Venus Atmospheric Structure Investigation (VASI) on DAVINCI : 2024 Development Status. R. D. Lorenz[1], J. B. Garvin[2], N. Johnson[2], S. Getty[2], G. Arney[2], E. Kohler[2], F. Forget[3], S. Lebonnois[3], N. Izenberg[1], D. Atkinson[4], D. Crisp[5], X. Li[2], A. Imasuen[2], M. Haglund[2] and S. Vidal[2]. [1]Johns Hopkins Applied Physics Lab, Laurel, MD, USA. (ralph.lorenz@jhuapl.edu). [2]NASA Goddard Spaceflight Center [3] LMD/IPSL, Sorbonne University, Paris, France [4]Whitman College, [4] Crisp Spectra LLC

Introduction: Only a single high-quality near-surface atmosphere profile exists of our twin planet, that obtained in 1985 by the VEGA-2 lander [1,2]. The handful of other probe missions have very limited vertical and sensor resolution (Venera), or have had outright sensor failures (Pioneer Venus [3], VEGA-1). Unlike altitudes above 40km, which have been relatively well-surveyed by radio occultation profiles from orbiter missions, the fine temperature structure of lowest part of the Venus atmosphere must be interrogated by direct measurement. The deep structure, dynamics and composition are important in several respects. First, worlds like this 'exoplanet in our back yard' may be more widely represented in the universe than is the Earth. Secondly, there are indications that particularly interesting phenomena may occur on Venus, not seen in the atmospheres of Earth, Mars or Titan (but analogous to aspects of ocean stratification on Earth): the VEGA-2 data are impossible to reconcile with a profile that is both convectively stable and compositionally uniform. A favored hypothesis [4] is that the lowest few kilometers are compositionally denser (depleted in N_2). The supercritical thermodynamics of carbon dioxide add to the interest in this region.

The exchange of angular momentum between the retrograde, slowly-rotating Venus and its dense atmosphere is reflected in the wind profile, which can now be interpreted by global circulation models. Again, while cloud-top (60-70km) winds are now well-known from Akatsuki and preceding missions, very little data exist on winds in the hidden lowest 40km, and how they mediate mixing of gases exchanged with the surface and subsurface. Doppler tracking, turbulence measurements via accelerometer and rate sensors, and trajectory reconstruction from descent imaging will shed unprecedented light on the lower atmospheric dynamics. Accelerometer measurements will also be performed during the hypersonic entry, providing a density profile that bridges orbital and cloud-top altitudes.

DAVINCI [5,6] has been selected for flight in the early 2030s. VASI's measurements of pressure, temperature and wind, superior (e.g. vertical resolution <100m) to those of previous missions, will improve our understanding of Venus and will complement DAVINCI composition measurements and imaging.

Investigation: VASI comprises an instrument (a data processing unit (DPU), connected to accelerometers and angular rate sensors mounted internally, and pressure and temperature sensors which are connected to a pressure port assembly to expose them to the Venus environment) and a trajectory reconstruction process, which will use inputs from Doppler shift measurements on the 2-way S-band radio relay link to the Carrier/Relay spacecraft, and geometric constraints from descent imaging. The pressure port assembly, incorporating protective housings for the temperature sensors and a flow-shaping Kiel tube to reduce pressure sensitivity to angle of attack, will likely exploit additive manufacturing. Sensor part selection is presently underway. Radio signal power will be monitored in both directions, to constrain propagation effects such as scintillations [7] and absorption by sulfuric acid vapor. In addition to its scientific goals of characterizing atmospheric structure and dynamics, VASI also contributes to NASA's Entry Science Investigation (ESI) to assess the performance of entry and descent systems to benefit future missions and technology development. VASI also hosts the VfOx (Venus Oxygen Fugacity) sensor, a Student Collaboration Experiment.

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