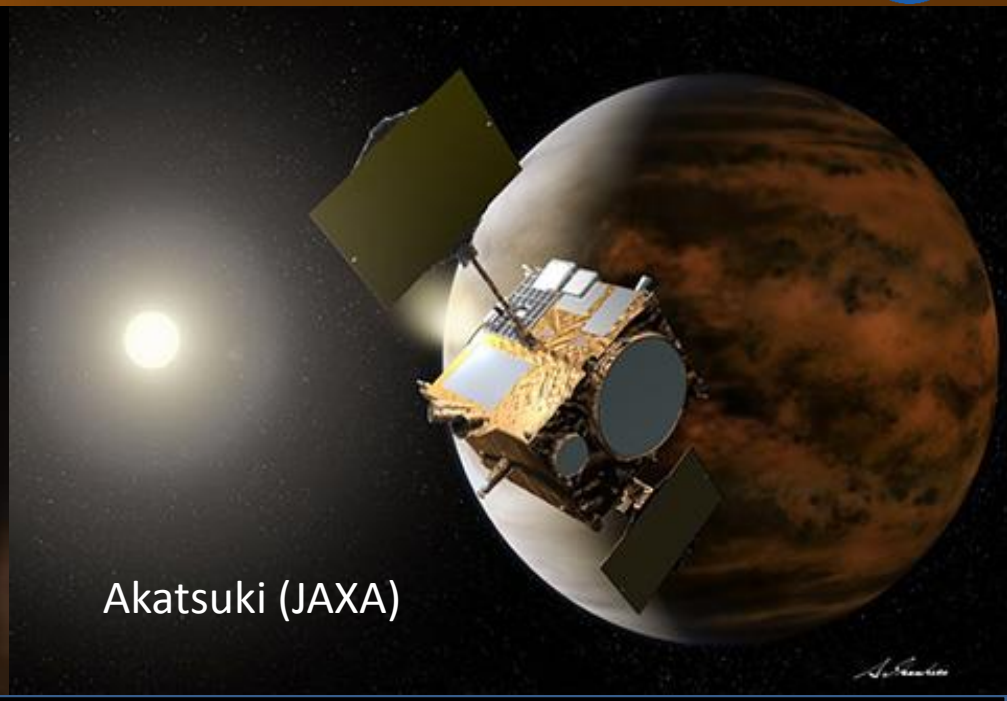
# Venus and Earth – Planetary Siblings



Magellan Galileo

Apollo 17

# Venus – Recent and on going Missions

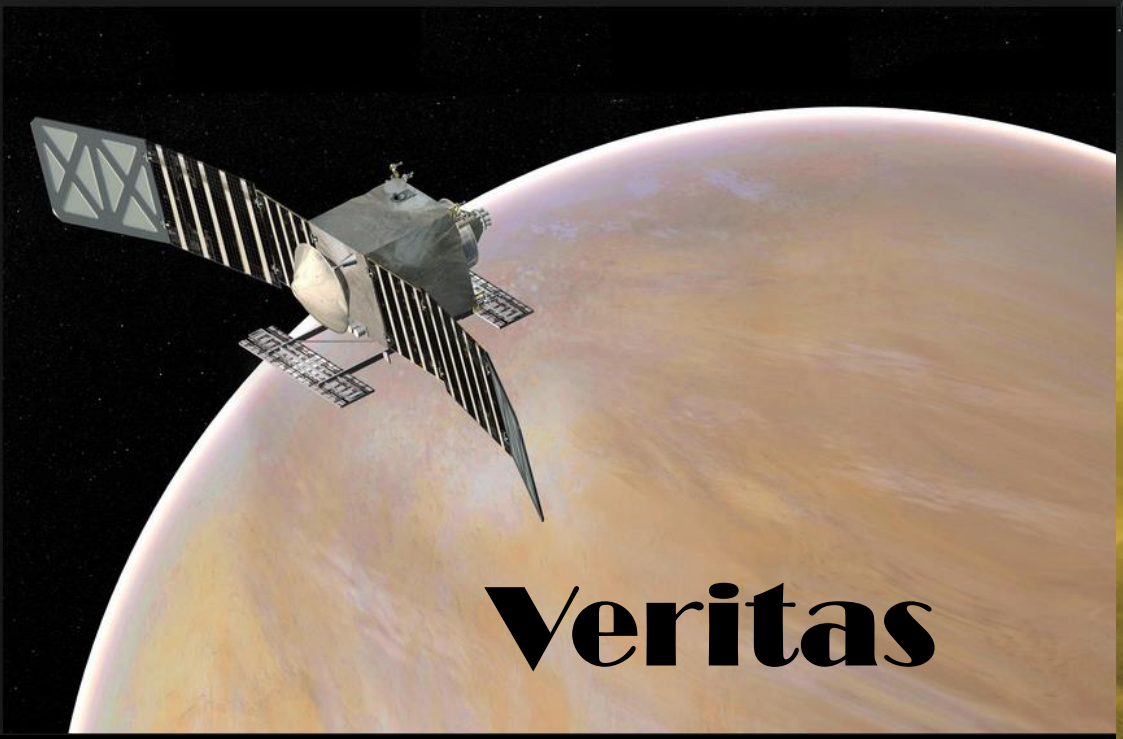


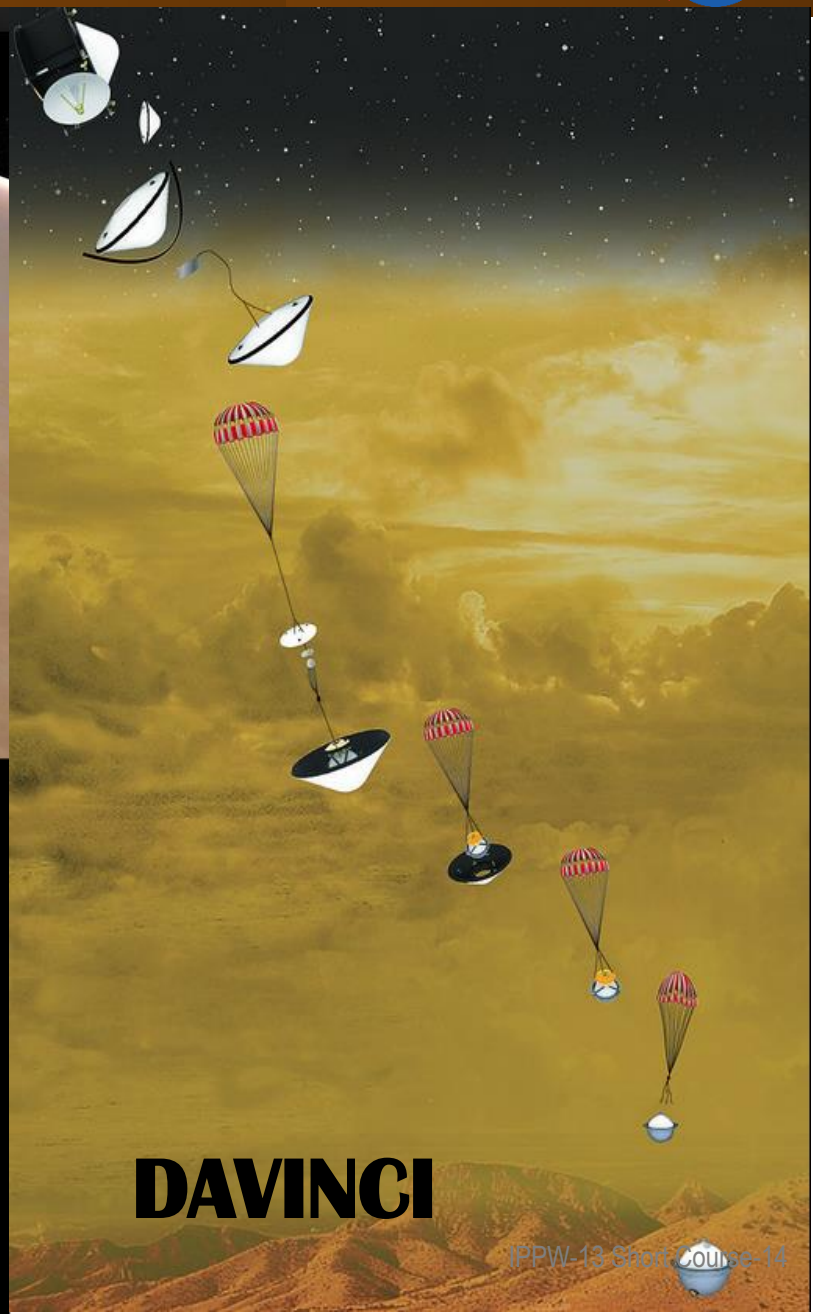

