MICROSCALE ATMOSPHERIC REENTRY SENSORS

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ABSTRACT

The area-to-mass dependence of the forces and torques caused by aerodynamic drag implies that aerodynamic accelerations are a function of a body's characteristic length. As characteristic length is reduced, the orbital and angular accelerations increase according to an inverse power law. This suggests that an extremely small body can efficiently aerobrake and aerocapture in the presence of an atmosphere. Likewise, aerothermal and radiative heat transfer scales according to characteristic length, such that sufficiently small bodies maintain lower quasi-equilibrium temperatures throughout an entry manoeuvre. The combination of these effects enables tens of thousands of metric tons of interplanetary dust to passively enter Earth's atmosphere each year instead of ablating as energetic meteorites.

Seeking to capitalize off of this unique feature of length scaling, the Space Systems Design Studio at Cornell University is developing an extremely small spacecraft dubbed "Sprite." The spacecraft's small size makes this spacecraft extremely sensitive to aerodynamic drag accelerations and therefore able to demonstrate new mission opportunities, such as ablation-free atmospheric entry. Simulations suggest that these low-cost spacecraft can re-enter Earth's atmosphere from a LEO orbit while maintaining a low enough temperature to continuously transmit data. A swarm of such spacecraft could offer distributed sensing applications, including real-time global studies of the atmosphere.

In collaboration with Sandia National Laboratories, our group has produced a 2cm x 2cm x 0.5mm solar powered multi-chip module prototype that can close the communications link from a 500 km orbit using matched filtering techniques. Each of the components is traceable to the objective application-specific integrated circuit design that achieves an area-to-mass ratio of 13 m2/kg and a ballistic coefficient of 0.03 kg/m2.