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Author: Dr. Sean Tuttle
UNSW Australia, Australia

Mr. Simon Barraclough
UNSW Australia, Australia
Ms. Klara Loos
Australia
Prof. Kei-ichi Okuyama
Japan
Dr. Takayuki Shimoda
Japan

MICRO- AND NANO- RE-ENTRY SPACECRAFT TECHNOLOGY DEVELOPMENTS

Abstract

This paper describes the technology developments which have been undertaken towards the realisation of a modular, scalable concept for a micro- or nano-sized spacecraft which can function operationally in orbit for a prolonged period of time and then perform an atmospheric entry at Earth, Venus or Mars with the jettison of minimal hardware. Such a concept could suit Low Earth Orbit research missions, companion or pathfinder planetary exploration missions and small sample-return missions. One of the key technological challenges to such a design is the aerodynamically-shaped heat shield. This heat shield performs three main functions. Firstly, it provides the main barrier between the external, aerothermodynamic heat loads and the internal payload and equipment. Secondly, it performs the primary shock-absorption role during the passive landing and thirdly, its shape contributes to the overall aerodynamic stability of the spacecraft immediately prior to and during the period of atmospheric flight. In certain mission configurations, it can additionally provide the physical support for a solar power generator. A second design-driving feature is the leeward radiator. This functions as a thermal radiator on orbit, for rejecting excess waste internal heat and then functions as part of the heat shield during the atmospheric entry, which means it requires significant thermal decoupling from the interior prior to this phase. The paper will concentrate on the thermal and shock absorption roles of the heat shield. Arc tunnel test results performed on samples of a light-weight, ablative heat shield material will be presented. These results have been used to predict the likely internal temperatures that could be maintained during an Earth re-entry. In addition, a preliminary confirmation of integrating solar cells into the heat shield has been obtained from the arc tunnel tests. Thermal analysis of the on-orbit performance in a number of mission scenarios will also be presented. Finally, the paper will present some preliminary results which have been performed to assess the characteristics of a hard (i.e. parachute-free) landing on the soil which is found in the Woomera region of Australia.