AUTOMATON ROVER FOR EXTREME ENVIRONMENTS: ENABLING LONG DURATION VENUS SURFACE MOBILITY J. SAUDER, E. HILGEMMAN, K. STACK, J. KAWATA, A. PARNESS, M. JOHNSON[1]
[1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr. Pasadena, CA

Introduction: Venus is one of the most challenging in-situ environments to explore. Most in-situ mission concepts to Venus are short-lived probes or landers with lifetimes between 2 to 24 hours, which limits the types of data that can be collected. However, the concept presented here, a mechanical rover powered by the wind, could not only survive for long durations of time but would also provide mobility. This opens up a myriad of opportunities for a Venus in-situ explorer, with one of the most compelling being obtaining samples from multiple geologic units across the surface of Venus. Such a rover is also enabling for Venus surface sample return concepts. However, to envision such a rover requires rethinking current interplanetary rover designs.

Background on Venus Rovers: Ideas for a long duration Venus rover began in the 1980s with the Russian DzhVS and the wind-powered Venerokhod rovers [1]. More recently radioisotope powered Stirling engines have been proposed to enable long duration landers [2] and rovers [3]. However, the concept still requires large amounts of R&D investment. A second approach would be to build a mission around gallium nitride or silicon carbide circuits, which have been demonstrated at Venus temperatures. Several long duration lander concepts use near-current technology [4]–[6]. However, current levels of integration are in the range of just a few hundred to thousand transistors, which results in extreme mission constraints when compared to the current Mars rovers. While there are a couple papers which discuss rover concepts utilizing high-temperature electronics, they rely heavily on future developments [7], [8], especially in the area of visual navigation.

Mechanical Approach: The Automaton Rover for Extreme Environments (AREE) is an exciting concept, which enables long duration in-situ mobility on the surface of Venus. An automaton is a mechanical device capable of performing a series of complex actions to achieve a specific result or a mechanical robot. Built of high-temperature alloys, the automaton rover reduces requirements on electronics and requires minimal human interaction by utilizing concepts from robotics including behavior-based control and emergent systems. Similar to subsumption architecture, this yields complex robotic behavior from simple mechanical rules [9].

Instead of being reliant on image processing and onboard navigation, which cannot be done with available high-temperature electronics, the rover physically senses the environment around it and uses those inputs to navigate. This is a departure from traditional rover control, required by Venus.

While mobility requires a significant amount of power, which is challenging on the surface of Venus, AREE enables exploration of the Venus surface by directly collecting mechanical wind energy and transferring it to the mobility system. Keeping the energy in a mechanical state conserves ninety percent of the mechanical energy when compared to using a generator and electric motor. The Venus wind provides a low speed, high torque input, which is directly beneficial for mobility, which requires low speed, high torque.

System Overview: Wind power would be collected and stored in a spring. This mechanical energy is then routed via shafts to the rest of the rover to run the mobility system and obstacle avoidance. When the rover detects an obstacle, energy is rerouted in the mobility system, so it performs an obstacle avoidance maneuver.

While early concepts explored keeping the entire system mechanical it was determined a hybrid system would be most effective, combining high temperature electronics with mechanical systems. Mobility and obstacle avoidance are mechanical, whereas data storage and instruments are electrical. Communication could be mechanical or electrical, depending on technology readiness.

Conclusion: AREE is a radical departure from traditional planetary rover models but enables access to the Venus surface without advanced cooling systems or orders of magnitude increase in the capability of high temperature electronics. The authors hope this concept contributes to shifting the conversation about a long-duration Venus rover mission, to something that could occur in the near future, as previous concepts have relied on yet-to-be developed technologies.

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