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Author: Mr. Douglas Mehoke
Johns Hopkins University Applied Physics Laboratory, United States, douglas.mehoke@jhuapl.edu

HYPER VELOCITY PROTECTION DEVELOPMENTS ON THE SOLAR PROBE PLUS MISSION

Abstract

The Solar Probe Plus (SPP) spacecraft will go closer to the Sun than any manmade object has gone before. The mission includes both solar flux and micrometeoroid environments much more severe than anything experienced by previous spacecraft. As a result, new analytical and testing methodologies are being developed to ensure the success of the mission. One of the major efforts is the development of an analytical approach for hypervelocity impacts (HVI) at speeds up to 300 km/s. This methodology is being used for the shielding design of all critical surfaces and to minimize the mass of the protection required. To date, the study has made several notable achievements. It has developed hydrocode HVI analyses using sophisticated material models for EOS and strength aimed at velocities well above the range where test verification is currently available. Furthermore, emerging higher velocity regime testing advancements are being exploited in our validations of these advanced models at the highest feasible velocities. It has also developed the algorithms to allow dust impact predictions for specific spacecraft surfaces that include the spacecraft geometry and mission trajectory. The protective designs developed include several new approaches for dust mitigation, such as porous and layered surfaces, that significantly increase the mass efficiency of the shielding. The paper summarizes the early work and achievements in the development and validation of the hydrocode modeling, including the generation of the equations of state (EOS) and material constitutive models needed for the high velocity impact analyses. The paper also describes how these techniques are being used to design one of the critical spacecraft systems. SPP spacecraft power is generated by a liquid-cooled system that moves the heat absorbed by the solar panels to large radiators mounted above the spacecraft body. Protection of the cooling system from HVI perforation is a critical design challenge. With a surface area of almost 6 square meters and a tight mass allocation, the protection of the cooling system components has to be both robust and mass efficient. Meeting these design challenges requires the generation of penetration and cumulative damage predictions for a wide range of particle/velocity impact combinations and the development of mass-efficient shielding options for the large surface area components. The paper describes the dust mitigation work being done on SPP and how the cost and mass benefits obtained from using this type of analytical approach to HVI protection could be used on near-Earth and deep-Space missions.