Jet Propulsion Laboratory
California Institute of Technology

Cupids Arrow

Presentation to the GFSC CubeSat Science Symposium

John D. Baker (JPL)
Nitin Arora (JPL)
Murray Darrach (JPL)
Anthony Freeman (JPL)
Glen Lightsey (GaTech)
Stojan Madzunkov (JPL)
Christophe Sotin (JPL)
Terry Stevenson (GaTech)

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Cupids Arrow Objectives

- Address Planetary Decadal Survey Goals, specifically Objective IA: 'How did the atmosphere of Venus form and evolve'
  - **Crosscutting Science Themes**: Building new worlds, planetary habitats, workings of solar systems
  - **Inner Planets Research Goals**: Origin and diversity of terrestrial planets, origin and evolution of life, processes that control climate.

- Measure the concentrations of noble gases and isotope ratios in Venus atmosphere (below the homopause @110 km) to provide key information on the formation and evolution of Venus.

- Use the smallest free-flying probe possible, a SmallSat

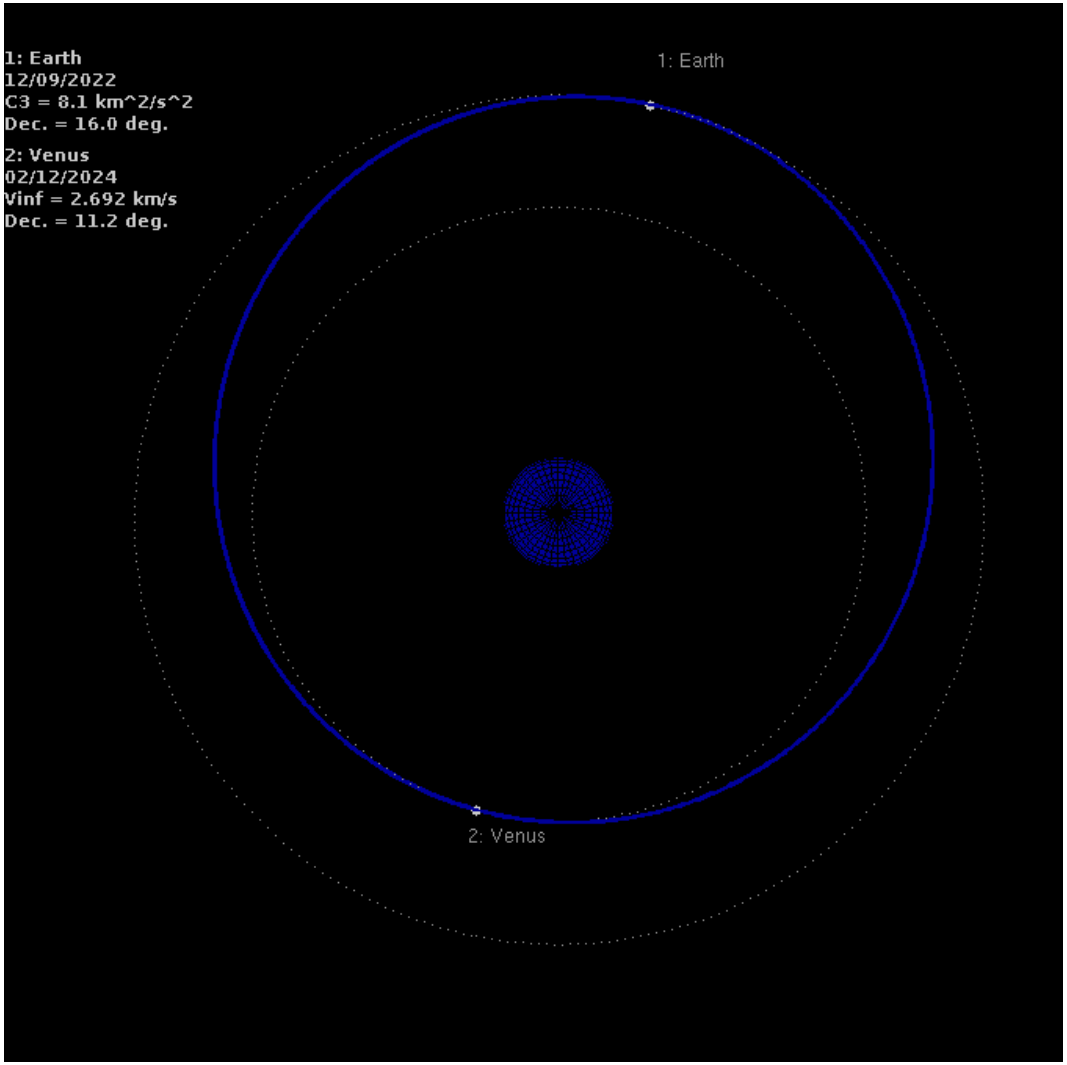
Background

- Cupids Arrow was selected for study by PSDS3
- Noble Gases are tracers of the evolution of Planets. They trace:
  - the supply of volatiles from the solar nebula
  - the supply of volatiles by asteroids and comets
  - the escape rate of planetary atmospheres
  - the degassing of the interior (volcanism)
  - the timing of these events
- Comparative planetology will help determine the processes involved in the distribution of noble gases.

Baseline Mission Design

- Flight time ~430 days
- Launch in 2022, December
- Launch C3 < 9 km^2/s^2
- Arrival Vinf. = ~2.7 km/s
- Initial large elliptical orbit ≈20 days

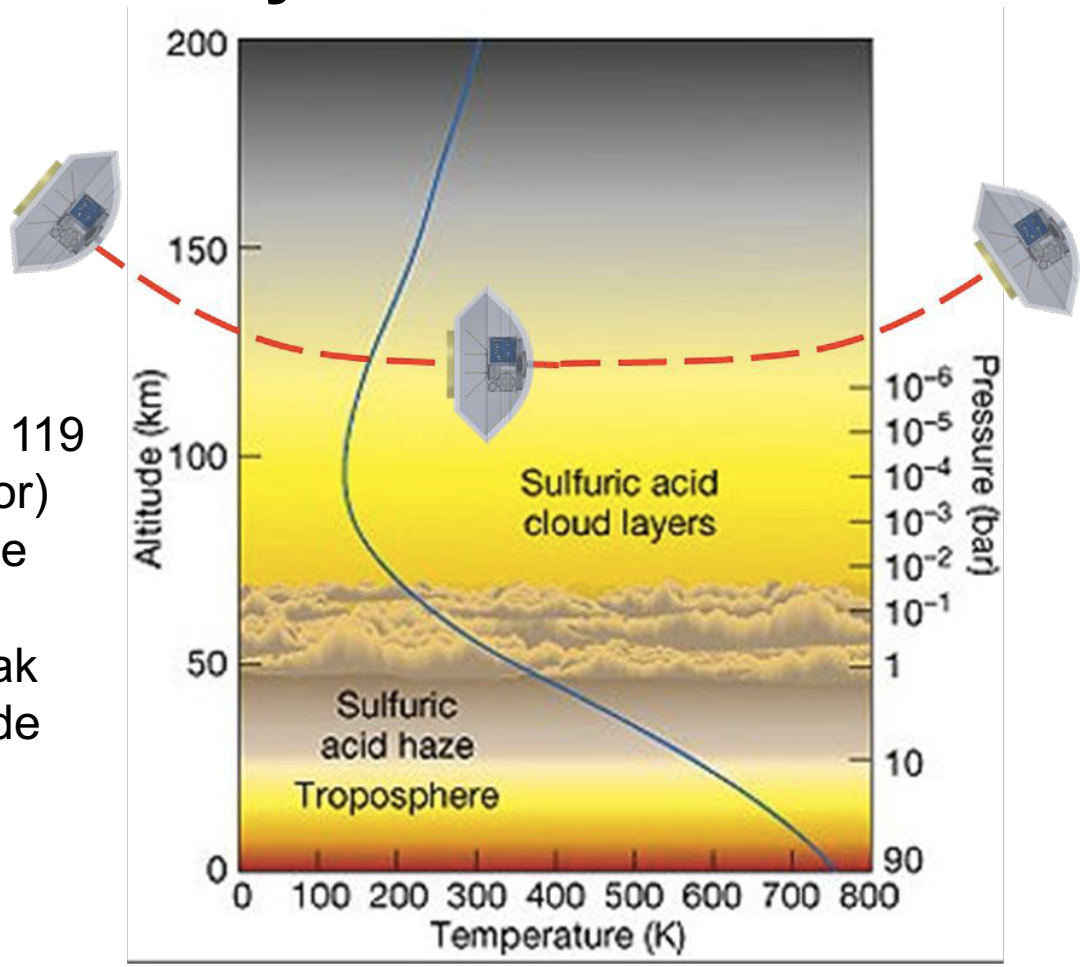
- Spin Stabilized for cruise and atmospheric pass
- Separate solid after VOI
- DV Monoprop capability ~60 m/s (in probe)
- DV VOI Capability ~433 m/s

