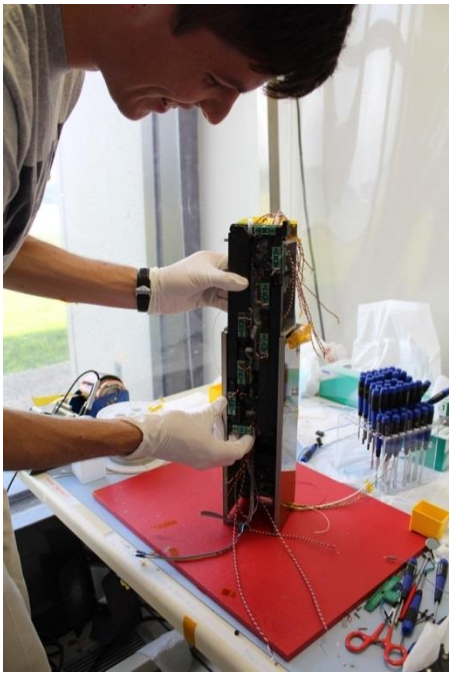
Thesis Paper Review - Leveraging the Autonomous Mobile On-Orbit Diagnostic System to Initiate a Doctrinal Shift in Spacecraft Operations

By DON Innovation

The Autonomous Mobile On-Orbit Diagnostic System (AMODS) is a research project developed by a team of Midshipmen from the United States Naval Academy which has the potential to instigate a paradigm shift in respect of how the DoD and the space industry as a whole develops and operates space assets. The goal of AMODS is to employ a small satellite platform to provide both new and legacy spacecraft with cost effective on-orbit assessment and repair services.

If a satellite makes it to orbit, there is no guarantee that it will work as intended. And those that actually work properly from launch can be expected, as with any machinery, to suffer the effects of wear and tear, whether over time or as a result of launch. The space environment is particularly harsh and greatly inhibits equipment reliability. Some spacecraft will suffer small but costly malfunctions and some will just stop working. Unfortunately, satellites cannot return to Earth for repair or maintenance. As a result, even seemingly

(Washington, DC) Autonomous Mobile On-orbit Diagnostic System Team (Left to Right) MIDN Dakota, ENS Hanlon and ENS Keegan received the 2016 Secretary of the Navy Innovation Awards trophy for the Innovation Scholar (Midshipman) category. (U.S. Navy photo by Mass Communication Specialist 2nd Class Jonathan B. Trejo/Released)

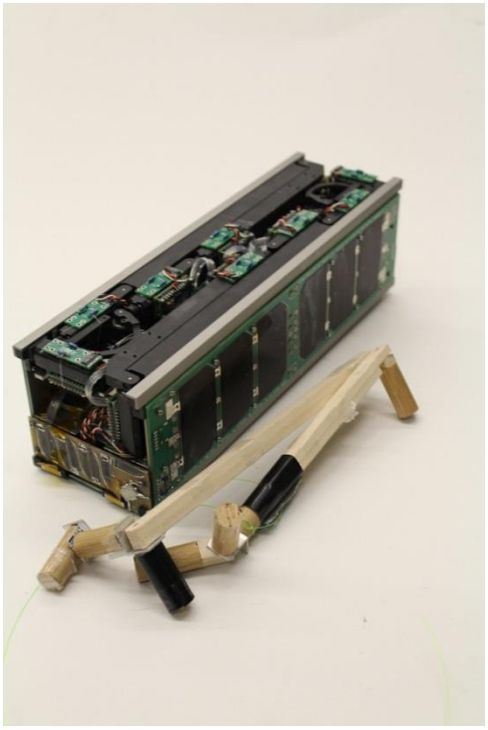


(Annapolis, MD) MIDN Hanlon assembling the RSat-P spacecraft. (U.S. Navy photo/Released)

benign failures can cripple a spacecraft, severely impede research and testing efforts, and ultimately frustrate a multi-million dollar investment. Furthermore, it is more than likely that a ground-based project team will never be able to conclusively determine why a failure or malfunction occurred.

In these cases, not only is the spacecraft lost, but invaluable experience vanishes with it. This lack of knowledge in the failure mode of a satellite decreases the ability to implement preventive or other innovative measures in replacement craft which in turn severely impedes the evolution of human ability in space. Current efforts to effect on-orbit satellite repair utilize conventional spacecraft and are consequently impeded by high cost.

AMODS takes advantage of the cost and profile efficiencies of the small satellite platform to offer satellite developers and operators a fundamentally new way to reduce risk, protect investment and effect design improvements correlated against observed space environment experience. The system embraces a multiple Cube Satellite construct including: 1) several repair CubeSat-class satellites (RSats) with manipulable arms and claws designed to latch onto a host satellite and maneuver around to image and potentially repair malfunctioning components on the host; and 2) one self-propelled transport CubeSat (BRICSat), a “space tug” with the ability to successively deliver multiple RSats to their respective host spacecraft on-orbit. Thus, there are two types of missions that the AMODS program will support: RSat deployment with future spacecraft and RSat deployment to existing on-orbit spacecraft. In each case, an RSat unit assigned to a host spacecraft will be able to provide ground teams with real-time imagery and other data in respect of spacecraft or component failure and even implement on-orbit repairs.



(Annapolis, MD) RSat-P spacecraft next to the original prototype wooden arm. (U.S. Navy photo/Released)

Put simply, AMODS deployment shifts conventional launch acuity from “launch and hope" to “launch and know." This means that the future space assets can be developed and operated at a much lower cost and at an accelerated schedule by enabling the space assets to be more risk tolerant.

AMODS will be validated in three phases. Phase one focuses on propulsive and proximity operations of the BRICSat vehicle and includes the launch

of prototype in in 2015 and an improved design in 2017. Phase two, the Q4 2017 launch of the prototype repair unit, will validate the on-orbit effectiveness of compact robotic manipulators. The full AMODS technology validation is anticipated to be launched into low Earth orbit in 2018. In addition to developing and testing an inexpensive, reliable repair system that can be placed on any future spacecraft thus greatly increasing the efficiency and effectiveness of humans in space, AMODS provides valuable satellite development and operational education and training to midshipmen and significantly broadens the capabilities, and thus potential uses for, the Cube satellite platform.

The research has been presented at numerous national and international conferences and has been well-received by the satellite community. The paper is published as a chapter in the book, Space Operations: Contributions from the Global Community, released in Spring 2017.

This thesis paper was written by Midshipmen Edward Hanlon, Benjamin Keegan, Morgan Lange, Jacob Pittman, Dakota Wenberg, and Gavin Roser while attending the United States Naval Academy.

Read the thesis paper in its entirety here.

MIDN Dakota, ENS Hanlon and ENS Keegan received the 2016 Secretary of the Navy (SECNAV) Innovation Award in the Innovation Scholar (Midshipmen) category in a prestigious ceremony officiated by Mr. Thomas Dee, performing the duties of the Under Secretary of the Navy, on 5 June 2017.

The SECNAV Innovation Awards recognize the top innovators within the Department of the Navy (DON). Their accomplishments are remarkable and serve as inspiration for the Navy and Marine Corps to think boldly and solve the fleet and force's most challenging problems.