Radio Frequency Emissions from Hypervelocity Impacts: Detecting Micrometeoroid Impacts to Spacecraft

M.J. Starks*[(1)], D.L. Cooke [(1)], P.E. Holladay[(1)], J.T. Griffith[(1)], W.D. Reinhart[(2)], T.F. Thornhill, III[(3)]
(1) Air Force Research Laboratory, Hanscom AFB, MA
(2) Sandia National Laboratories, Kirtland AFB, NM
(3) Ktech Corporation, Albuquerque, NM

Humanity's ever-increasing reliance on space assets inevitably raises the risk of serious consequences from spacecraft damage or failure due to hypervelocity micrometeoroid impacts. Carbonaceous or nickel-iron particles of cometary origin may reach velocities of 70 km/s, and current sensor technologies are generally incapable of distinguishing a micrometeoroid strike from other satellite failure mechanisms. Additionally – as recent discoveries of impact damage to the International Space Station make clear – plans by various nations for increased manned space flight and permanent lunar habitats drive the need for effective detection and location of hypervelocity impacts so that inspection and possibly repair may be performed expeditiously.

The Air Force Research Laboratory has conducted hypervelocity impact experiments with Sandia National Laboratories aimed at characterizing the usefulness of radio frequency emissions for the detection of micrometeoroid impacts. Using a modified two-stage light gas gun, titanium projectiles have been accelerated in a light vacuum to 1 – 18 km/s, striking aluminum plates covered with multi-layer thermal insulation characteristic of satellites. In each case, transient electromagnetic emissions generated by the impact were recorded using a combination of broadband microwave horns, low frequency DC plates and HF antennae. The recorded waveforms were then subjected to wavelet analysis in order to characterize the structure of the signals. These early measurements across a wide velocity range suggest the feasibility of constructing an RF-based hypervelocity impact detector that would effectively monitor the entire surface area of a spacecraft.

Further experiments are planned using more sophisticated optical, radio frequency and micro- and millimeter wave sensors. The experimental setup, initial results and future plans for this project will be discussed.