U.S. NAVAL RESEARCH LABORATORY

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Black Relieves Petrovic as the 42nd NRL Commander

Capt. Jesse Black, U.S. Naval Research Laboratory (NRL)'s incoming commanding officer, is piped aboard during the NRL change of command in Washington, D.C., on July 14, 2023. Black became NRL's 42nd commanding officer. (U.S. Navy photo by Sarah Peterson)

Capt. Jesse Black relieved Capt. Gregory Petrovic and assumed command as the 42nd commanding officer of the U.S. Naval Research Laboratory (NRL) during a ceremony on July 14, 2023. Black assumed command of NRL following his tour of duty as it's executive officer.

Chief of Naval Research Rear Adm. Kurt Rothenhaus presented Petrovic with a Legion of Merit award for his exceptionally meritorious service as executive officer and commanding officer of NRL from June 2019 to June 2023.

During his tenure, Petrovic made significant contributions to the security of the United States by enabling the performance of a wide range of critical military research that will have enduring long-range impacts on both military and economic instruments of power.

Black is a graduate of the Naval Postgraduate School, publishing his thesis on solid state power systems. As an officer, Black has led teams tasked with solving complex engineering challenges, such as Gerald R. Ford-class advanced weapons elevators, nuclear refueling complex overhauls and maintenance availabilities, and integrated power and propulsion systems on Zumwalt-class destroyers and Columbia-class submarines.

"I thought I came from a dangerous world, but when you are the first to touch science that has never been touched before, it is dangerous," said Black. "As commanding officer, I will ensure safety remains at the forefront of our work while providing cutting-edge capabilities to our sailors and Marines."

Black was specially selected to serve in the White House as a senior sustainability officer under two presidential administrations. He graduated from the University of Idaho with a Bachelor of Science in civil engineering and earned a Master of Science degree in electrical engineering from the Naval Postgraduate School in 2007.

Cmdr. Aaron Roberts takes Command of NRL's Scientific Development Squadron

Cmdr. Aaron Roberts, U.S. Naval Research Laboratory's Scientific Development Squadron (VXS) 1 commanding officer, gives his welcoming remarks during a change-of-command ceremony at Naval Air Station Patuxent River in Patuxent River, Maryland, on May 18, 2023. (U.S. Navy photo by Sarah Peterson)

Cmdr. Aaron Roberts relieved Cmdr. Jeffrey Webb as commander of the U.S. Naval Research Laboratory's (NRL) Scientific Development Squadron (VXS-1), the Warlocks, May 18 during a change-of-command ceremony held at Naval Air Station Patuxent River, Maryland.

In 2022, the Warlocks flew more than 220 sorties executing over 880 flight hours providing direct support to the Office of Naval Research, NRL, and the greater Naval Research Enterprise. The squadron completed research detachments to California, Cuba, Florida, Greenland, Iceland, New Mexico, and North Carolina.

In his remarks, Webb thanked VXS-1 personnel who remained steadfast in their commitment to support the Naval Research Enterprise airborne research missions.