- Orbit insertion April 2006.
- Mission ended December 2014

- Orbit insertion Dec 2015
- Five year mission is now planned

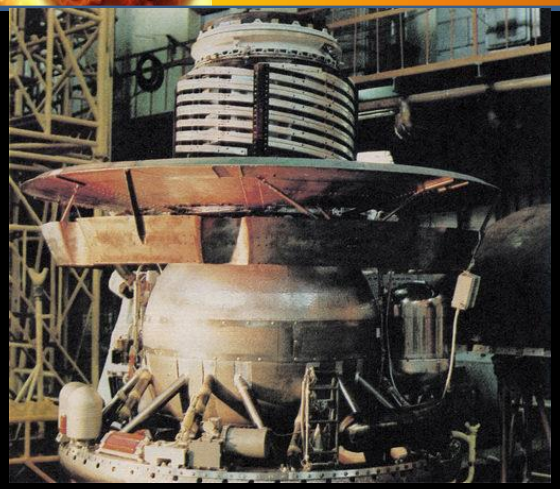
- Both missions primarily focus on investigations of the Venus atmosphere

# Proposed NASA and ESA Venus Missions



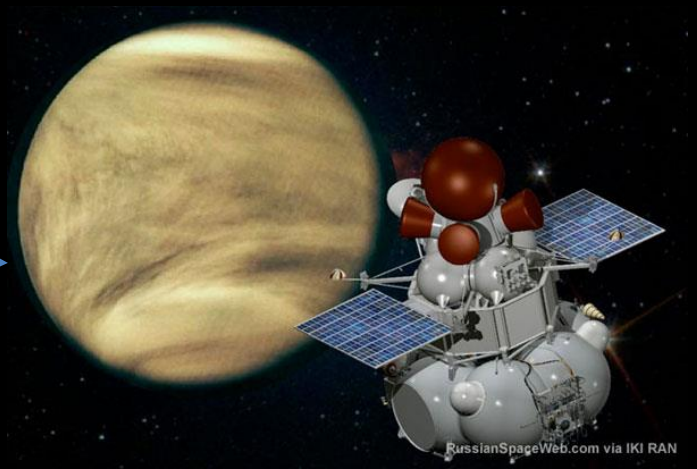


# Landed Missions – Past and Proposed

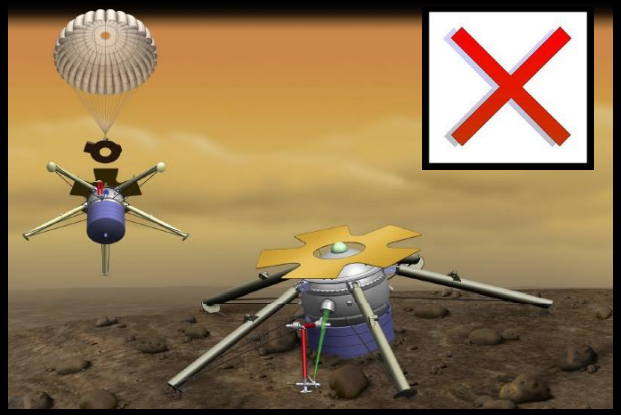


VEGA (USSR, 1985)

