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SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Technologies (5)

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ORBITAL DEBRIS REMOVAL WITH GECKO-LIKE ADHESIVES; TECHNOLOGY DEVELOPMENT AND MISSION DESIGN

Abstract

It is well-established that space debris poses a significant threat, exemplified by the satellite collision in 2009 and the several-times per year that the International Space Station must alter its orbit to ensure the safety of the crew. Large pieces of debris, like dead satellites and rocket bodies, pose a unique threat in their ability to obliterate any active system in the event of a collision and in the challenges they present for grappling and control. The most dangerous of these large pieces of debris are often tumbling and have limited hard points for grappling, exceeding the proven capabilities of rendezvous and docking technologies or cooperative grappling systems being developed for satellite servicing.

This paper presents a grappling technology and a mission concept for mitigating the threat of the largest of these debris objects. The grappling tool relies on synthetic gecko-adhesives, which use microscopic angled hairs to selectively stick to a wide range of surfaces. The adhesion can be turned ON and OFF by reversing the load direction tangential to the surface. Prior work demonstrated over 30,000 adhesion cycles, more than a 1 year lifetime, adhesion in vacuum and at cold temperatures, and function on over 30 common spacecraft surfaces. This paper will present the maturation of the gripper mechanism technology to include both flat and curved surfaces as well as an increase in adhesive capability of over 4-fold. Results from a zero-gravity experiment, the integration onto a robotic arm, and gripper/arm system test results from the flat floor facility at JPL will be presented. Using adhesive grappling significantly reduces the requirements that are levied on other subsystems like perception and spacecraft control (as well as the robotic arm) because large areas on the debris can be targeted, like solar panels and fuel tanks. Current grappling systems and rendezvous and docking technologies require extremely precise motions to grapple the Marman ring or other hard points on a target, driving the overall cost and complexity of the mission.

The paper will present a low-cost mission concept (<30M USD) developed during a workshop at JPL with representation by all relevant subsystems for the spacecraft including the primary innovations in the perception, propulsion, and the robotic grappling systems.