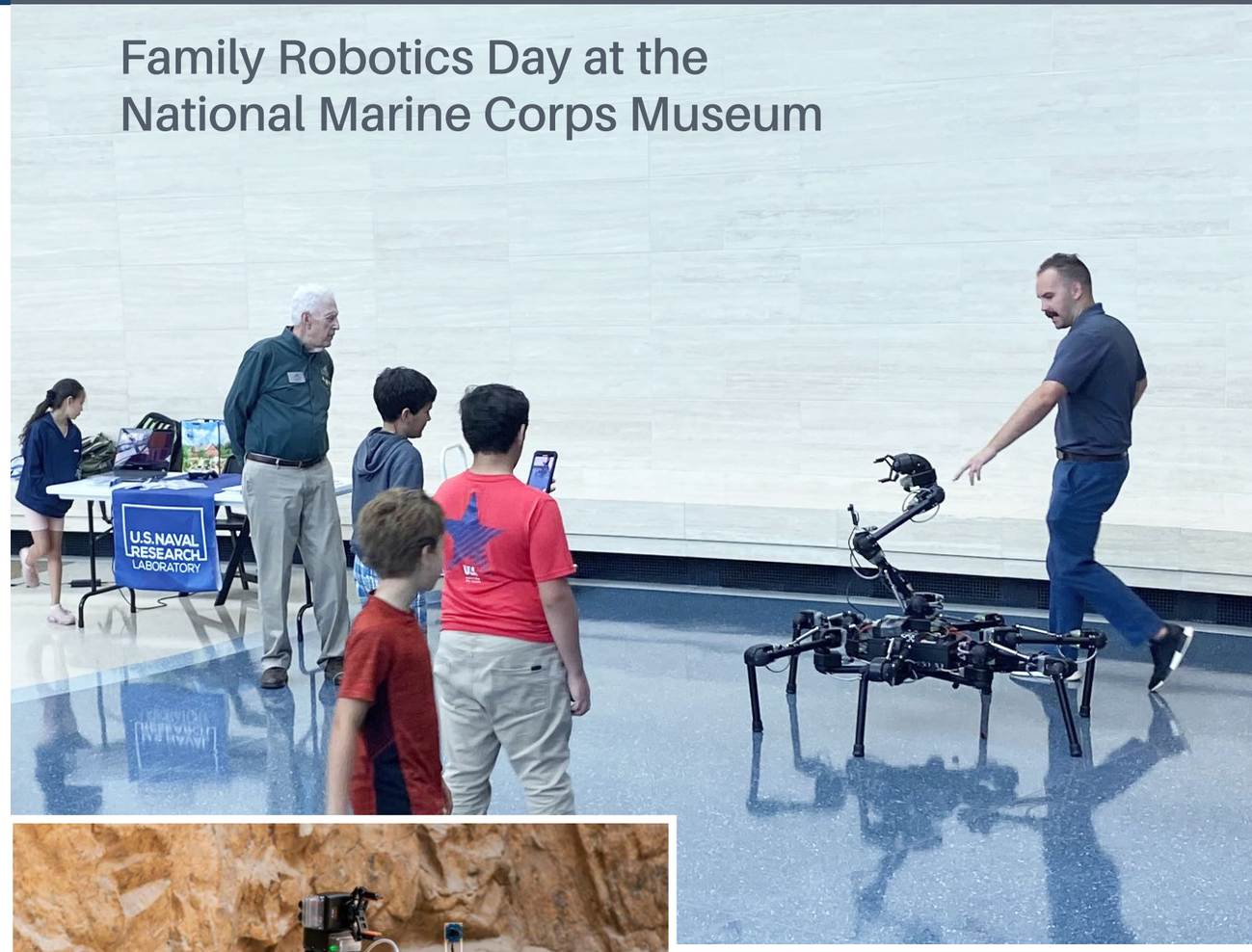
"I am deeply honored and excited to lead this talented squadron as its 16th commanding officer," Roberts said. "Our mission remains imperative to deliver essential scientific solutions to the warfighter. As the Navy, Marine Corps, and Department of Defense modernize and propel the rapid advances in technology that we see today, VXS-1 provides the ability to test, integrate, and field new systems to win the fight."

Roberts, a native of Greenville, Indiana, graduated magna cum laude from North Carolina State University in 2003 with a Bachelor of Science degree in electrical engineering and received his Master of Arts in national security and strategic studies from the U.S. Naval War College.

VXS-1's aircraft operate worldwide on extended detachments and annually log more than 500 flight hours. These aircraft are the sole airborne platforms for numerous projects such as bathymetry, electronic countermeasures, tropical storm modeling, gravity mapping, light detection and ranging, and radar developmental research.

The squadron has a flawless safety record, having amassed more than 78,000 hours of accident-free flying since 1963.

Family Robotics Day at the National Marine Corps Museum



The U.S. Naval Research Laboratory's (NRL) Distributed Autonomous Systems Group demonstrates how a hexapod robot can maneuver through different terrains at NRL in Washington, D.C., on July 20, 2021. The hexapod tracks human movement in order to fulfill military communication needs. (U.S. Navy photo by Sarah Peterson)

Tristan Schuler, a research scientist and roboticist at the Navy Center for Applied Research in Artificial Intelligence, demonstrates one of NRL's "Lily" hexapod robots at Family Robotics Day at the National Marine Corps Museum in Triangle, Virginia, on September 10, 2022. A hexapod robot is a multilegged robotic platform with onboard tracking capabilities used for investigating collaboration in autonomous multiple-robot teams operating in challenging terrains such as sandy, wooded, or wet environments, where wheeled or tracked platforms may not operate effectively. Photo provided by Tristan Schuler.

