



# SPHERES International Space Station National Laboratory Facility

Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES)



*Astronaut Scott Kelly shows off the SPHERES satellites on ISS*

## Overview

These are, in fact, the droids that NASA and its research partners are looking for. Inspired by a floating droid battling Luke Skywalker in the film *Star Wars*, the free-flying satellites known as Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) have been flying aboard the International Space Station (ISS) since Expedition 8 in 2003. Although there have been numerous SPHERES investigations held on the orbiting laboratory, five current and upcoming SPHERES projects are of particular significance to robotics engineers, rocket launch companies, NASA exploration and anyone who uses communications systems on Earth. SPHERES provide a unique low-risk, low-cost, long-term microgravity research facility that supports quick-reaction testing of technologies that can be repeated numerous times.

Powered not by an astronaut's use of "The Force," but by AA batteries and compressed CO<sub>2</sub>, the satellites act as free-flying platforms that can accommodate various mounting features and mechanisms in order to test and examine the physical or mechanical properties of materials in microgravity. Each satellite is an 18-sided polyhedron and is roughly the size of a volleyball.

NASA's Ames Research Center in Moffett Field, Calif., operates and maintains the SPHERES research facility aboard the space station,

which is funded by the Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington. The facility at NASA Ames includes world-class ground based microgravity testing labs including the 2D Granite lab and the 3D Microgravity Testing Facility (MGTF) lab. Both labs provide unique and important testing capabilities increasing the reliability of what's sent to the space station.

## Current Investigations

**SmartSPHERES:** NASA's "Human Exploration Telerobotics" project is using the SPHERES as remotely operated robots to experiment with a variety of intravehicular activities (IVA) inside the space station, such as environmental monitoring surveys and mobile camera work.

Because the SPHERES were originally designed as miniature satellites for studying spacecraft control algorithms, they required modification in order to be used as telerobots. Thus, in 2011, the project added a commercial smartphone to SPHERES—transforming the system into "SmartSPHERES". The smartphone provides the robot with a built-in camera to take pictures and video, sensors to help conduct inspections, a powerful computing unit to make calculations, and a Wi-Fi connection to transfer data in real-time to the computers aboard the space station and to mission control in Houston.



*Smartphone integrated with SPHERES*

NASAfacts

The existing SmartSPHERES smartphones will be upgraded. NASA will launch a “Project Tango” prototype Android smartphone developed by Google’s Advanced Technology and Projects division of Mountain View, Calif. The prototype phone includes an integrated custom 3D sensor, which means the device is capable of tracking its own position and orientation in real time as well as generating a full 3-D model of the environment.

**SPHERES-VERTIGO:** Operating intermittently since February 2013, the SPHERES Visual Estimation and Relative Tracking for Inspection of Generic Objects (SPHERES-VERTIGO) investigation uses what looks like eye goggles and other new hardware and software on multiple satellites during testing. The purpose of the study is to build 3D models of a target using mapping algorithms and computer vision-based navigation. These additions to the satellites help researchers create 3D maps of a previously unknown object for navigation by flying the SPHERES in a path around that object while taking photos.

**SPHERES-RINGS:** The DOD SPHERES-Resonant Inductive Near-field Generation System (SPHERES-RINGS) investigation is the first demonstration of electromagnetic formation flight in microgravity, as well as of wireless power transfer in space. The RINGS project demonstrates the use of electromagnetic coils to maneuver individual SPHERES with respect to one another. The current running through the ring of coils controls the satellites, so that two ring-outfitted SPHERES are able to attract, repel and rotate.

**SPHERES-Slosh:** The new SPHERES-Slosh investigation was named for the sound of liquids sloshing. SPHERES-Slosh seeks to understand how fluids move inside containers during long-duration flight in microgravity. The study will demonstrate how applied external forces impact the contained fluids. The goal is to simulate how rocket fuels move around inside their tanks, as in response to motor thrusts used to push a rocket through space. The study of the physics of liquid motion in microgravity is important because Earth’s most powerful rockets use liquid fuels to take satellites and other spacecraft into orbit.

**SPHERES-InSPIRE:** In 2014, the SPHERES-Inspire investigation added a series of universal docking ports and a series of Halo interfaces to existing SPHERES on the space station. The Halos consist of six ports each and surround the small satellites, as the name would suggest. The Halo and docking ports expand SPHERES processing power and data handling capabilities for extensive testing scenarios. The SPHERES-VERTIGO “eye goggles” can be attached to the Halo to provide vision-based navigation.

With every new hardware addition to SPHERES, significant advancements are made in robotics proficiencies, and one day, older or non-functional satellites will be repaired or refurbished in orbit. The science fiction of robotic droids buzzing around to equip and repair spacecraft and space travelers is no longer just the fantasy of *Star Wars*. Rather, the use of robotic capabilities is fast becoming more of a reality thanks to these free-flying SPHERES.

**For more information on SPHERES, please visit:**  
<http://www.nasa.gov/spheres>

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Astronaut Thomas Marshburn tests the SPHERES-VERTIGO on ISS



Astronaut Mike Hopkins conducting a SPHERES-RINGS science experiment on ISS



SPHERES-Slosh with tanks partially filled with water conducting a test on ISS

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