Utilization of a Radioisotope Power System to Enable Long-Term Venus Mission

Despite being Earth's closest celestial neighbor, Venus has had very limited in-situ studies compared to Mars and other inner solar system bodies. The Venusian surface is extremely hostile, with a chemically corrosive, high-pressure, and high-temperature atmosphere. Further, the thick atmosphere blocks sunlight for solar power. The combination of these factors is deadly to spacecraft, limiting the capabilities exploration missions, and previously precluding long-duration surface observations. Past missions to the surface were contained in pressure vessels, lacking solar arrays or other ways to generate power. Without having the ability to generate power, the mission duration was less than two hours. If a spacecraft could generate power in the harsh Venusian environment, however, the lifetime of such spacecraft could potentially lengthen dramatically. A longer-lived spacecraft could gather more data, which would be invaluable for the planetary science community. It could even pave the wave for rovers or lower atmospheric autonomous aerial vehicles.

Radioisotope power systems have been used extensively for solar-independent power for deep space exploration missions but primarily in cold space environments. Zeno Power proposes adapting a radioisotope thermoelectric generator (RTG) to produce power in the extreme temperatures on the surface of Venus, enabling long-duration missions enabling scientific exploration and discovery. Effective thermal management and the use of high-temperature materials have the potential to maintain a thermal gradient across thermoelectrics, with the higher operating temperature enabling use of higher efficiency thermoelectrics with low-power RTGs.

The study of the planet Venus has been highly limited in the past. Over the last four decades, scientists have identified a list of objectives for Venusian research. An exploration craft utilizing an RPS would be able to address some of these objectives, including the processes that shape the surface of the planet, how the Venusian atmosphere changes over time, and characterizing how the atmosphere, surface and interior of Venus interact.

The benefits of such a technology are not limited to the study of Venus. RPS technology has been widely used in the study of the outer solar system, meaning any benefits derived during the Venus project could lead to follow on improvements for other space systems, especially in extreme environments that lack solar availability. Beyond improving the state of the art for space RPS systems, if RPSs can work at high temperatures, that could have spin-offs for terrestrial applications.