~40 Years



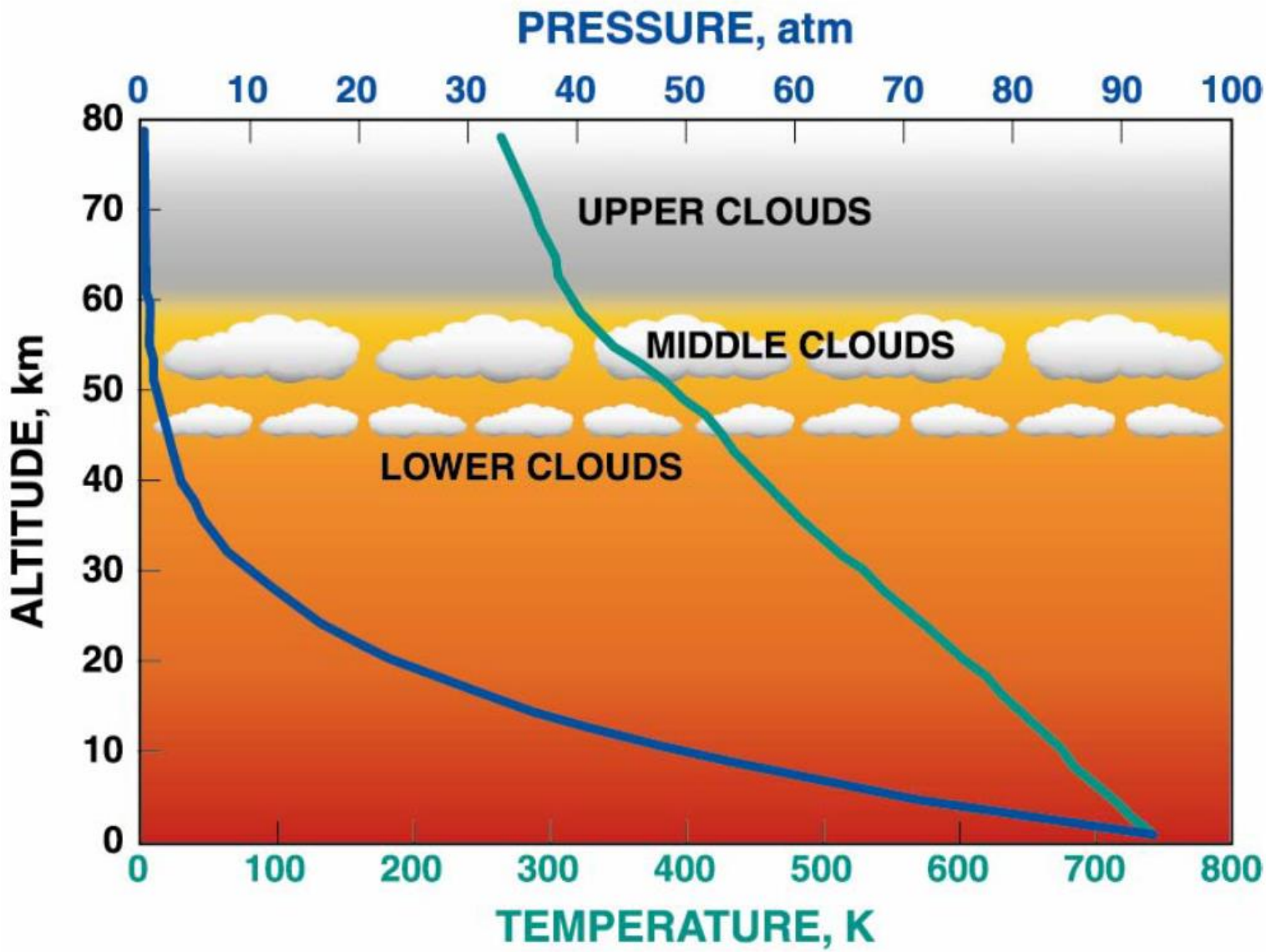

Venera D (USSR, 202X)



