Paper ID: 51457
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26th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Spacecraft for Deep-Space Exploration (8)

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SMALLSAT AEROCAPTURE: BREAKING THE ROCKET EQUATION TO ENABLE A NEW CLASS OF PLANETARY MISSIONS

Abstract

With increasing interest in planetary science missions using small spacecraft, there are numerous technical challenges to address. While much focus (and recent success with the MarCO spacecraft) has been on getting small satellites to deep space destinations, the journey to get there is only half of the challenge; the spacecraft must also be able to slow down to enter orbit. For decades, traditional methods of orbit insertion have utilized a chemical propulsion system, which is governed by the rocket equation, dictating that large amounts of propellant mass are needed to enact changes of velocity on a spacecraft. For any system, but especially a SmallSat, which is often volume and mass constrained, accommodating significant amounts of propellant can be prohibitive or impossible.

This paper presents a technology development initiative focused on delivering SmallSats to orbit a variety of destinations using aerocapture. Aerocapture uses the drag of a single pass through the atmosphere to capture into orbit instead of relying on large quantities of rocket fuel. Using drag modulation flight control, an aerocapture vehicle adjusts its drag area during atmospheric flight, allowing it to target a particular orbit in the presence of navigational and atmospheric uncertainties.

A multidisciplinary team from NASA and university, led by JPL, has been studying aerocapture for small satellites at destinations such as Venus and Mars. We have made great progress in addressing the key technical challenges of this technology, including: demonstrating the ability to target a specific orbit through a robust simulation toolset and Monte Carlo analyses, assessing vehicle stability in the atmosphere through advanced CFD simulations and subscale ballistic range testing, and quantifying thermal protection system requirements through expert analysis to show that mature TPS materials are adequate. We present here an overview of the SmallSat aerocapture technology, including design trades that have been addressed, such as exploring deployable versus rigid heatshields. We also enumerate the benefits of aerocapture across multiple planetary destinations, with results indicating that up to 85