Droids on the ISS

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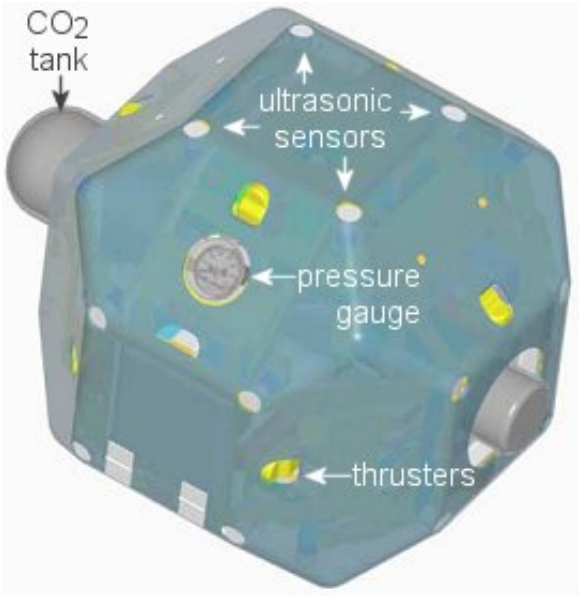
MIT undergrads flight-test a prototype droid onboard NASA's KC-135 reduced gravity aircraft.

Six years ago, MIT engineering Professor David Miller showed the movie Star Wars to his students on their first day of class. There's a scene Miller is particularly fond of, the one where Luke Skywalker spars with a floating battle droid. Miller stood up and pointed: "I want you to build me some of those."

So they did. With support from the Department of Defense and NASA, Miller's undergraduates built five working droids. And now, one of them is onboard the International Space Station (ISS).

"It only looks like a battle droid," laughs Miller. It's actually a tiny satellite—the first of three NASA plans to send to the ISS. Together, they'll navigate the corridors of the space station, learning how to fly in formation.



A CAD-model of a SPHERES satellite.

Tiny satellites are a hot new idea in space exploration: Instead of launching one big, heavy satellite to do a job, why not launch lots of little ones? They can orbit Earth in tandem, each doing their own small part of the overall mission. If a solar flare zaps one satellite—no problem. The rest can close ranks and carry on. Launch costs are reduced, too, because tiny satellites can hitch a ride inside larger payloads, getting to space almost free of charge.

But there's a problem: Flying in formation is trickier than it sounds. Ask a crowd of people to line up single file, and they'll be able to figure it out and do it rather easily. Getting a group of orbiting satellites to do the

same thing, it turns out, is extremely hard.

"Suppose you've got a cluster of satellites in orbit," says Miller, "and one or two of them lose their place." Maybe a solar flare temporarily scrambles their nav-computers, or a thruster firing didn't work as expected. The whole cluster finds itself out of whack. Correcting the problem requires a complex set of 3-dimensional adjustments, coordinated among all the satellites—perhaps dozens or hundreds of them. "We've got to break this down into step-by-step, concrete instructions that a computer can understand," Miller says.

And that takes us back to the ISS:

Miller's challenge to his undergraduate engineering class back in 1999 was to design a small, roughly spherical robot that could float aboard the ISS and maneuver using compressed CO_2 thrusters. The project, called SPHERES (Synchronized Position Hold Engage Re-orient Experimental Satellite), would serve as a testbed for trying out experimental software to control clusters of satellites. The robotic spheres provide a generic platform consisting of sensors, thrusters, communications and a microprocessor; scientists working on new software ideas can load their software into that platform to see how well those ideas work. It's a quick and relatively cheap way to test new theories on software design.

Possible applications include NASA's return to the Moon. One way to build a moonship is to assemble it piece by piece in Earth orbit. "Software designed to control small satellites could just as well be used to maneuver the pieces of a spaceship together," says Miller.

The first SPHERE arrived on the ISS in April tucked inside a Progress supply rocket. (Remember, tiny satellites make good hitchhikers.) Eventually two more SPHERES will join it, one later this year when the space shuttle Discovery (STS-121) returns to the station, and another

carried to orbit by a future shuttle mission.

How will astronauts tell the three SPHERES apart? "They're color coded," explains Miller. The one onboard now is red; the second will be blue and the third yellow.

"Red" is already busy. "We've commanded it to do a variety of maneuvers—loops and turns, for instance. And we've tested the robot's ability to solve problems." Astronauts tried to trick Red by causing one of its thrusters to stick "on." The robot diagnosed the fault, turned the thruster off, and returned to station-keeping.

"Not bad for one little droid," says Miller. "I can't wait to see what three of them can do."

Source: Science@NASA, by Dr. Tony Phillips and Patrick L. Barry