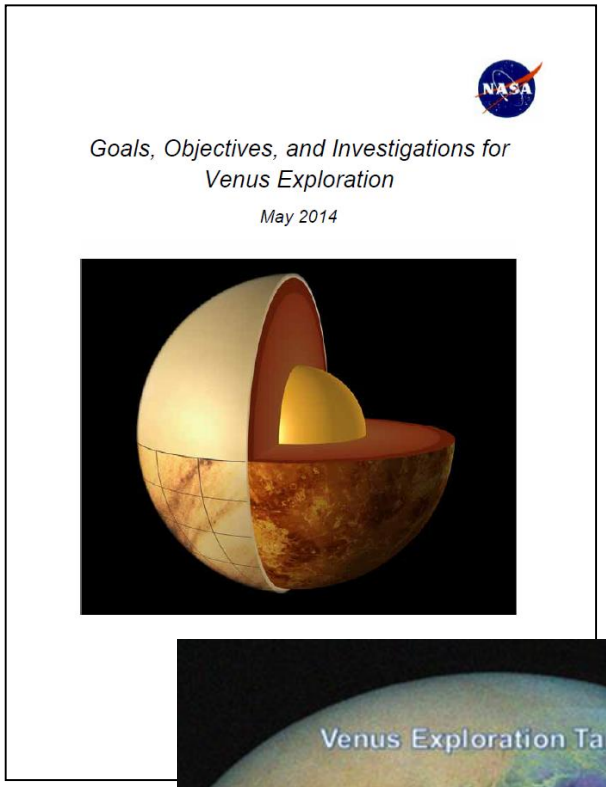
NASA New Frontiers 3 (2010)
SAGE (JPL)

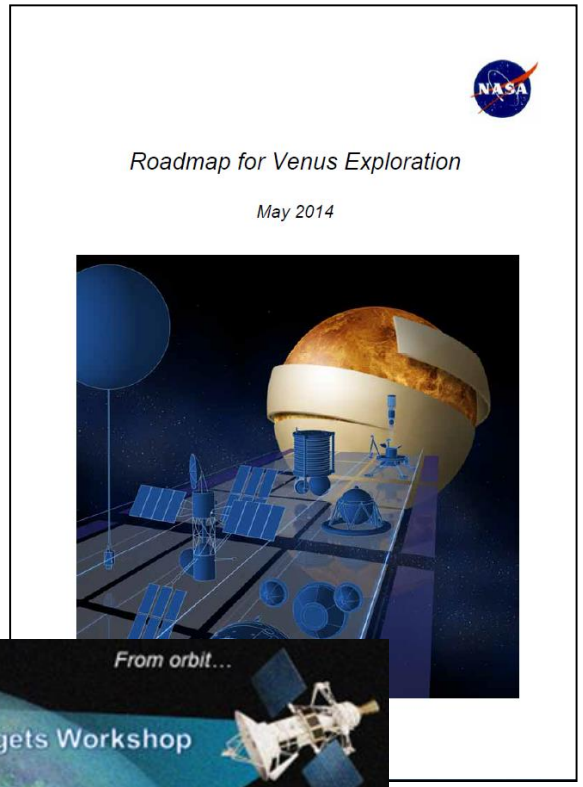
NASA New Frontiers 4, 2016)

