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Author: Mr. Pradikshan A K
Virginia Tech, United States

Ms. Monica Shanmugam
Virginia Tech, United States
Mr. Sudhir S
SASTRA University, India

THE ADVENT OF BALLISTIC RE-ENTRY PROBES: A NEW ERA IN EXTRA-TERRESTRIAL SPACE EXPLORATION

Abstract

In 2005, the European Space Agency's (ESA) Huygens probe made a historic triumph to transmit a wealth of data from the satellite from Titan, one of the largest moons of Saturn. The return of Huygens to Titan is considered to be the most remote land ever reached by humanity, and since then ballistic probes have gained popularity for deep space exploration. In the early days of exploration, NASA identified that re-entry spacecraft like Mercury, Gemini, and Apollo experienced Hypersonic regimes during re-entry. Generally, direct atmospheric entry of probes and capsules into any planet's atmosphere should be either ballistic or lifting. With an emerging focus on deep space exploration missions and interplanetary missions, there is a greater demand for efficient, reliable, and cost-effective re-entry capsule configuration that can survive very severe thermal and mechanical stresses experienced during descent. Ballistic probes have shown to be favourable in terms of budget, prices, mission and/or vehicle dependability, tolerated landing distortion, and so on, as they do not require guidance and control mechanisms. As a result, these concepts are less expensive than those that require lifting, but they require low ballistic factors for direct entry. A large reference area, a high drag coefficient and a low mass contribute to a low ballistic factor. It is ideal to increase the frontal area of the re-entry probe to reduce the ballistic factor, but this comes with its own disadvantage - increased thermal heat shield mass. By contrast, low ballistic factors result in low thermal loads. The goal of this project is to design a cost-effective re-entry probe and to decrease the ballistic factor by roughening the probe surface in order to increase the drag coefficient and reduce the thermal load. When compared with HUYGENS' re-entry capsule, we found that the drag coefficient could be increased and the ballistic factor could be reduced without significantly altering its shape.