Aerocapture as an Option for Ice Giants Missions

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Abstract

Aerocapture is an atmospheric maneuver where the aerodynamic forces of the vehicle (lift and drag) are used to provide the DeltaV needed to slow down from the approach hyperbolic trajectory to achieve the desired captured orbit around the target planet. The aeroassist capture provides a large savings in propulsion needed to change the velocity of the vehicle, since aerodynamic forces rather than propulsive systems provide the change in velocity. Aerocapture requires an integrated system level design, including thermal protection systems, actuator systems for aerodynamic modulation, and guidance and control systems that can autonomously command the change in the aeroassist forces.
Although aerocapture has been proposed for many situations in the past, including Mars, Venus, Titan, Saturn, Uranus, and Neptune orbiters as well as for Earth demonstration missions, it has not been attempted on any missions. However, many studies in the past three decades that have considered aerocapture as a design option have concluded that there are large mass savings that come from using aeroassist forces rather than propulsive forces to put a spacecraft into a captured orbit. The benefits are destination dependent, but some of the largest mass savings occur for the Ice Giants planets. Due to the large hyperbolic velocities of interplanetary trajectories approaching Uranus and Neptune, large amount of propulsion must be used to put a spacecraft in science orbits around these planets. Aerocapture can reduce the propulsion needs by dissipating energy in the sizable atmospheres of Uranus and Neptune. NASA commissioned a detailed study analysis to quantify the benefits, if any, for use at Neptune. The study found that even having to provide a heat shield aerocapture could deliver 40% more payload than an all-propulsive vehicle, and also provides for a 3-4 year reduction in trip time. Mass savings are expected also at Uranus with an aerocapture mission. Additionally, more recent advances in thermal protection systems and guidance and control systems show a path to increase capabilities beyond those results.
This talk will discuss the merits of including aerocapture as an option for an Ice Giants mission. The discussion will focus on the cost and mass savings of using aerocapture instead of propulsive burns for Ice Giants orbiter mission scenarios while also detailing a potential concept of operations and entry vehicle design. Finally, the talk will discuss more recent work being done regarding aerocapture design that can improve science capabilities for an Ice Giants mission.

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