

Autonomous Proximity Operations: A Coming Collision in Orbit?

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As satellites become smaller and smarter, they will become increasingly capable of sophisticated operations in orbit. One class of operations—autonomous proximity operations—would allow satellites to inspect other satellites, diagnose malfunctions and provide on-orbit servicing. Such satellites could also provide sophisticated surveillance in space and would make excellent anti-satellite weapons. The rapid development of satellites capable of conducting close maneuvers to one another, in-orbit, may increase tension—suggesting that now may be the time to consider “rules of the road” for such operations.

The *Defense Technology Area Plan* (2000) called for “the development of micro-satellite vehicles with significant capability” including the ability to “conduct missions such as diagnostic inspection of malfunctioning satellites through autonomous guidance, rendezvous, and even docking techniques.”¹ These missions—generally referred to as autonomous proximity operations—are being pursued by NASA, DARPA and the Air Force, each of which intends to launch demonstrators in coming years (See chart).

Upcoming Autonomous Proximity Demonstrations

Satellite	Agency	Firm	Launch	Kg
DART Demonstration for Autonomous Rendezvous Technology	NASA	Orbital	Oct. 2004	48
XSS-11 Experimental Spacecraft System-11	USAF	Lockheed	Nov. 2004	100
ASTRO Autonomous Space Transport Robotic Operations	DARPA	Boeing	Mar. 2006	700

- NASA’s Demonstration of Autonomous Rendezvous Technology (DART) is an advanced flight demonstrator scheduled for launch in 2004. Once in orbit, the DART satellite will rendezvous with a DOD communications satellite and perform several autonomous rendezvous and close proximity operations, such as moving toward and away from the satellite using navigation data provided by an advanced video guidance (AVG) sensor and other on-board sensors. Orbital’s contract for DART is valued at \$47 million.
- The Air Force’s Experimental Spacecraft System (XSS) is a series of Air Force Research Laboratory satellites designed to demonstrate imaging applications of proximity operations. The most recent satellite, the XSS-10, was launched in 2003. That satellite maneuvered to within 35 meters of an expended Delta II rocket body, transmitting digital images to the earth, and conducted a number of other on orbit maneuvers for twenty-four hours before completing its mission; the next satellite in the series, the XSS-11, is scheduled for launch this year. Unlike the XSS-10, the XSS-11 will remain in orbit for a year and conduct close-proximity operations to multiple targets of opportunity. The USAF requested \$18.6 million in FY 2005 for the XSS micro-satellites. Lockheed’s contract for the XSS-11 is valued at \$21 million.

¹ Department of Defense, *Defense Technology Area Plan*, 2000, VIII-14.

- DARPA's Orbital Express will demonstrate the feasibility of using automated spacecraft to refuel, upgrade, and extend the life of on-orbit spacecraft.² Boeing is building two satellites—the Autonomous Space Transport Robotic Operations satellite (ASTRO) and a surrogate next generation serviceable satellite (NEXTSat)—for an on-orbit demonstration of autonomous satellite servicing set for launch in March 2006.³ DARPA is spending \$ 56.6 million in FY 2005 on its Orbital Express program. Boeing's contract for ASTRO is valued at \$113 million.

There may be other research into autonomous proximity operations at the classified level. At least one Air Force classified small-or micro-satellite is schedule to launch on a Minotaur launch vehicle in 2005; its function is unknown."

Although none of these satellites is a dedicated anti-satellite, each has that capability. As the head of the Air Force XSS program told *Space News*: "You can't closely inspect a vehicle—say, one with an on-orbit malfunction—without getting 'close' and approaching from the right angle. To refuel, obviously you'd have to get more than close, and 'dock' with the vehicle."⁴

The three programs are already contributing to an innocuous "anti-satellite" mission of sorts: NASA is planning to launch an autonomous "space tug" in 2006, using technology from DART, XSS and ASTRO, to de-orbit the Hubble Space Telescope. "We actually think that having three programs that are funded right now to look at aspects of this issue are really going to be a great help," noted one NASA official.⁵ The same might be said by Air Force Officials, one of whom told *Space News* that the "XSS-11 can be used as an ASAT weapon." In fact, the "single strongest recommendation" of the Air Force's 1999 *Microsatellite Technology and Requirements Study*, was "the deployment, as rapidly as possible, of XSS-10-based satellites to intercept, image and, if needed, take action against a target satellite" based on technology from the Army's Kinetic Energy Anti-Satellite program.

