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ASTROBEE: CURRENT STATUS AND FUTURE USE AS AN INTERNATIONAL RESEARCH  
PLATFORM

**Abstract**

The Astrobees are NASA's next generation free-flying robots for the International Space Station (ISS). In this paper we update Astrobees development status, describe its software, and the ground facilities used for testing. We also describe initial uses of Astrobees as a research and educational platform, including the Zero Robotics competition for students ages 12-18.

Astrobees are NASA's next-generation free-flying robot that will replace the Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) on board the ISS. Astrobees will operate inside the ISS, where they will assist astronauts, ground controllers, and researchers. The Astrobees Robot Software (ARS) is the open-source, Robot Operating System (ROS) based software in charge of Astrobees' correct autonomous operation. The ARS can be used interchangeably as an Astrobees Simulator or as Astrobees' on board software, facilitating the robot's development.

In addition to simulation-based testing, further evaluation has been performed using the SPHERES "Granite Lab" and "Micro-Gravity Test Facility" (MGTF) at NASA Ames. The Granite lab consists of a 3m x 3m granite table used to mimic microgravity conditions in three axes (x/y/yaw) by mounting one or multiple Astrobees on mobile air bearings to eliminate friction. This facility also replicates a section of the ISS including lighting, handrails, and the Astrobees dock.

The MGTF expands the Granite lab's capabilities by allowing an Astrobees to maneuver with 6 degrees of freedom (DOF). A Gantry structure allows linear displacement in x-y-z, and a Gimbal performs rotations about those axes. Motion is driven by a physics simulation that responds to simulated thrust command from the robot. The MGTF expands the capabilities to test at a higher fidelity Astrobees features from path planning and obstacle avoidance to computer vision based mobility control algorithms.

In addition to carrying out tasks to support ISS operations, Astrobees were designed to support a broad range of "guest science". Guest scientists will be able to use Astrobees to test a variety of mobile payloads and sensors, as well as carry out experiments ranging from human-robot interaction studies to examination of fluid behavior in microgravity. Industrial and academic researchers can run their experiments using these free-flying robots. We describe several of the hardware and software payloads currently under development for Astrobees, as well as discuss the transition from SPHERES to Astrobees in the Zero Robotics program.