TPS Design to Manufacturing in Support of Rocket Lab's Probe Mission to Venus. K. Peterson[1], M. Gasch and E.Venkatapathy. [1] Keith.h.peterson@nasa.gov, Bldg 232, NASA Ames Research Center, Moffett Field, CA

Introduction: The last successful probe/landed missions to Venus, Vega 2 by the U.S.S.R and Pioneer-Venus Probes by the U.S., were carried out four decades ago. Since then, there have been numerous flyby missions as well as orbiters but no probe or lander. While in the intervening decades, Mars has been the center of attention with numerous orbiters, landers, and rovers ranging from cube-sat to flagship missions. With the Mars Sample Return mission in development, the driver for Mars missions has been to "search for life," and as a result Venus has been a neglected destination. The selections of DAVINCI and VERITAS under the Discovery Program is very timely and important, and their launch at the beginning of next decade is anticipated to answer many questions.

In the last two decades, commercial space companies have focused on development of launch technologies that lowered the cost of small, medium, and large mass payloads. Launch of constellations of cube-sats and multiple-small sats through ride sharing have opened opportunities in space commerce. Beginning this decade, many commercial companies are attempting sample return from LEO. Recently Varda Space Industries successfully demonstrated low-cost sample return by bringing back in-space manufactured pharmaceuticals.

In the coming decade, commercial companies are expected to extend their capabilities beyond LEO and enable missions to the Moon and Mars because of NASA's Moon to Mars approach using commercial services. NASA's approach related to science investigation of the solar system, especially the Outer Planets and Venus, is likely to continue using established PI driven missions under the Discovery and New Frontiers programs but leverage emerging commercial capabilities to a greater extent. The commercial capabilities once demonstrated for LEO and lunar missions, can then enable missions to Mars and by extension Venus. There are developments unique to Mars and Venus that will require tailoring of capabilities and will demand balancing the commercial approach with scientific rigor.

Venus Small Probe Private Mission: Rocket Lab's founder and CEO has been pursuing a privately funded mission to Venus to not only demonstrate their capabilities, but also to demonstrate that small and low-cost missions have a significant role to play [1]. Rocket Lab partnered with an MIT alumni-funded science instrument team led by Dr. Seager for droplet measurement technologies, NASA Ames Research Center for Thermal Protection Systems, and JPL for Deep Space Network access. The mission engineering goals are to deliver a small probe to Venus, thereby demonstrating a high-performance, low-cost, planetary entry mission with small spacecraft and small launch vehicles. The science goals are to search for habitable conditions in the "temperate zone" of the Venus clouds by searching for the presence of organic material within cloud-layer particles as well as anomalous cloud components, including aspherical particles and their relative abundance as a function of altitude [2] (Fig.1).

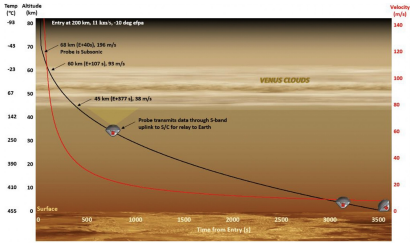

Figure 1. The science phase targets the Venus cloud layer between 45 and 60 km altitude.

While the Rocket Lab Venus mission is mostly privately funded [1], Rocket Lab approached NASA Ames specifically for the thermal protections system for a couple of reasons. NASA has funded the development of HEEET during the last decade specifically targeting entry of Venus probes, and the development was matured to TRL 6. While Rocket Lab has been very successful in the development of launch vehicles as well as spacecraft capable of interplanetary navigation and delivery, the needed expertise to design entry systems was lacking and by seeking NASA's help, Rocket Lab was able to conceive a rapid design to probe delivery.

The Rocket Lab small probe is nearly ½ of the size of the Pioneer-Venus small probe. Unlike the P-V large probe or the DAVINCI probe, the science measurement does not require the heat shield or back shell to be separated nor requires a parachute during descent therefore simplifying the engineering design. The burden then shifts to the science team and required them to focus on optical measurement techniques. Our effort in this regard was to accommodate optical window access on the back shell and TPS to be RF transparent.

This presentation will describe the engineering design, development, manufacturing and integration associated with the heat shield and back shell thermal protection system for the small probe. The presentation will describe the engineering challenges and solutions associated with the smallest probe to ever enter Venus.[3]

References: [1] French, R., et al (2022). [2] Seager, S., et al (2022). [3] Venkatapathy, E. and Cassell, A. (2020).