AN AUTOMATON ROVER FOR EXTREME ENVIRONMENTS: RETHINKING AN APPROACH TO SURFACE MOBILITY

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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 automaton 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 uses for a Venus in-situ explorer, with one of the most compelling being obtaining samples from multiple geologic units across the surface of Venus. However to create 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 fall far short of the requirements for standard rovers. While there are a couple papers which discuss rover concepts utilizing high-temperature electronics, they rely heavily on future developments [7], [8].

The Automaton Rover: Automaton Rover for Extreme Environments (AREE) is an exciting concept, which enables long duration in-situ mobility on the surface of Venus through robust mechanisms, designed to operate for months in Venus's hostile environment.

An automaton is a mechanical device capable of performing a series of complex actions to achieve a specific result, or a mechanical robot. The automaton rover is designed to reduce requirements on electronics and require minimal human interaction by utilizing concepts from robotics including behavior based control and emergent systems in a similar manner to the subsumption architecture which yields complex robotic behavior from simple rules. [9].

System Overview: Wind power would be collected and stored mechanical in a spring. This energy is then routed to the rest of the rover to run the mobility system, distributed computing and obstacle avoidance, signaling system, and instruments. While initially a purely mechanical rover was considered, it was realized high temperature electronic instruments would be required to do science.

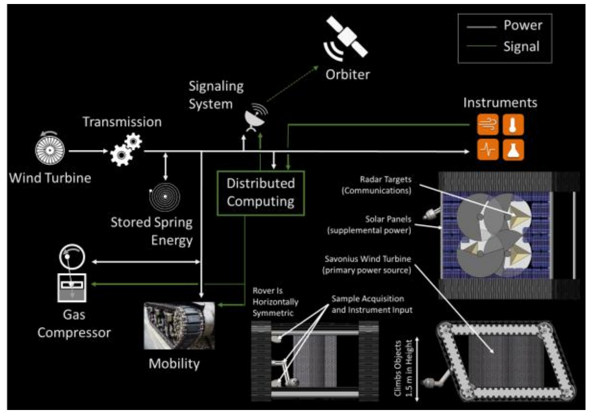

Figure 1: Automaton Rover System

Another key concept illustrated in Figure 1 is the rover geometry. It has tracked mobility with a parallelogram shape, much like WWI tanks, to enable to climb as large of obstacles as possible. The rover is also symmetric, which means it can flip upside down and continue operation as normal.

Conclusion: AREE is a radical departure from traditional planetary rover models in terms of terrain accessed and cost, due to heavy use of distributed, reactive controls and the implementation of novel mechanical solutions. 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.

References:

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