Laboratory for Autonomous Systems Research Celebrates 10-Year Anniversary

The Laboratory for Autonomous Systems Research, or LASR, and personnel from the U.S. Naval Research Laboratory celebrated the facility's 10 years of service to NRL on December 5 and 6, 2022.

Signe Redfield, Ph.D., director of the Laboratory for Autonomous Systems Research, kicked off the two-day event opening with an in-depth presentation of the laboratory's history, capabilities, and future endeavors, followed by a series of "lightning talks" highlighting autonomous systems research performed at NRL.

"Since then, [LASR] has supported research across a huge number of domains and areas — perception, navigation and locomotion, autonomous behavior, human interaction, platform development, power sources and manipulation, across ground, cognitive, maritime, and aerial domains," Redfield said. "When LASR was designed, it was at the cutting edge of integrated autonomous system experimentation and design. Even today, no other facility combines these environments."

LASR is a 50,000-square-foot facility that supports basic and applied research. The objective of this one-of-a-kind laboratory is to enable continued Navy and Department of Defense scientific leadership in autonomy and to provide opportunities in this complex, emerging area to identify advances in future defense technologies. The laboratory capitalizes on the broad multidisciplinary character of NRL, bringing together scientists and engineers with disparate training and backgrounds to attack common goals in autonomous systems at the intersection of their respective fields.

"Every area was carefully designed to provide varying degrees of complexity, to be reconfigurable and support the widest variety of experimentation," Redfield said. "The outdoor woodland, for example, included a water feature, a rock canyon, and a variety of topographical features and foliage types."

Some of the unique features of LASR include:

- Prototyping High Bay, which can be used for small autonomous air and ground vehicles and the people who work with them. This space contains the world's largest real-time motion capture volume, allowing scientists to get extremely accurate ground truth of the motion of vehicles and people, as well as allowing closed loop control of systems.
- Littoral High Bay, which features a pool that is 45 feet long, 25 feet wide, and 5.5 feet deep pool with a wave generator capable of producing directional waves and a slope that allows littoral environments to be recreated.
- Desert High Bay, which contains a an expanse of sand that is 40 feet long, by 14 feet wide, and 2.5 feet deep and contains 18-foot-high rock walls that allow testing of robots and sensors in a desert-like environment.
- Tropical High Bay, which is a 60-foot-by-40-foot greenhouse that contains a re-creation of a Southeast Asian rain forest.
- Electrical and machine shops, which allow prototypes to be constructed. In addition to metal and woodworking tools, the facility includes a 3D prototyping machine, which allows the direct creation of parts from CAD drawings. LASR also has a dedicated sensor lab that includes large environmental and altitude chambers and an anechoic chamber, as well as a power-and-energy lab for battery development and testing.
- Outdoor test range, which is a 1/3-acre highland forest with a waterfall, a stream, a pond, and terrain of varying difficulty, including large boulder structures and earthen berms.

Spring flowers adorn the lawn in front of the Laboratory for Autonomous System Research building at the U.S. Naval Research Laboratory on April 11, 2022. (Photo by Jonathan Steffen)

NRL Partners to Advance Anthrax Treatments

U.S. Naval Research Laboratory (NRL) scientists partnered with researchers from the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) and the University of Washington to develop and investigate a treatment for multi-drug-resistant anthrax.

The team of researchers detailed their research findings funded by the Defense Threat Reduction Agency (DTRA) in an article published December 8, 2022, in Science Translational Medicine.

Anthrax is a severe infectious disease caused by gram-positive, rod-shaped bacteria known as Bacillus anthracis. According to the authors, it is also considered one of the most dangerous bioweapon agents.

While there are vaccine and antibiotic therapies available for anthrax, the rise of multi-drug-resistant strains of the disease is a growing concern.

Leading the project for NRL is Patricia Legler, Ph.D., senior scientist in chemical and biodefense at the Center for Biomolecular Science and Engineering.

"The capsule is like a 'cloak of invisibility' so your immune system doesn't see the encapsulated bacteria," Legler said. "In the blood, it can grow and cause lethal septicemia."

Co-author Arthur M. Friedlander, M.D., senior scientist at USAMRIID, postulated that the enzyme CapD had the potential to be used as a therapeutic.

Legler served as the team's enzymologist to develop a highly active form of the CapD enzyme. To accomplish this, she used a method called PEGylation. In PEGylation, the biological molecules are modified by covalent conjugation with polyethylene glycol (PEG), a nontoxic, non-immunogenic polymer.

