

PROTOTYPE DESIGN OF A FLEXIBLE TAPE AND ROLLER SAMPLING SYSTEM FOR VENUSIAN ATMOSPHERE AEROSOL CAPTURE AND DELIVERY. I. R. King¹, K. Bywaters¹, K. Zacny¹, S. Seager², J. J. Petkowski², ¹Honeybee Robotics, 2408 Lincoln Ave., Altadena, CA 91001 (irking@honeyberobotics.com), ²Massachusetts Institute of Technology, 54-1718, 77 Mass. Ave., Cambridge, MA 02139

Introduction: Building on work published last year [1] Honeybee Robotics has designed a prototype of a tape and roller sampling system for use in aerosol collection from the Venusian atmosphere. As described in King et al., (2021) the tape and roller design concept is inherently small and flexible, making it adaptable to many mission architectures and instrument types. The prototype design also includes a spool eject mechanism, which enables sample return to Earth. This prototype may be used for testing both in the field and in the laboratory to demonstrate viability of the design concept and compatibility with a Venusian atmosphere concept of operations.

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 deposited. The feed spool is actively driven by a motor such that the sampled section of tape is delivered to an instrument for analysis. The tape acts as a conveyor belt, placing the sample under a knife edge instrument inlet. An elevator sealing mechanism creates a 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 can be reverse driven to analyze a sample a second time. A schematic of this design concept is shown in Figure 1.

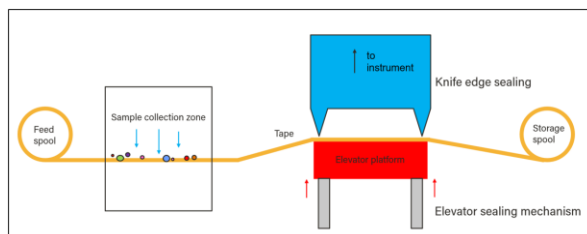


Figure 1: Schematic illustrating the tape and roller sampling system concept

Concept 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) [2]. In this system, select portions of a heterogeneous 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.

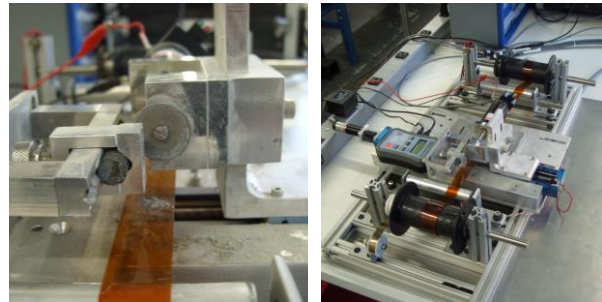


Figure 2: Honeybee prototype and testing of PSS

Prototype Design: From this concept, a prototype design was created to help inform the feasibility of this concept for use in the Venus atmosphere. The design is broken down into four primary sections. First is the spool drive mechanism, which pushes the tape forward. Next is the sample collection zone, where sample is deposited onto a gold tape's surface using a fan and diverging nozzle that slows particles immediately before they impact the tape. Third is the instrument interface. While a specific instrument has not been baselined here, an elevator mechanism is in place that can create a knife edge seal to a generic instrument inlet. Finally, there is the spool eject mechanism that utilizes a spring-loaded mechanism and frangible nut to detach the storage spool from the rest of the system for enclosure and ultimate return to Earth. The full design is mounted to a base plate for portability and useability, which also renders the design inherently modular. The sample collection mechanism and instrument interface are of particular interest for future design iterations. The 3D model of this design is shown in Figure 3.

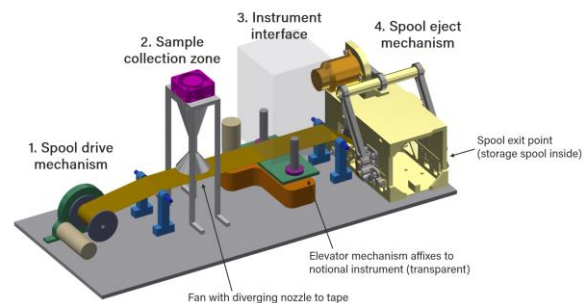


Figure 3: 3D model of prototype design

Prototype Utility: Key questions that can be addressed with prototype testing are (1) what capture efficiency for liquid and solid particles can be achieved with gold tape under atmospheric flow, (2) how strongly sulfuric acid adheres to gold tape, (3) overall feasibility of a tape and roller mechanism with gold tape, and (4) the scientific value of a spool returned to Earth with embedded Venusian particles. Testing of the prototype may be performed in a laboratory environment using aerosols representative of the Venusian atmosphere in addition to sulfuric acid, or it may be taken to the field for testing in Earth's atmosphere. While many of the open questions are regarding gold as the material choice for the tape, Honeybee has baselined gold 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 [3].

References: [1] King, I. R. et al (2021) LPI Contributions 2620: 4015. [2] Brinckerhoff, W., et. al. (2010). Earth and Space 1364-1381. [3] Moeller, R. C. et al. (2021) Space Sci Rev 217:1-4.