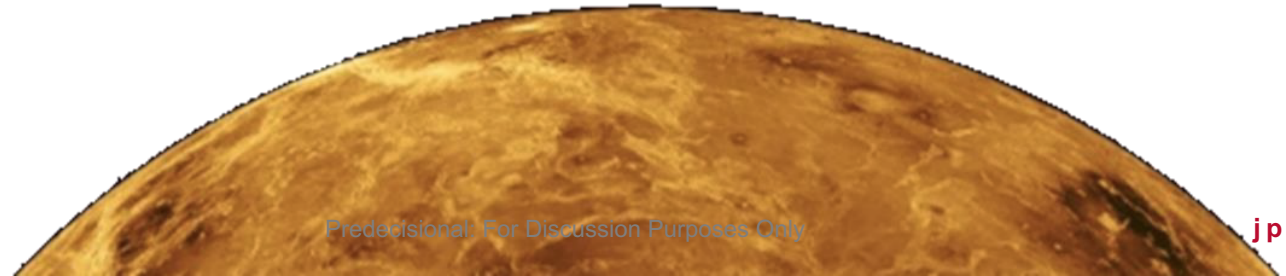


Atmospheric Entry Conditions

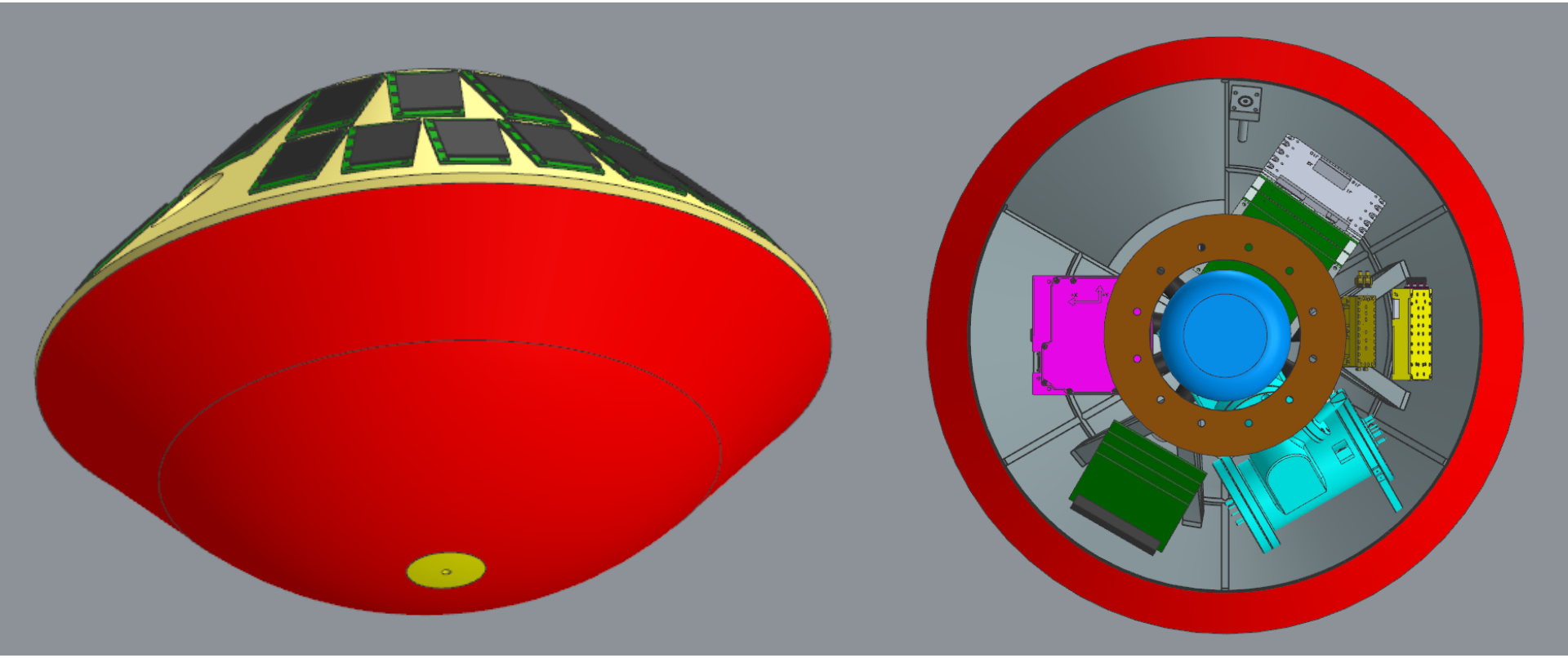
Velocity of 10 km/s
Altitude of 110 km

Homopause between 119 km (evening terminator) and 135 km (night side close to the morning terminator) with a weak dependence on latitude (Limaye et al., 2017)

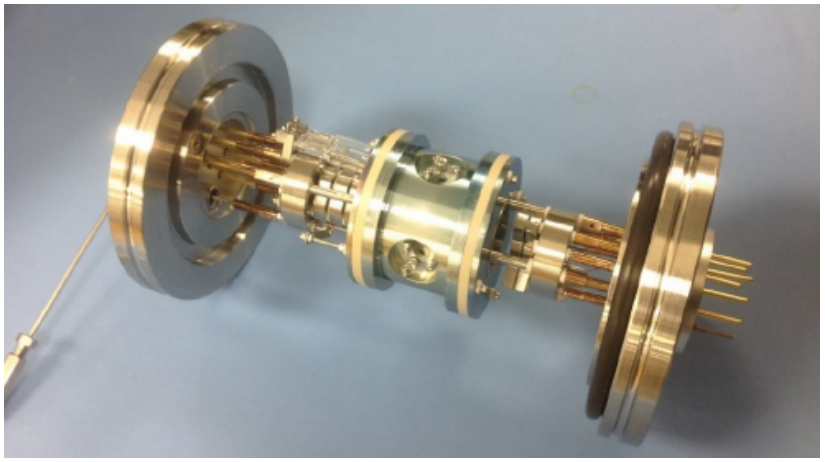




Mechanical Configuration



Mini Quadra-pole Ion Trap Mass Spec (QITMS)



- No discrete wires to make electrical connections to mass spectrometer parts.
- 4 kg mass; 2U volume
- Extremely robust against shock/vibe loads
- Very stable measurements

- Each generation of QITMS is getting progressively smaller with lower mass and without compromising performance
  - 8kg → 4kg
- Builds on previous developments for HEOMD; e-Nose and VCAM.

QITMS Isotopic Precision is 3-5 times better than required

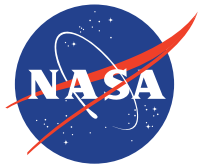
Summary

- Understanding how Earth and Venus have diverged in their geological history is key to understanding the habitability of earth-like planets.

- A miniaturized QITMS measuring the concentrations of noble gases and isotope ratios in Venus atmosphere would provide key information on the formation and evolution of Venus.

- A free-flying SmallSat probe may be able to deliver high-priority science at Venus for a fraction of the cost of a conventional Discovery mission.

- Same approach could be adapted to other environments: Titan's atmosphere, Enceladus' plume, possible plume at Europa, …



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