Tape and Roller Sampling System for Flexible Venusian Atmosphere Aerosol Capture and Delivery. I. R. King[1], K. Bywaters[1], K. Zacny[1], S. Seager[2], and J. Petkowski[2] [1]Honeybee Robotics, 2408 Lincoln Ave., Altadena, CA USA, 91001 (irking@honeybeerobotics.com), [2]Massachusetts Institute of Technology, 54-1718, 77 Mass. Ave., Cambridge, MA 02139

Introduction: Honeybee Robotics has developed an all-in-one collection, delivery and sealing system for studying aerosols in the Venusian atmosphere. The system utilizes only two actuators and is mechanically simple; thus it is relatively reliable, inexpensive, and low power. The system's small and flexible packaging size make it adaptable to many mission architectures and instrument types.

Tape and Roller Sampling System Concept: The sampling system is comprised of a tape wound between two spools: the feed and storage spools. Venusian air containing aerosols is directed, either actively or passively, to a select area of the tape's surface where particles are collected. The feed spool is actively driven by a motor such that the sampled section of tape is delivered to an instrument. The tape acts as a conveyer belt, placing the sample under a knife edge instrument inlet. An elevator sealing mechanism creates a knife edge seal, with the tape acting as a gasket. At this point, another sample may be collected, and the sampling process repeated. By nature, continuing operations will cause the previously sampled tape sections to be stored in the storage spool. If desired, the drive motor could be reverse driven to analyze a sample a second time. A schematic of this design concept is shown in Figure 1.

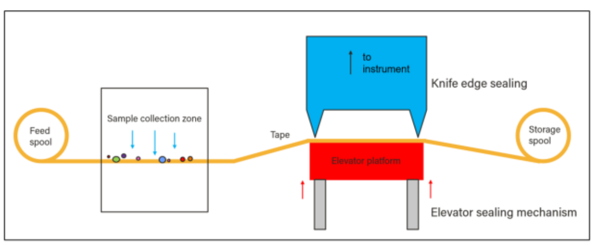

Figure 1: Schematic illustrating the tape and roller sampling system concept.

Mechanical complexity is minimized by having only two actuators: one for driving the feed spool, and one for sealing. In the case of sealing, a paraffin actuator (requiring heat to operate) is proposed to further minimize avionics size and complexity. A clock spring ensures the two spools are coupled, and that the length of tape between them is always taut.

Architecture Flexibility: This simple design concept can be readily adapted to meet many proposed Venusian instrument or mission architectures. The tape length could be increased, and the geometry altered to house several in-line instruments. The method of sample acquisition may be either active or passive, depending on the cost-benefit of sampling time as compared to power consumption and mass. For missions concerned with cross-contamination, this system would be preferable to a container- or filter-based system, because a fresh section of tape surface is exposed for each sample collection. Additionally, it is easy to add sampling capability for relatively little added mass and volume overall. Because movement is equally possible both "forwards" and "backwards," there is excellent control over tape placement.

With respect to instrument compatibility, materials used in the system may also be changed as needed. However, Honeybee has baselined a gold foil for the tape due to its material compatibility with the Venusian atmosphere and most instruments, its malleability, and high free surface energy, which attracts particles. To this end, Honeybee has previously used gold in the witness plate assemblies (WPA) on the Mars 2020 sample return [1].

System Heritage: This concept is based on the Precision Subsampling System (PSS), a previous Honeybee design created for use with a time-of-flight mass spectrometer (TOF-MS) developed by Will Brinckerhoff at the Goddard Space Flight Center (GSFC) [2]. In this system, select portions of a heterogenous rock core are powdered by a subsampling device. The rock cuttings are collected on Kapton tape and, using the paired spools approach, are moved to the knife edge inlet of the instrument. An elevator sealing mechanism is used to create a knife edge seal, with the Kapton tape acting as the gasket. The prototype system is pictured in Figure 2.

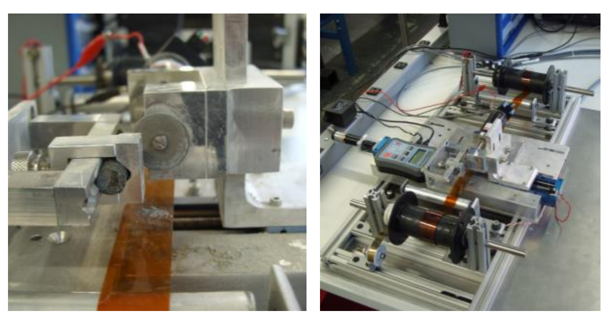

Figure 2: Honeybee prototype and testing of PSS

References: [1] Moeller, R.C. et al. (2021) Space Sci Rev 217:1-4. [2] Brinckerhoff, W., et. al. (2010). Earth and Space 1364-1381.