19th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Interactive Presentations - 19th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (IP)

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ADVANCING ASTEROID SURFACE SIMULATIONS AND MISSIONS USING AN ON-ORBIT CENTRIFUGE LABORATORY WITHOUT REACTION WHEELS

Abstract

The recent explorations of near-Earth asteroids Ryugu and Bennu have provided some significant surprises regarding the dynamics of regolith in rubble pile asteroids. Sample and return activities have discovered that what appears to be a solid surface is actually very tenuous, with the OSIRIS-REx sample probe not even registering contact as the spacecraft pushed it down below the surface. Advances are needed in landing, anchoring and manipulation of asteroid surfaces to facilitate future asteroid prospecting, material extraction and processing.

The Asteroid Origins Satellite I (AOSat I) mission proposes to establish a microgravity laboratory in Low Earth Orbit using centripetal acceleration to simulate the gravity on a rubble pile asteroid. This experiment includes vibration and impact experiments to understand the physics of micro gravity accretion and deflection. Cameras record the settling of material over time, allowing validation of models designed for this purpose. These centripetal laboratories are analogous to small-scale wind tunnels that could be used experiment, characterize and advance the next generation of asteroid landers, prospectors and asteroid mining vehicles without going to an asteroid. Similar strategies could be taken to recreate lunar and even Martian surface environment using a centrifuge spacecraft laboratory. These laboratories could be used evaluate, iterate and optimize next generation landers, rovers and human missions without having to go to the target body. Such a strategy can speed-up technological advancement and minimize cost.

A major challenge with a satellite such as AOSAT 1 is to determine how to effectively spin to produce artificial gravity. Often times, expensive, energy-hungry reaction wheels need to be used. The reaction wheels by conventional wisdom permit starting and stopping of rotation. The reaction wheels also cause jitter that impacts the quality of the artificial gravity being simulated.

To eliminate the vibration environment due to reaction wheels, the satellite is stabilized with torque rods only, providing a stable long term rotational environment that mimics rubble pile asteroids. Use of torque rods instead of reaction wheels is challenging due to the fact that the Earth's magnetic field is relatively strong in two axes while showing minimal strength in the third axes. For this we use an innovative method that exploits the variances in the Earth's magnetic field and a machine learning approach that provides rapid compensation. The resulting low cost 3U bus system leaves 2U of space for the payload while significantly reducing system cost and complexity and substantially increasing accessibility.