"The PEG molecule wraps around the enzyme much like an octopus binding its prey," Legler said.

Using kinetic and biophysical methods, Legler was able to create a stable and active PEGylated enzyme in high yield that could unencapsulate the anthrax bacteria and allow the innate immune system to clear the bacteria. Adding the PEG to the wrong location on the enzyme can block the active site and end all of the enzyme's activity.

PEGylation accomplished both raising the temperature tolerance and the sustainability of the enzyme in vivo.

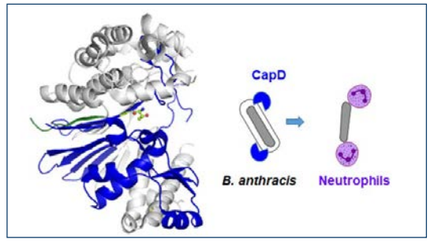
"When proteins are heated, they tend to unfold and aggregate irreversibly," Legler said. "With the PEG, I was able to elevate the melting temperature of the enzyme by about 7 degrees. This enabled the enzyme to withstand the 37 degrees Celsius body temperature for long periods."

Legler's PEGylated enzyme allowed the team to evaluate the success of the enzyme treatment in a mouse model using the lethal Ames strain of the bacteria.

Based on the results of the rodent testing, protection levels were achieved solely with enzyme treatment without the addition of vaccines or antibiotics.

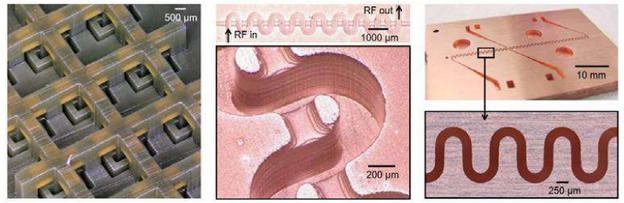
"Engineered threats or naturally developed threats are of concern," Legler said. "Most people aren't vaccinated for B. anthracis, and inhalation anthrax is highly lethal. By developing enzyme therapies, we can potentially treat these types of threats and eliminate them."

Besides the demonstrated efficacy of the treatment, it is also noteworthy that the research is one of the first to successfully produce and test enzyme therapies in vivo for bacterial infections.



B. anthracis CapD (left) removes the capsule from the bacterium in vivo. The resulting unencapsulated bacterium can be cleared by the innate immune responses. (Graphic created by Patricia Legler, Ph.D., U.S. Naval Research Laboratory.)

NRL Electronic Science and Technology Division Leading the Wave of Crucial DoD Electronic Technological Advances



U.S. Naval Research Laboratory Electronics Science and Technology Division researchers print 3D structures in a UV-hardened plastic material that is then plated with metal or otherwise functionalized depending on the needs of the research, such as 3D printed metamaterials (left) and millimeter-wave amplifier circuits (right). (Photo provided by U.S. Naval Research Laboratory Electronics Science and Technology Division)

The U.S. Naval Research Laboratory (NRL) Electronics Science and Technology Division (ESTD) actively performs research and development in a variety of materials science, physics, and engineering fields pursuing technological advances crucial to the Department of Defense's (DoD) future high-performance electronic systems.

Research topics span all aspects of electronics, such as advanced fabrication methods for radio frequency (RF) devices, growth and characterization of exotic electronic materials, quantum information science, neuromorphic computing, power devices and solar cells, nanofabrication, and solid state and vacuum electronic RF sources.

"NRL's ESTD aims to harness 3D printing for electromagnetics, such as antennas, metamaterials, and millimeter-wave with RF amplifiers operating in very high frequency bands, such as 5G and beyond," said Alan Cook, Ph.D., head of the Vacuum Electronics and Material Section. "With precision-build capabilities of these machines ranging in resolution from small fractions of a millimeter down to the 100-nanometer scale, NRL's ESTD aims to foster DoD and Department of Navy concepts."

Several types of wireless devices make use of radio frequency fields; cordless and cell phones, radio and television broadcast stations, satellite communication systems, Bluetooth module and Wi-Fi, and two-way radios all work in the RF spectrum.

The ESTD's significant achievements in past decades have grown into the current, cutting-edge research that are areas of leadership for NRL.