Given growing suspicion about motives of other space faring states, a proximity operation might lead to a serious incident in space. Already, there are signs that the growing presence of micro-satellites is undermining confidence in outer space security: Surrey Satellite Technology Ltd. (SSTL) launched a satellite SNAP-1, that maneuvered to within 9 meters of a Chinese university micro-satellite in 2000. The Chinese satellite, built by SSTL and a group of scientists at Tsinghua (Qinghua) University in Beijing, contained a multi-spectral camera with 40 meter resolution to demonstrate a constellation of remote sensing micro-satellites for natural disaster monitoring and mitigation.⁶ Despite the innocuous mission of

² Gerry Gottselig, "Orbital Express Advanced Technology Demonstration," *Presentation to 2002 Core Technologies for Space Systems Conference*, Colorado Springs, Colorado November 19-21, 2002.

³ "Boeing Team Selected to Build Orbital Express Advanced Technology Demonstration System," *Press Release*, March 15, 2002.

⁴ Elaine M. Grossman and Keith J. Costa, "Small, Experimental Satellite May Offer More Than Meets The Eye," *Inside The Pentagon*, December 4, 2003.

⁵ Brian Berger, "NASA Proposes \$300 Million Tug To Deorbit Hubble," *Space News*, November 24, 2003.

⁶ You Zheng and M. Sweeting, "Initial Mission status analysis of 3-axis stable Tsinghua-I Microsatellite," *The 14th Annual AIAA/Utah State University Conference on Small Satellites*, 2000. and Xiong Jianping et al , Cheng Zhenyu, You Zheng, Gong Ke, and Jia Huibo, "On board computer Subsystem Design for the

the Chinese satellite, and its relatively limited capabilities, the Department of Defense has identified TsinghuaSat-I as evidence that China is developing “parasitic microsattellites” for use as anti-satellite weapons.⁷ The launch of a Chinese micro-satellite with the capability of SNAP-I, let alone the XSS-II or DART, would generate concern in many quarters of the United States. If the Chinese were to conduct a proximity maneuver near a U.S. satellite, the reaction would be apoplectic.

Already, some proponents of micro-satellites are proposing that the United States develop a micro-satellite “space guard” force, analogous to the Coast Guard, to patrol low earth and geostationary orbit.⁸ Although proponents point to the stabilizing effect of the US Navy in combating piracy, there is a plausible case to be made that such efforts may stimulate other states to pursue micro-satellites and other anti-satellite capabilities—since a space-guard force could just as easily be used to deny other states the ability to operate in outer space.

The potential for a serious incident in outer space is being driven by advances in technology that challenge the existing rules and norms governing space activity. Micro-satellite proximity operations would be best regulated with confidence building measures in outer space. One solution may be an “Incidents in Space” agreement, modeled on the 1972 US-USSR Incidents at Sea Agreement. Such an agreement might regulate proximity operations and establish a code of conduct for operations on orbit.⁹ Any regime will have to be founded on principles widely recognized as legitimate. The guiding principles must reflect the tenets of the Outer Space Treaty, which states that the use of outer space be “carried out for the benefit and in the interests of all countries” and recognizes the “common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes.”¹⁰

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Tsinghua Nanosatellite,” *20th AIAA International Communication Satellite Systems Conference*, May 12-15, 2002.

⁷ Department of Defense, *Chinese Military Power*, 2003, 36.

⁸ Matt Bille et al, “A Microsatellite Space Guard Force,” *13th Annual AIAA/USU Small Satellite Conference*, 1999.

⁹ Michael Krepon with Christopher Clary, *Space Assurance or Space Dominance*, Henry L. Stimson Center, 2003, 114-123.

¹⁰ *Treaty On Principles Governing The Activities Of States In The Exploration And Use Of Outer Space, Including The Moon And Other Celestial Bodies*