Naval Research Lab Sharpens Navy’s Sights with a Domain-Centric Path for Smarter Sensing

The U.S. Naval Research Laboratory (NRL) launched a groundbreaking remote sensing experiment, Coastal Hyperspectral Reflectance Object Material Analysis (CHROMA), Sept. 4-19, 2025, designed to accelerate the application of artificial intelligence (AI) in hyperspectral imaging and strengthen environmental intelligence and resource management capabilities across the Department of War and the wider scientific community. CHROMA participants are seen in a thermal infrared image during the second week of the Rochester Institute of Technology’s (RIT) Open Community eXperiment (ROCX). (Photo by Nathan Stein of Matter Intelligence)

From Nicholas E. M. Pasquini, U.S. Naval Research Laboratory Corporate Communications

Jan. 7, 2026

The U.S. Naval Research Laboratory (NRL) launched a remote sensing experiment to sharpen artificial intelligence (AI) applications in hyperspectral imaging across the Department of the Navy and broader scientific community.

The U.S. Naval Research Laboratory (NRL) launched a remote sensing experiment to sharpen artificial intelligence (AI) applications in hyperspectral imaging across the Department of the Navy and broader scientific community.

Hyperspectral imaging, often described as capturing “the color of color,” provides a unique spectral fingerprint for each pixel. Combined with AI, these fingerprints support powerful tools for detecting subtle material differences and observing environmental change.

In coastal and aquatic environments, such AI tools could help identify hazardous materials, monitor infrastructure degradation, and assess natural resources with unprecedented accuracy.

The initiative, known as the Coastal Hyperspectral Reflectance Object Material Analysis (CHROMA) experiment, ran Sept. 4–19 as part of the Rochester Institute of Technology’s (RIT) Open Community eXperiment (ROCX).

“NRL was a key partner in the success of ROCX,” said RIT Research Professor John Kerekes, Ph.D. “The variety of material deployments on water and land enriched the overall value of the experiment and the professionalism of their staff was a great example for participating students and collaborators.”

Led by Kerekes, the multi-agency effort brought together federal, academic, and industry partners to collect detailed imaging data and match it with real-world measurements taken on the ground.

“The Navy has always depended on its ability to sense, interpret, and respond to the environment,” said NRL’s Information Operations Branch Head Gautam Trivedi, Ph.D. “With

CHROMA, we're building the foundation for the next generation of environmental intelligence, where AI and advanced sensing work hand-in-hand."

The laboratory is leveraging multi-scale data collected from airborne platforms, unmanned aerial vehicles, and satellites over engineered and natural targets at the Tait Preserve in Penfield, New York — an environment chosen for its coastal and aquatic-adjacent features.

"This experiment moves hyperspectral technology out of the lab and into a realistic operational setting," said NRL Information Technology Division Superintendent Joey Mathews. "It represents a critical step in elevating the Technology Readiness Level of AI-enhanced sensing applications, moving us toward demonstrations that directly support naval missions."

A Multi-Platform, Domain-Centric Approach The NRL team synchronized flights and different types of sensors to capture observations at nearly the same time. This approach ensures data from satellites, airplanes, drones, and ground sensors can be accurately compared, offering researchers a richer dataset to build better AI. CHROMA's design centers on generating detailed, multi-modal datasets of known material spectral responses. Researchers collected measurements from custom-fabricated metal panels with painted coatings, as well as from natural rock and mineral samples. These targets serve as known reference points — like the bullseye on a target — for improving AI algorithms that solve a longstanding remote sensing challenge called hyperspectral unmixing. Hyperspectral unmixing is the process of separating mixed spectral signatures within a single pixel. When unresolved, mixed pixels can obscure object detection and reduce identification accuracy — especially in complex, cluttered coastal environments. "We are enhancing the efficacy of AI-driven approaches in resolving sub-pixel material compositions," said NRL CHROMA Project Lead Katarina Doctor, Ph.D. "By methodically changing the targets and viewing them with different sensors, we can learn how an object's signature changes based on its material, the weather, and the type of sensor used to view it." Doctor emphasized the data's direct application to naval missions, stating it will significantly improve our ability to detect and identify objects in crowded littoral zones. She

noted that this improved hyperspectral detection is key to assessing threats, monitoring critical infrastructure, and ensuring the U.S. Navy can maintain a clear operational advantage in any coastal environment.

Elevating Naval Survivability The NRL Signature Technology Office contributed coated panels for the experiment, supporting research on how artificial surfaces appear in natural maritime settings. "This project, enhanced by Doctor's work with advanced AI, uses the collected data to develop more effective camouflage coatings that will make naval platforms harder to detect by advanced surveillance systems," said Scott Ramsey, Head of the NRL Signature Technology Office. "This research is key to improving naval asset survivability by making them harder to spot against natural backgrounds." The resulting AI systems will be better able to distinguish between natural environments, like ocean surface, and coated, fabricated objects, like a ship's hull. The approach provides reference points for evaluating how AI-based unmixing performs across varying environmental and spectral conditions.

Data for the Global Research Community

Doctor said ROCX will produce comprehensive hyperspectral datasets, encompassing engineered surfaces, geological samples, and a range of environmental conditions. The dataset will be shared openly with the remote sensing community, supporting defense and civilian research in coastal resource management, environmental intelligence, and infrastructure monitoring. ROCX's multi-platform framework ensures experiment data is broadly applicable and scientifically rigorous. The combined dataset also enables researchers to study how an object's spectral signature is affected by its material properties, the atmosphere, and other environmental factors. "The integration of diverse data types is what makes CHROMA unique," Mathews said. "It's not just about building better algorithms – it's about understanding how they perform in the complexity of the real world."

AI's Domain-Centric Future

CHROMA also reflects a shift in AI development from traditional, model-centric approaches toward what researchers call Domain-Centric AI. This approach embeds expert scientific knowledge into the AI development process from the start, ensuring the final system understands the real-world context of its mission, which makes the AI more reliable.

"This paradigm addresses the 'why' behind the data. Real-world applicability and trustworthiness depend heavily on understanding the problem's context and leveraging specialized human expertise," Doctor said. "The ROCX experiment is a prime example of Domain-Centric AI. We are not just gathering raw information – we are creating a dataset informed by deep understanding of the target materials, their environment, and the sensors collecting them – which makes the resulting AI models more effective."

About the U.S. Naval Research Laboratory

NRL is a scientific and engineering command dedicated to research that drives innovative advances for the U.S. Navy and Marine Corps from the seafloor to space and in the information domain. NRL, located in Washington, D.C. with major field sites in Stennis Space Center, Mississippi; Key West, Florida; Monterey, California, and employs approximately 3,000 civilian scientists, engineers and support personnel. NRL offers several mechanisms for collaborating with the broader scientific community, within and outside of the Federal government. These include Cooperative Research and Development Agreements (CRADAs), LP-CRADAs, Educational Partnership Agreements, agreements under the authority of 10 USC 4892, licensing agreements, FAR contracts, and other applicable agreements. For more information, contact NRL Corporate Communications at NRLPAO@us.navy.mil.