MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

Author: Dr. Aaron Parness
Caltech/JPL, United States

Mr. Russell Smith
United States
Ms. Christine Fuller
United States
Mr. Nicholas Wiltsie
United States
Mr. Simon Kalouche
Carnegie Mellon University, United States
Dr. Donald Ruffatto III
Illinois Institute of Technology, United States
Dr. Mohammad Dadkhah
Illinois Institute of Technology, United States
Mr. Jaakko Karras
United States
Mr. Kalind Carpenter
United States
Prof. Matthew Spenko
Illinois Institute of Technology, United States

ZERO GRAVITY ROBOTIC MOBILITY EXPERIMENTS WITH ELECTROSTATIC AND GECKO-LIKE ADHESIVES ABOARD NASA'S ZERO GRAVITY AIRPLANE

Abstract

This paper will present the results of zero gravity adhesion and mobility experiments from two campaigns of zero gravity flights aboard NASA's C9B zero-gravity airplane, totaling more than 300 parabolas. Two primary adhesion technologies were tested independently and as a hybrid system: gecko-like adhesives and electrostatic adhesives. Gecko-like adhesives use van der Waals forces generated by microscopic hairs to stick to surfaces while electrostatic adhesives create an electric field that polarizes non-conductive surfaces to create adhesion and creates a capacitive clamping force on conductive surfaces where electrons are free to move.

In zero gravity, grappling experiments were performed using a robotic gripper and a 10 kg target piece of debris to verify the performance of the adhesive materials. Based on these initial results, mobility experiments were devised for the second campaign of flights the following year. Experimental results from three mobile robot concepts that can provide mobility on the exterior of the spacecraft will be presented. The first robot uses an inchworm style gait with two feet, each of which contains a pair of opposed adhesive pads. The second robot uses adhesive wheels that contain flaps of the hybridized electro-gecko material. This robot can make transitions between planes, and adheres to a much broader range of surface materials. Both of these robots weigh less than 500 grams and serve as representative technology demonstration platforms that were relatively easy to deploy during the zero-gravity experiments. A third microgravity robot will also be presented based on JPL's history of limbed robots. This robot has a 20

kg mass and uses four limbs, each with 7 degrees of freedom. Each limb terminates in a gecko-adhesive gripper that provides anchoring capability to spacecraft surfaces. This robot has not been tested in the zero-gravity airplane, but results from air bearing flat floor tests and ground-based gravity-offload tests will be presented.

The applications of robots that can inch, roll, or crawl across satellites, space stations, and future spaceships include inspection, repair, assembly, and photo/video documentation. The pathway of validating this technology aboard the International Space Station before use in future long-duration spacecraft will also be presented.