

THE VENUS ATMOSPHERIC SAMPLE RETURN (VATMOS-SR) MISSION CONCEPT.

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Brief Presenter Biography (35 word limit): Jason Rabinovitch is an Assistant Professor at Stevens Institute of Technology in Hoboken, NJ, USA. His research interests combine high-speed fluid mechanics and space exploration.

Mission Concept Summary: VATMOS-SR (Venus ATMOSpheric - Sample Return) is a small spacecraft mission concept that would return several gas samples from the upper atmosphere of Venus (< 110 km) to Earth for scientific analysis. This could be the first sample return mission for an extraterrestrial atmosphere and potentially the first sample return from an Earth-sized planet. The VATMOS-SR mission concept consists of a SmallSat atmospheric sampling probe (45 deg. sphere/cone geometry, <1 m diameter) that is designed to skim through the Venus upper atmosphere and acquire gas samples below the homopause altitude (around ~110 km altitude), where the different atmospheric gases are mixed. The velocity of the spacecraft where sampling would occur is expected to be between ~10.5 km/s and ~13.1 km/s, depending on the trajectory chosen (e.g. trajectory shown in Fig. 1).

Science Case: Noble gases in planetary atmospheres are tracers of the entire geological evolution of the planet. They carry the fingerprints of processes driving atmospheric composition, including, the original supply of volatiles from the solar nebula, delivery of volatiles by asteroids and comets, escape rate of planetary atmospheres, degassing of the interior, and its timing in the planet's history [1-2]. To date, planetary scientists have successfully made these challenging measurements at Earth, Mars, Jupiter, and comet GC. An incomplete set of noble gases (Ar and Ne) were measured in Titan's atmosphere by the Huygens probe. However, a major observational missing link in our understanding of Venus' evolution is the elementary and isotopic pattern of noble gases and stable isotopes in its atmosphere, which remain poorly known [2]. The concentrations of heavy noble gases (Kr, Xe) and their isotopes are mostly unknown, and our knowledge of light noble gases (He, Ne, Ar) is incomplete and imprecise. NASA's community-based forum, the Venus Exploration Analysis Group (VEXAG), has placed a high priority on obtaining such measurements in its 2019 *Goals, Objectives, and Investigations* document.¹

Only a sample return mission will be able to provide unambiguous scientific data to answer the science questions regarding the origin and evolution of Venus. This presentation will discuss the overall mission concept design, (e.g. Fig. 1 for a sample trajectory), the spacecraft (Fig. 2) design, discuss detailed simulations of the hypervelocity sampling system, and highlight the technologies required to enable this mission concept.

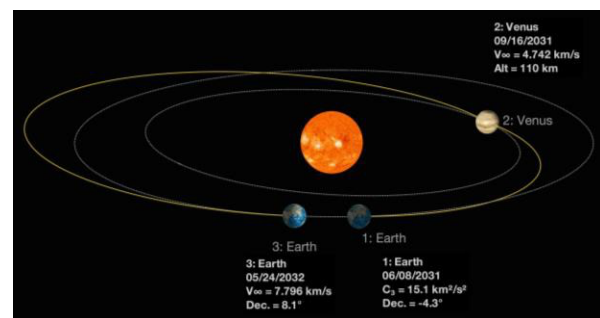


Figure 1 – Example Venus-Earth return trajectory for the VATMOS-SR mission concept. The total mission duration for this trajectory is < 1 year.

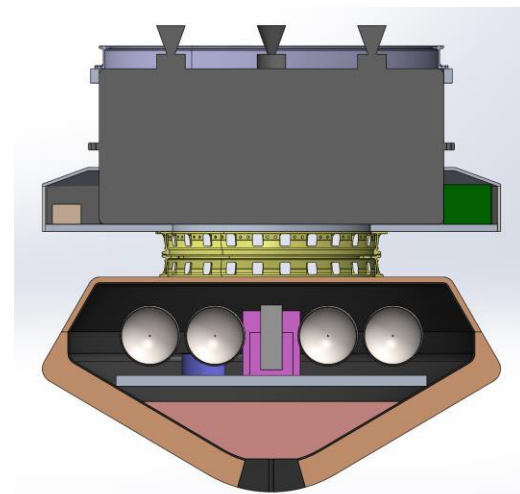


Figure 2 – Potential VATMOS-SR spacecraft design. The added volume aft of the main probe is for a propulsion system required for the Venus-return trajectory.

¹ https://www.lpi.usra.edu/vexag/documents/reports/VEXAG_Venus_GOI_2019.pdf

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References: [1] Pepin, R.O. *Icarus*, Vol. 92, No. 1, 1991. [2] E. Chassefière, E., *et al.*, *Planetary and Space Science*, Vols. 63-64, 2012.