DEFEND ABOVE

DEFENDING FROM ABOVE

SPACE DOMAIN AWARENESS CAPABILITIES ARE THE KEY TO PROTECTING CRITICAL SPACE ASSETS

REDWIRE

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The sharp rise in congestion, competition, and even provocative activities on orbit has made space security a top defense and intelligence priority for the U.S., its Allies, and partners.

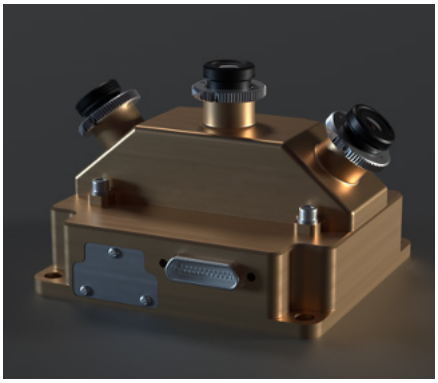
Reports earlier this year that Russia aims to develop a space-based nuclear weapon capable of anti-satellite (ASAT) operations captured the attention of the mainstream media and the general public alike. But the gradual reach of Great Power Competition into space has been happening for some time. For example, Russia used a direct-ascent ASAT weapon to destroy one of its own systems in 2021 shortly before it invaded Ukraine, signaling to the world its ability to target satellites that are critical to military operations. China also demonstrated direct-ascent ASAT capabilities in both 2007 and 2012. In the past few years, Russia and China have demonstrated a broader range of suspicious or threatening activity on orbit that could be used for spying or offensive purposes.

The U.S. Space Force's (USSF) 2025 budget proposal included $484 million for Space Domain Awareness (SDA) services. Space is now indisputably a significant warfighting domain, and achieving the theory of "competitive endurance" hailed by USSF Chief of Space Operations Gen. B. Chance Saltzman will require the ability to gain and maintain space-based SDA.

THE EYES OF SPACE-BASED SDA

Realizing competitive endurance will require proliferated systems for mesh (overlapping) coverage and resiliency. A shift from exquisite satellites to larger constellations is necessary to achieve effective "neighborhood watches" on orbit and to deter ASAT activities. A collaborative, expansive ecosystem is essential to avoid operational surprise and adequately detect, monitor, characterize, and respond to activity and threats in space. For example, there are certain types of adversarial activity that are better suited to detection and monitoring by ground- or space-based systems. Further, ground systems may be used to initially identify suspicious activity, with space-based systems on standby to take a closer look.

Reliable, high-quality optics are a key element for successful space-based SDA missions. Global space infrastructure provider Redwire has a strong heritage in this area. The company currently offers three types of proven optical systems that meet demanding SDA requirements at an affordable price point. In partnership with Lockheed Martin, Redwire is providing inspection and navigation cameras for the Orion spacecraft, which will carry astronauts from Earth to lunar orbit for NASA's Artemis missions. The same optical technologies Redwire provides in support of historic civil and commercial milestones also offer incredible utility for national security SDA missions.



Redwire's Argus Vision System provides autonomous proximity awareness and can be configured for a range of SDA, ISAM, and RPO missions. Image: Redwire

AUTONOMOUS PROXIMITY AWARENESS

In 2023, Starfish Space used Redwire's ARGUS smart camera for its satellite docking mission, Otter Pup. ARGUS is also used by Firefly Aerospace to provide avionics and critical navigation systems for its Blue Ghost lunar lander, which will deliver science investigations and technology demonstrations to the Moon for NASA's Artemis program.

The adaptable, high-performance ARGUS platform is ideal for payload deployment verification, vehicle inspection, close- to medium-range SDA, in-space assembly and manufacturing (ISAM), and rendezvous and proximity operations (RPO). ARGUS also offers onboard processing features such as image compression and storage for mission-specific computer vision applications.

Redwire's SpectraCAM is a low-cost, high-resolution camera designed to serve applications including SDA, docking, navigation, and inspection. Image: Redwire

HIGH-RESOLUTION SDA AND RELATIVE NAVIGATION

Redwire provided multiple SpectraCAM cameras for Intuitive Machines' IM-1 Moon landing mission, during which the cameras helped the spacecraft navigate the lunar terrain by detecting and avoiding hazards. The high-resolution SpectraCAM flight camera provides detailed domain awareness, especially for SDA missions within a specific orbital neighborhood. In addition to navigation and SDA, SpectraCAM applications also include RPO and docking in LEO.