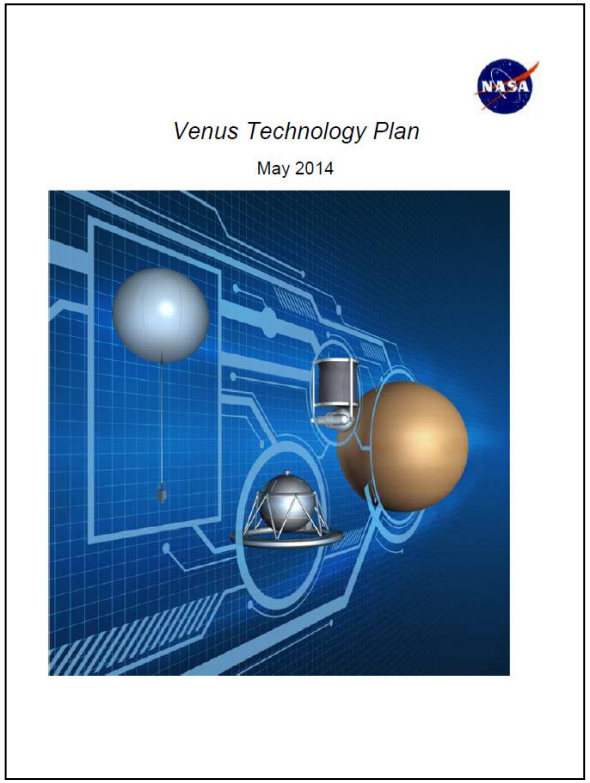
# Extreme Environments on Venus

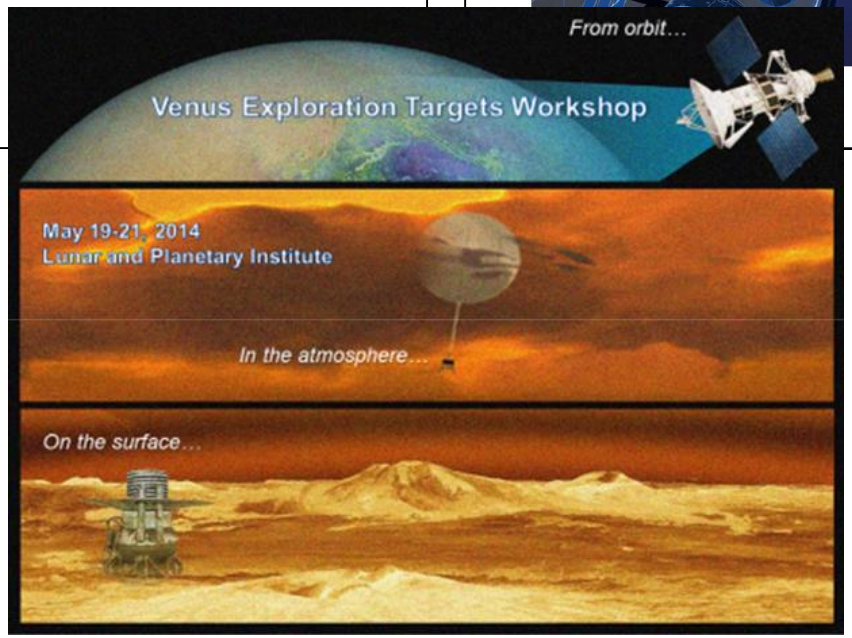


# VEXAG Venus Exploration Documents



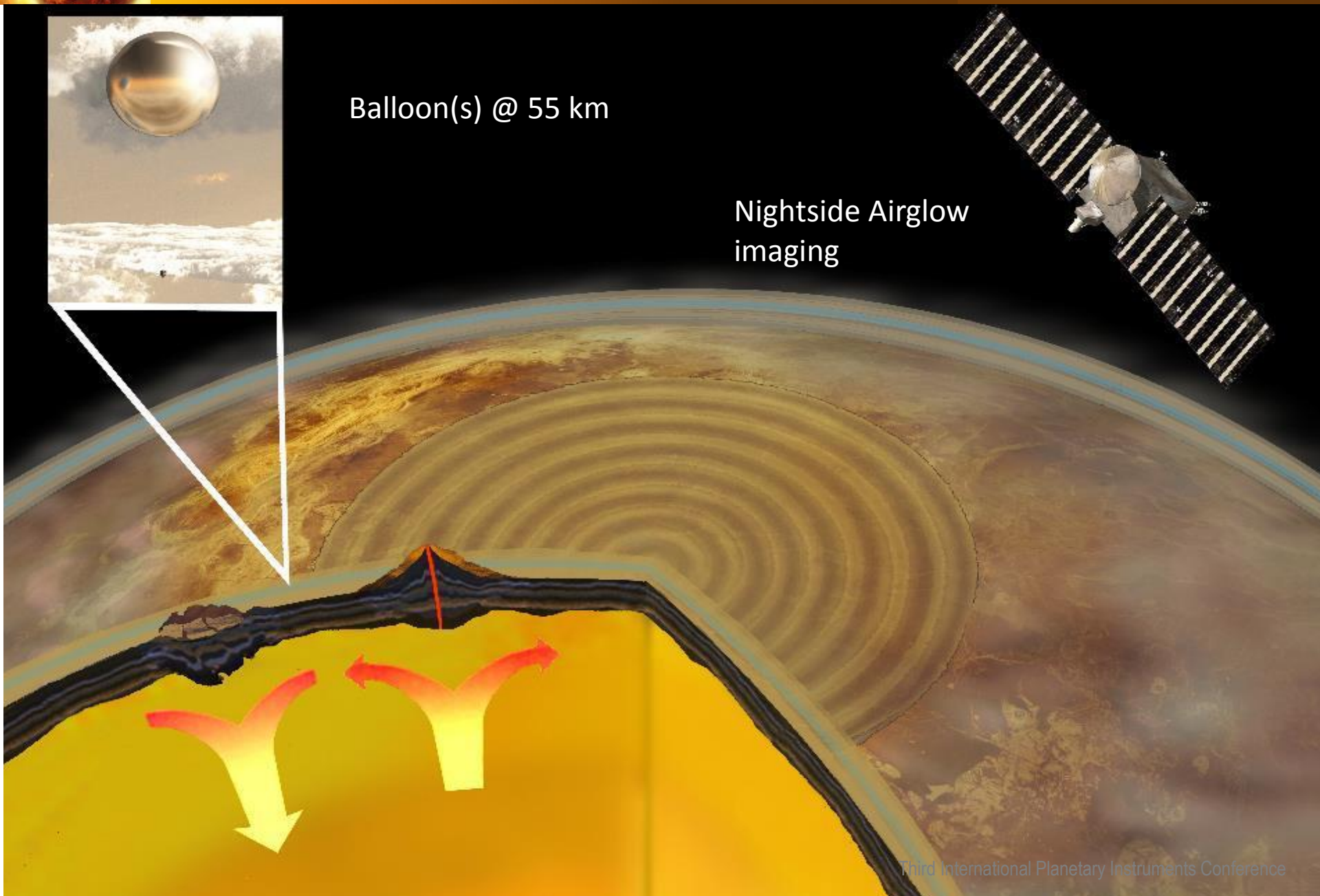

Venus Exploration VEXAG Analysis Group

All available on the VEXAG website;
http://www.lpi.usra.edu/vexag/

# Strategies for Future Venus Exploration

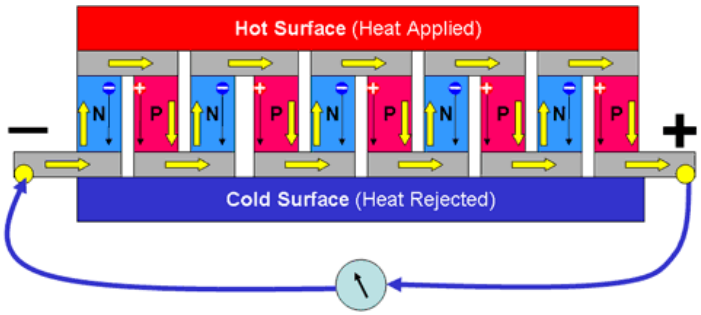
- Apply instrument technologies developed for other planetary destinations on traditional Venus platforms (orbiters, short duration landers)
- Develop high temperature technologies to enable long duration surface and near-surface exploration – NASA HotTech program initiated in FY16
- Deploy experiments on long lived aerial platforms (balloons or airplanes) operating in cooler parts of the atmosphere
- Develop Venus-specific techniques exploiting unique Venus characteristics such as dense atmosphere and near isothermal surface regions

