Synchronized tumbling: how to catch a retired satellite

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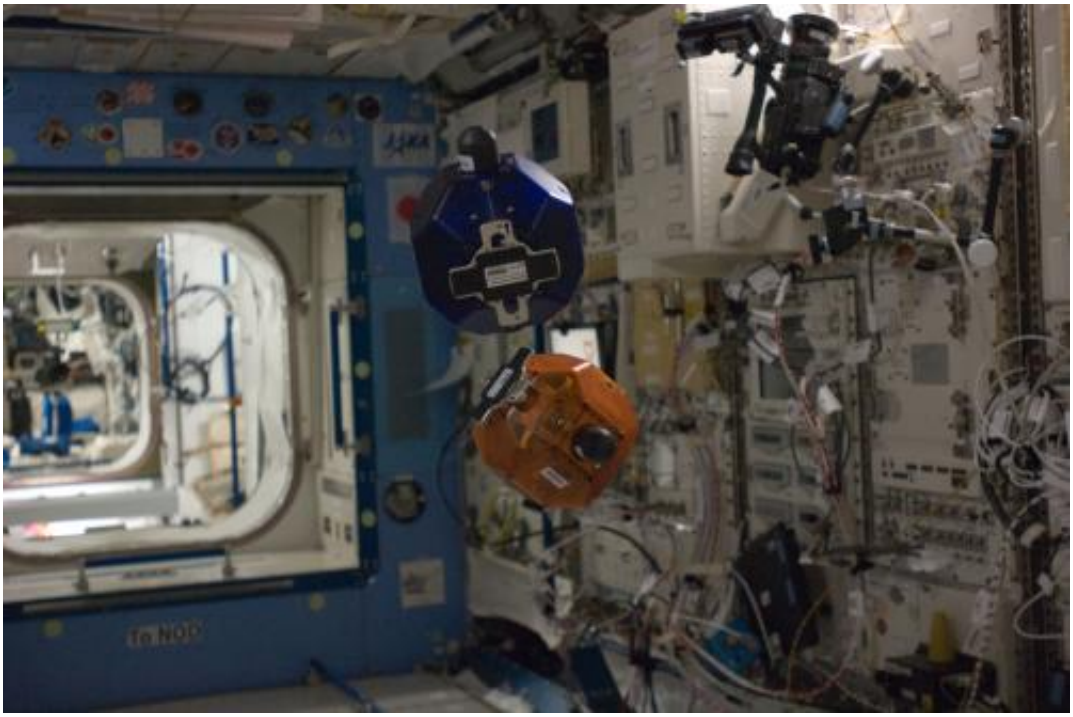

In space, there are no brakes. Active satellites and spacecraft achieve controlled movement with thrusters. Retired satellites, on the other hand, no longer controlled from Earth, tumble in their orbits through space while traveling at high speed. A spacecraft seeking to rendezvous with such a satellite must perform a delicate dance to safely approach and synchronize movements. With the help of teams of individuals from

around the world, DARPA is beginning to determine the steps required. Their work could inform the design of autonomous control mechanisms for all manner of complex future space operations.

Before going big, DARPA started small. Participants in the Zero Robotics Autonomous Space Capture Challenge designed and recently demonstrated algorithms to control a bowling-ball-sized programmable SPHERES satellite aboard the International Space Station (ISS). Three finalist teams—based on high school teams that participated in previous Zero Robotics challenges—emerged from a series of four, one-week qualifying rounds: "y0b0tics!" (Montclair, NJ); "The Catcher in the Skye" (Sparta, NJ); and "Nitro"(Eagleville, PA). On June 22, the teams gathered at the Massachusetts Institute of Technology to watch via videolink as their algorithms were tested on board the ISS. The algorithms were applied across three scenarios in which the SPHERES satellite simulated an active spacecraft approaching an object tumbling through space. In each scenario, at least one of the teams was able to approach the tumbling target and remain synchronized within the predefined capture region.

Now to scale this work: through its Phoenix program, DARPA intends to develop and demonstrate technologies to cooperatively harvest and re-use valuable components from retired, nonworking communications satellites in geosynchronous orbit. Success will require that the Phoenix spacecraft maneuver itself into position and synchronize with a tumbling object such that tools can be extended to remove or attach necessary parts. Future Zero Robotics competitions and other DARPA efforts will be aimed at further developing and refining the algorithms that enable these capabilities.

"The latest competition on the ISS helped identify key attributes in how to optimize fuel use and time to match an object's random tumble in space and be able to approach and dock with it safely," said Dave

Barnhart, DARPA program manager. "The control procedures that were developed for the Zero Robotics Challenge will certainly benefit the Phoenix program, but they also potentially have much wider implications for space-based technologies. Our efforts can help to reduce the risks and costs of future complex satellite-to-satellite interactions in space to lower the barrier of entry for future space operations and missions."

The next Zero Robotics High School Tournament starts on Sept. 8, 2012, offering high school students the opportunity to design experiments that will be tested in space on DARPA's SPHERES. For more information and to register, go to zerorobotics.mit.edu/ .

Provided by DARPA