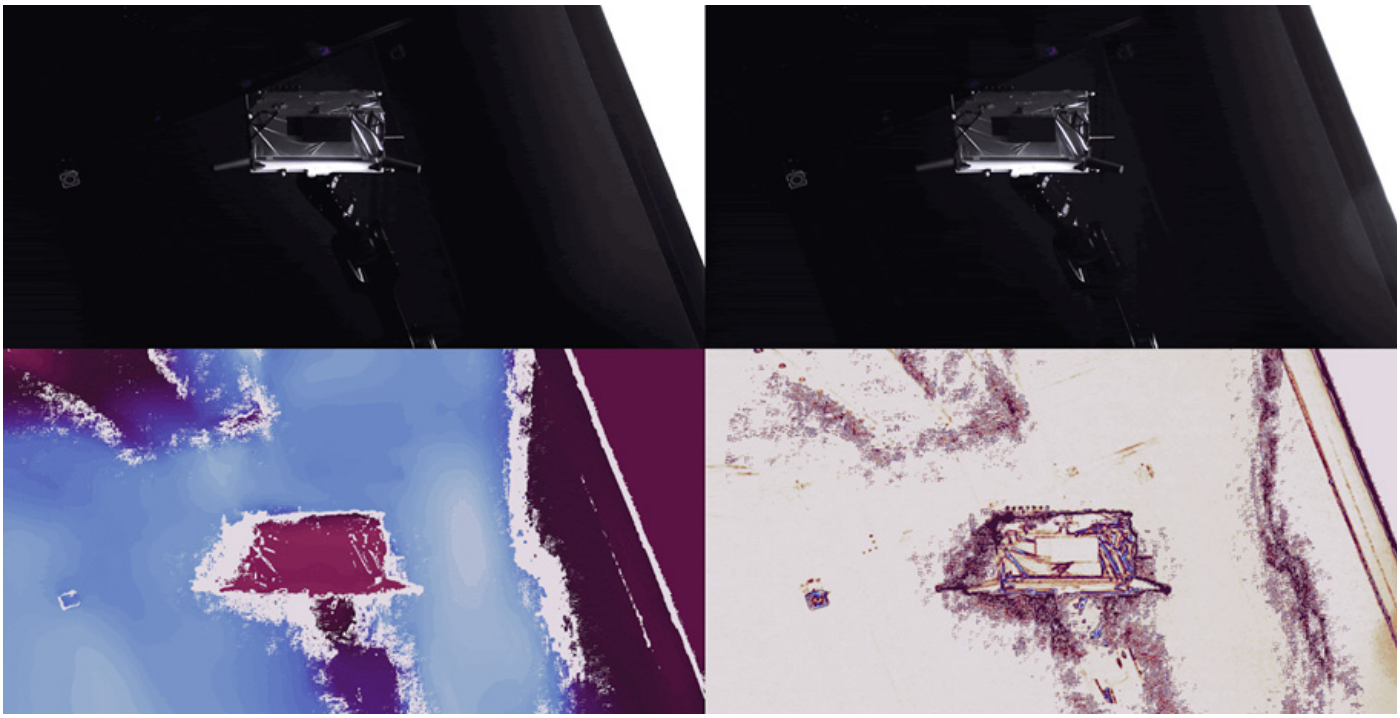
Redwire's SpectraTRAC star tracker is compact, autonomous, ruggedized, and radiation tested. Image: Redwire

PRECISE POSITIONING AND OBJECT CHARACTERIZATION

Redwire's SpectraTRAC star tracker is designed for spaceflight and cubesat missions and has an advanced algorithm to accurately determine a spacecraft's position relative to the stars. It's also radiation hardened, a requirement that will be increasingly important if space-based nuclear threats become a greater concern. Tools like SpectraTRAC offer low-cost solutions that could add significant value for data collection, debris detection, and reinforcing norms of behavior on orbit if widely adopted. SpectraTRAC can recognize when resident space objects pass through its field of view, and Redwire is developing software that will also enable it to perform ephemeris characterization.

RESILIENT SUN SENSING

Sun sensors, another key element for spacecraft guidance, navigation, and control (GNC), also need to deliver high performance and resiliency in the modern space environment. Thousands of Redwire sun sensors have been deployed on hundreds of spacecraft since the 1960s, when they were first used aboard the National Reconnaissance Office's Poppy signals intelligence satellite system to detect emissions from Soviet air and missile defense radars. Today, Redwire offers radiation-hardened coarse and fine sun sensor components to ensure continuity of operations for awareness on orbit in contested and hostile environments.



Redwire researchers are working with researchers at Stanford's Center for Aerospace Autonomy Research (CAESAR) to advance AI/ML capabilities for autonomous detection, characterization, and navigation in space. Image courtesy of CAESAR

CHARACTERIZATION AT THE EDGE

Capabilities for identifying unknown space objects are decades behind those available for missions in the air domain. Without the ability to differentiate a friend from foe on orbit, there is increased risk for uncertainty and unnecessary military escalation in space.

SDA data collection is poised to increase exponentially, and fortunately, there are many lessons learned from other defense and intelligence disciplines (e.g., Earth observation data) that can be applied for rapid sensemaking.

Redwire is conducting research at the forefront of advanced digital engineering efforts to harness artificial intelligence and machine learning (AI/ML) for SDA missions. As a scientific collaborator and founding corporate sponsor of the Center for Aerospace Autonomy Research (CAESAR) at Stanford University, which was formed in May, Redwire is helping to advance AI/ML capabilities for autonomous detection, characterization, and navigation around known and unknown space objects. Similar to how computer vision algorithms have been trained to identify anomalies, changes, or certain objects in satellite and airborne imagery of the Earth, the research is focused on training algorithms to perform detection and analysis using space-to-space images.

The goal of the research is to develop onboard processing that can extract decision-quality insights for operators. The results of this intersection of AI and space operations research have the potential to be valuable for mission sets that require speedy autonomous decision-making, including GNC, ISAM, and RPO.

Similarly, Redwire's Belgium-based team is collaborating as part of the Mastering Onboard Vision and Intelligence (MOVIQ) consortium to define a preliminary system architecture and proof of concept for an ML-powered edge computing platform. The project is targeted at missions such as wildfire detection that can benefit most from low-latency information, but there is potential to repurpose the resulting onboard processing capabilities for applications such as maritime monitoring and SDA.

Redwire's advancements and investments in next-generation SDA capabilities are vital in the context of today's competition for space superiority. With heritage across more than 50 years and 250 space missions, and several veterans among its leadership ranks, the company offers an unwavering commitment to mission and the fundamental building blocks of space infrastructure for national security. From subsystems to system-level, turnkey solutions, Redwire is answering the call for innovative, mission-critical SDA capabilities necessary to safeguard the rapidly evolving space domain. ■