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Space Technology
Game Changing Development
Astrobee: Space Station Robotic Free Flyer

Overview

The Astrobee project is developing a set of three free-flying robots—each roughly one foot by one foot by one foot—that will operate inside the International Space Station. Astrobee's primary objective is to provide a zero-g research facility for guest scientists. The Astrobees—Honey, Queen, and Bumble—will replace the Synchronized Position Hold Engage and Reorient Experimental Satellite (SPHERES) robots that have been among the most-used facilities on station since they arrived in 2006, hosting experiments on topics ranging from magnetic propulsion, to simulated satellite inspection, to studying the dynamics of tethers and fuel slosh in zero-g.

Astrobee is part of the NASA Human Exploration Telerobotics 2 project at NASA's Ames Research Center in California's Silicon Valley. Astrobee will carry on the SPHERES legacy, while opening up new areas of research with expanded capabilities, including improved autonomy, better support for guest science hardware add-ons, a built-in suite of cameras, and a robotic arm. After launch and commissioning in 2019, the Astrobees will transition to become the Astrobee Research Facility, managed by the NASA Advanced Exploration Systems Program.

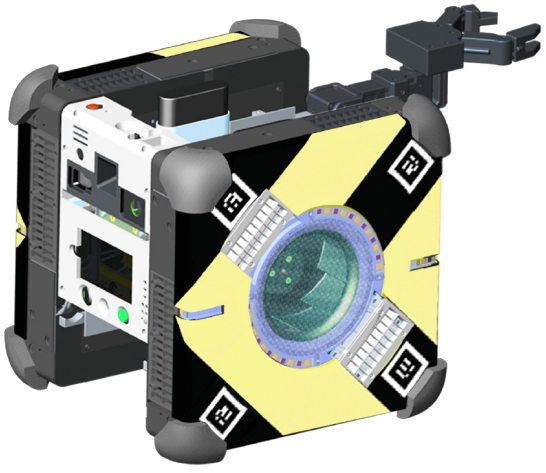
The dock-resupply station hardware for the project was launched to the space station on November 17, 2018 aboard Northrop Grumman CRS-10 from NASA's Wallops Flight Facility in Virginia and was installed on the station on February 15, 2019. Two of the Astrobee robots, to be named Honey and Bumble, are planned to launch no earlier than April 17, 2019 aboard the Northrop Grumman CRS-11 mission from NASA's Wallops Flight Facility in Virginia. The robot to be named Queen is planned to launch this summer.

Caretaker Robot

Today, astronauts on the space station must split their time between science activities and maintenance tasks. Remote monitoring and operation by ground control has become common practice for certain tasks. However, in terms of telerobotics, these tasks are limited to coarse positioning of external payloads/structures using manipulator arms.

Future space exploration will return humans to the moon and go beyond to deep space. During these complex missions, astronaut time will continue to be a critical resource, and some maintenance may be needed while the crew is not present. Robots can complement astronauts by working under remote supervision by humans from a space station, spacecraft, habitat, or even from Earth.

Supporting this vision, the Astrobee robots have two related objectives. First, they act as free-flying cameras to aid flight controllers. Each Astrobee robot can downlink live, high-definition video. Using the intuitive 3D interface of the Astrobee control station, an operator on the ground can easily maneuver an Astrobee to provide an ideal view of astronaut activities. Each Astrobee has enough battery life to fly for hours and can reduce power consumption by collecting video while using its arm to perch on a handrail. Currently, the



Astrobee robotic free flyer.

astronauts manually change the batteries for the SPHERES robots. Astrobee robots will navigate themselves to the dock hardware (already installed on the station) to access power and self-charge their batteries without astronaut intervention.

The second objective is to collect environmental data throughout the station. The first sensor to integrate with Astrobee robots after launch will be a radio-frequency identification (RFID) reader that will enable Astrobee robots to ping the RFID tags on key equipment and track its location. The space station program also plans to use Astrobee robots to monitor levels of carbon dioxide, radiation, and noise. Robotic sensor surveys will save crew time, while more frequent and thorough sampling will inform future improvements to the life support systems the astronauts depend on.

To save astronaut time, each Astrobee robot was designed to operate autonomously, from separation from its battery recharging dock, through flying a complete plan, to autonomously returning to dock. Operators on the ground will generally monitor the Astrobee robot whenever it is active and can take over to teleoperate the robot or handle anomalies.

Astrobee Research Facility

Each Astrobee robot has a quad-core processor devoted to running guest software. For sensing, it carries a suite of six cameras. For communicating with astronauts, it carries a touch screen, speaker, microphone, laser pointer, and an array of signal lights. For manipulation research, it carries a 2 degree-of-freedom (DOF) arm with a gripper. For research on motion control, each Astrobee robot has 6-DOF holonomic flight capability (it can move and turn in any direction), and multiple Astrobees can communicate to coordinate their motion.

Researchers with new ideas about how to use a zero-g robot can find out how to get involved with this research by viewing the Astrobee Guest Science Guide, which can be found at https://www.nasa.gov/astrobee, along with project contact and schedule information.

Education

Astrobee will continue the SPHERES tradition of hosting the Center for the Advancement of Science in Space-sponsored Zero Robotics (ZR) Competition, managed by Massachusetts Institute of Technology. The competition

Illustration of an Astrobee robot perched on a handrail to take video of a crew activity.

theme changes each year. In 2015, over 171 middle school and high school teams from 18 countries competed to program the SPHERES robots in a game that simulated deploying GPS satellites around Mars. After ZR transitions to the Astrobees, their improved capabilities will give students new learning opportunities, like using the new cameras and a robotic arm.

Acknowledgments

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GCD is part of NASA's Space Technology Mission Directorate. The GCD Program aims to advance exploratory concepts and deliver technology solutions that enable new capabilities or radically alter current approaches.

For more information about GCD, please visit http://gameon.nasa.gov/

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