The Deep Purple lead mechanical designer verifies the final mechanical torque on the assembly. He developed the overall design and assembly for the payload.

GLOBAL SECURITY

Reducing the threat from terrorism and weapons of mass destruction, providing cyber and space security, and enhancing global strategic stability

COMPACT LLNL ORBITAL PAYLOADS

In FY 2024, the Laboratory's Space Program continued to demonstrate its leadership in developing and delivering small satellite tools and capabilities—notably LLNL's patented monolithic telescope technology, which enables rapid deployment of modular optical designs for high-resolution or high-sensitivity space imagery. In August 2024, SpaceX successfully deployed NASA's Pathfinder Technology Demonstrator-R satellite, which features the now operational "Deep Purple" telescope. Deep Purple was designed, developed, qualified, and delivered in less than one year for under $1 million by a team of LLNL spacecraft engineers. It utilizes a new design for an ultra-violet (UV) and short-wave infrared (SWIR) monolithic telescope system. Deep Purple is simultaneously observing the UV and SWIR light from high-UV stars and the Milky Way's galactic bulge via two co-bore-sighted, 85-millimeter aperture monolithic telescopes.

The design features a new, compact, custom electronics module and a novel, lightweight, carbon-composite optical housing and radiator, likely making it the smallest telescope in orbit providing both SWIR and UV imaging. Such simultaneous imagery enables observation of time-domain astronomical events, such as Fast Blue Optical Transients—a phenomenon recently discovered and yet to be understood. Deep Purple also will attempt to demonstrate real-time space domain awareness using the UV and SWIR sensing bands.

The Space Program is also building an optical space domain awareness payload for an upcoming U.S. Space Force mission, VICTUS HAZE, to demonstrate rapid characterization of an on-orbit threat. The LLNL-developed payload for this mission will use a monolithic telescope built out of a single piece of fused silica, eliminating the need for alignment and calibration after production. The robustness of the monolithic telescopes and their ability to work immediately after launch make them ideal for responsive space missions like VICTUS HAZE. Livermore will build, qualify, and integrate its optical payload for launch in 2025. This will be the Laboratory's second payload for tactically responsive space missions. The first was the Tactically Responsive Launch-2 mission, which launched and operated on-orbit in 2021 and 2022.

AUTONOMOUS DRONE SWARM TESTING

The Laboratory's autonomous sensors team received the Federal Aviation Administration's (FAA's) first and, to date, only certificate of authorization (COA) allowing autonomous drone swarming exercises. These flights will test swarm controls and sensor payloads for a variety of national security applications. LLNL has been exploring how to apply cutting-edge AI and machine learning (ML) to its autonomous sensors. Receiving this approval further enables research into how swarms learn and respond in real time. Prior FAA field-testing authorization required one operator per drone. This COA allows one operator to manage multiple drones at once. To prevent leaving from the Laboratory campus, the autonomous drones have geofences—pre-defined virtual boundaries—and an emergency stop.

Autonomous drones developed at Livermore utilize a portfolio of Laboratory-developed software and AI/ML tools designed to teach the drones how to communicate and work together in real time, respond to environmental degradations, and course-correct when issues arise. The swarms differ from those used for entertainment purposes that might be seen at a sport stadium because autonomous drones are designed to operate spontaneously and independently in real time. Public drone shows that are controlled by a single operator use a 3D animation tool to create shapes, and recognizable characters are generated in advance as a pre-set series of commands.

AI FOR CRITICAL ENERGY INFRASTRUCTURE

In April 2024, the DOE Office of Cybersecurity, Energy Security, and Emergency Response (CESER) issued their summary report *Potential Benefits and Risks of Artificial Intelligence for Critical Infrastructure*. The report is an interim assessment, prepared over a 90-day timeframe as directed by Executive Order 14110, *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. The assessment was led by CESER with support from ML researchers and energy systems engineers at LLNL. CESER's summary report identifies potential benefits as well as key sources of risk. It finds "that AI has the potential to be of tremendous benefit to critical energy infrastructure, with a wide range of benefits that can dramatically improve nearly all aspects of the sector—including security, reliability, and resilience. However, the path to realizing these benefits reveals the clear need for regularly updated, risk-aware best practice guidance to facilitate the safe, secure, and beneficial deployment of AI in critical infrastructure."

The study identified 10 broad categories of beneficial AI applications covering such topics as operational awareness, active controls, predictive maintenance, system planning, and anomalous and malicious event detection and diagnosis. The applications were examined over three timeframes. Four categories of risk ranging from unintentional to adversarial attacks also were identified and considered. The assessment found "that while a number of significant risks exist if AI is used or deployed naïvely, most risks can be mitigated through best practices putting appropriate protections around important data and models, and in some cases, funding further research on mitigation techniques."

A NONPROLIFERATION SUMMER SCHOOL

Twenty students attended a week-long Nuclear Security and Nonproliferation Summer School at the Laboratory, which focused on the nuclear nonproliferation missions of the DOE and NNSA. The program was designed to introduce the students to LLNL's work and provide overviews of emergency response, nuclear forensics, and treaty verification. This summer school was co-sponsored by the Laboratory and the Nuclear Science and Security Consortium, which is led by the University of California, Berkeley. During the program, students performed hands-on activities in a unique, high-fidelity training facility equipped with a range of radiation materials and sources, including special nuclear materials and neutron and x-ray generators. The summer school also covered nuclear forensics and nuclear emergency response, providing student exercises in crime-scene forensics and in the search for and identification of radiological materials.

The Laboratory's autonomous sensors team has received the Federal Aviation Administration's first and—to date—only certificate of authorization allowing autonomous drone swarming exercises.