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AEROBRAKING AT VENUS: A SCIENCE AND TECHNOLOGY ENABLER

Abstract

Venus remains one of the great unexplored planets in our solar system with key questions remaining on the evolution of its atmosphere and climate, volatile cycles, and the thermal and magmatic evolution of the planet's surface. One potential approach toward answering these questions is to fly a reconnaissance mission that utilizes a multi-mode radar in a near-circular low-altitude orbit of approximately 400 km and 60-70 inclination. This type of mission profile results in a total mission delta-V of approximately 4.4 km/s. Aerobraking could account for a significant portion, potentially up to half, of this energy transfer, thereby permitting more mass to be allocated to the spacecraft and science payload or facilitating the use of smaller, cheaper launch vehicles. Aerobraking at Venus also provides additional science benefits through measurements of upper atmospheric density (recovered from accelerometer data) and temperature values, especially near the terminator where temperature changes are abrupt and constant pressure levels drop dramatically in altitude from day to night. The scientifically rich Venus is also an ideal location to utilize aerobraking techniques. Venus's thick lower atmosphere and slow planet rotation results in more predictable atmospheric densities. The Venus atmosphere has a density variation of 8The nature of aerobraking at Venus provides ideal opportunities to demonstrate aerobraking enhancements and techniques yet to be used at Mars, such as flying a temperature corridor (vice a heat rate corridor) and autonomous aerobraking using thermal response surface analysis. This method, based on spacecraft component maximum temperatures, can be employed on a spacecraft specifically designed for aerobraking, and will autonomously predict subsequent aerobraking orbits and prescribe apoapsis propulsive maneuvers to maintain the spacecraft with its specified temperature limits. A spacecraft specifically designed for aerobraking in the Venus environment can provide a cost-effective platform for achieving these expanded science and technology goals. This paper will discuss the science merits of a low-altitude circular orbit at Venus, highlight the differences in aerobraking at Venus versus Mars, and presents a case for using a flight system specifically designed for an aerobraking mission at Venus to achieve new science and technology heights.