23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 23rd IAA SYMPOSIUM ON SPACE DEBRIS (IP)

Author: Mr. Fabio von Coburg
Universität der Bundeswehr München, Germany

EXPERIMENTAL VALIDATION OF HYPERVELOCITY IMPACT DETECTION USING A STRUCTURAL HEALTH AND EVENT MONITORING SYSTEM FOR THE ATHENE-1 SATELLITE

Abstract

With the growing population of satellite constellations in Low Earth Orbit, the flux of microparticles and orbital debris (MMOD) increases simultaneously due to fragmentation processes, mechanical deterioration, thruster residues, and secondary debris ejecta from hypervelocity impacts. Additionally, the purposeful destruction of satellites—whether through anti-satellite (ASAT) missile tests or other means—has recently emerged as a significant contributor to the micro-debris environment. As a result, even small particles contribute to the continuous growth of the orbital debris population, exacerbating risks for operational satellites and space sustainability. Recognizing MMOD impacts as a hazard to space vehicles and satellites, dedicated Structural Health and Event Monitoring (SHEM) systems have received significant attention over the last decades. In response to this challenge, researchers at the University of the Bundeswehr Munich have developed a SHEM system for the scientific satellite Athene-1, part of the SeRANIS mission. This system enables real-time detection of structural anomalies, including MMOD impact events, using advanced vibrational and ultrasonic sensing combined with onboard data processing. By continuously monitoring the satellite's structural integrity, the integrated SHEM system enhances situational awareness and improves in-orbit damage assessment. To evaluate the detection capabilities of the developed SHEM system, a series of controlled experiments were conducted using a payload-encapsulating sandwich panel representative of the Athene-1 satellite structure. Previous studies have demonstrated that laser-induced pulse excitations generate ultrasonic wave patterns comparable to those observed in hypervelocity impact events. High-energy Nd:YAG laser pulses were applied to the panel at multiple locations, while the resulting wave pulses propagating through the structure were simultaneously measured. Various detection algorithms were tested to assess their effectiveness in identifying impact events, with the system exhibiting high detection sensitivity. Additionally, an evaluation was performed to optimize sensor placement for enhanced monitoring performance. The results of this study will be presented, providing insights into the system's detection capabilities and fostering the integration of in-orbit SHEM applications.