# Observing infrasound signatures of Venus quakes

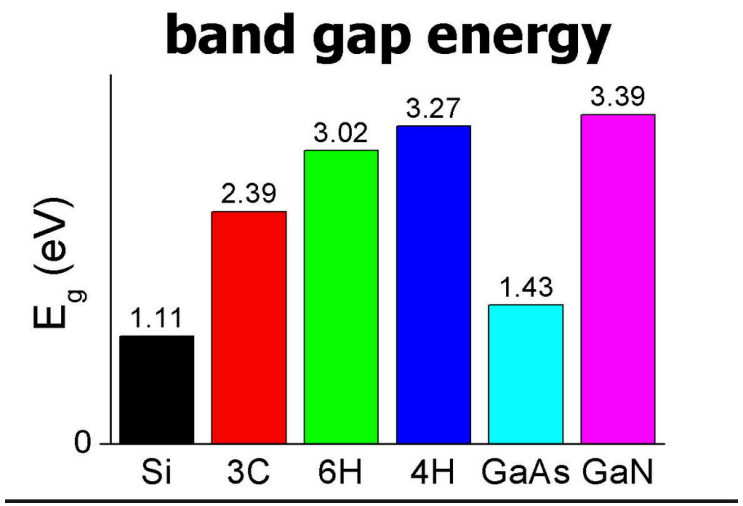


# Back Up Charts

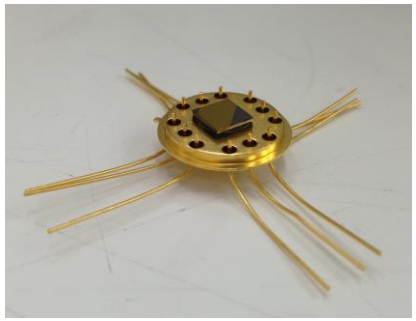
# High temperature technologies- HOTTech




Thermoelectric Generator (TEG)




Si-C polymorphs



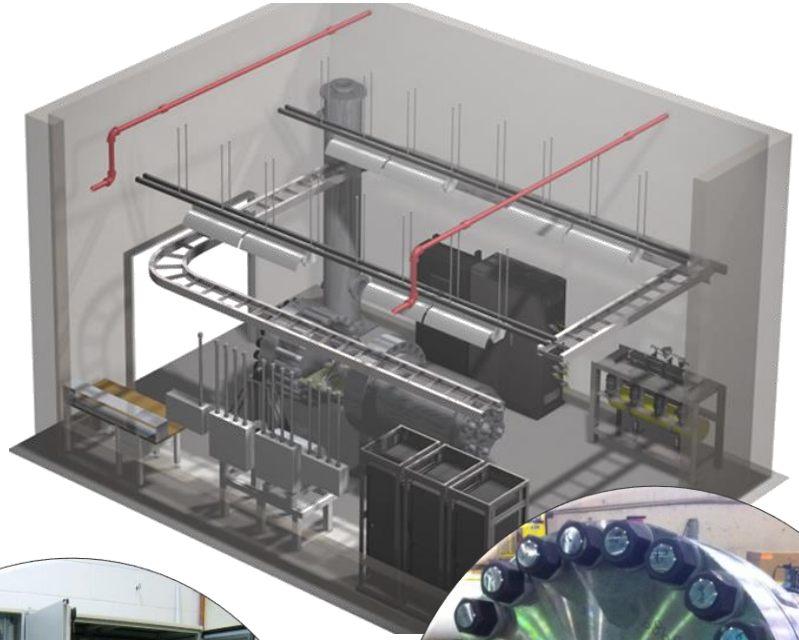
**CNT vacuum triode prior to vacuum packaging**

**Brushless High-temperature DC motor (Honeybee)**

- NASA recently announced **the Hot Operating Temperature Technology (HOTTech) Program** supports the advanced development of technologies for the robotic exploration of high-temperature environments
- **HOTtech** will develop and mature technologies that will enable, significantly enhance, or reduce technical risk for *in situ* missions to high-temperature environments with temperatures approaching 500 degrees Celsius or higher

# Importance of Test Facilities for Venus Environment e.g.Glenn Extreme Environments Rig (GEER)

Supporting science and technology testing in high temperature, high pressure, cryogenic, and vacuum environments with time accurate, parts per billion atmospheric mixing

- Unique chamber developed for up to 1500 PSI and 500°C full atmospheric testing

- Any atmosphere
- Vacuum & Cryo
- Dynamic PPB accuracy
- Science
- Technology Development