"After pioneering gallium nitride (GaN) as a material for high-power RF devices and helping develop it into the industry-standard high-performance replacement for silicon electronics in many systems, ESTD is developing other wideband gap semiconductors to usher in the next generation of electronic devices for DoD systems," Cook said. "ESTD research on quantum materials provided the foundation for the newly minted Navy Quantum Information Research Center, all housed at NRL's facilities."

Within its branches, ESTD carries out research to demonstrate new, basic, scientific phenomena and electronic component prototypes to enable new capabilities for future Navy electronic systems.

Additive manufacturing (AM), which includes 3D printing, is a method for building a 3D object bit by bit by depositing small pieces or layers of material using computer control. "AM is an area of Navy interest, spans a wide range of different technologies and materials, and has become important in nearly every sector of engineering," Cook said.

Specific advantages of AM include manufacturing flexibility, the ability to combine many parts into one, and rapid production of parts in the field. Recent investment in new AM capabilities brings a variety of general-use 3D printer machines to NRL used for research by multiple divisions. Within the lab, ESTD often collaborates with other divisions and the Laboratory for Autonomous Systems Research (LASR) to develop new programs and research opportunities based on these capabilities.

"In terms of future production, ESTD is interested in using AM to advance Navy RF systems and other areas of electronics and has unique 3D printing capabilities acquired specifically for NRL research programs," Cook said.

So Little Time: NRL Father-in-Law and Son-in-Law Construct World's Smallest Sundial

A father-in-law-and-son-in-law duo, both scientists with knowledge and experience in astronomy, engaged in a dynamic conversation about sundial technology while on a family car trip in August 2021. Jeremy T. Robinson, a materials research scientist at the U.S. Naval Research Laboratory (NRL), and Woodruff T. Sullivan III, who served as a summer student at NRL in the 1960s, discussed the idea of crafting a nano-sundial.

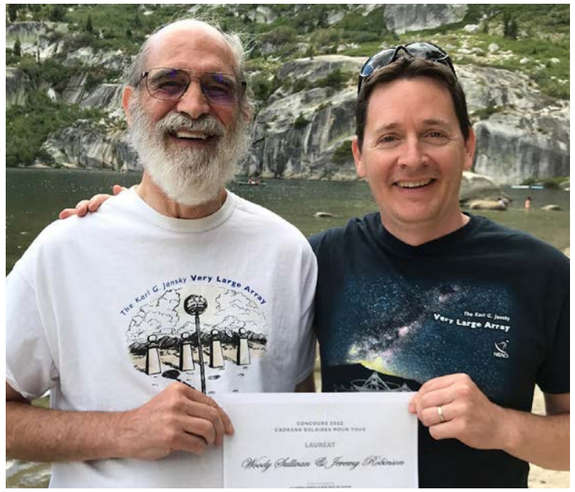
After testing half a dozen prototypes, their invention was awarded a provisional patent nine months later for "MicroDial: Miniaturized apparatus for solar time keeping" and went on to win an international contest for the "world's smallest sundial," hosted by the French magazine *Cadrans Solaires Pour Tous* (translation: Sundials for All).

"We never imagined our casual conversation would turn into a patentable device," said Robinson.

The working area of the sundial is over 1000-times smaller than the existing world record and is approximately the width of a human hair (~100 microns). Beyond the novelty of going small, the apparatus has the potential to provide situational awareness in GPS-denied environments, especially where celestial timing and navigation can be beneficial.

"While conventional sundials are read with the human eye, data from this dial are captured digitally. This allows the use of image-recognition software to extract time and latitude information and placement on systems that are sensitive to size, weight, and power," Robinson said.

The first breakthrough in the project came with the realization that rather than work with a shadow as a conventional sundial would, an improved design would allow sunlight to fall onto a surface with the sundial pattern after passing through a very small aperture. Furthermore, standard glass cover slips for microscopes can be very thin (0.1 mm) and lithographic techniques exist to print very fine features on glass. An aperture-type dial would provide a successful configuration, with an aperture on the top surface and a dial pattern on bottom surface.



Jeremy T. Robinson, right, and and his father-in-law, Woodruff T. Sullivan III, hold their certificate for the world's smallest sundial from a competition sponsored by the French sundial magazine Cadrans Solaires pour Tous. (Photo by Jeremy Robinson)

Robinson and Sullivan's second break was recognizing that they could view the transmitted light spot through the aperture dial using a standard digital camera, or more specifically, the image sensor of a camera without its lenses. Since the typical size of a camera's pixel is 1–3 microns and the focal plane of the sensor is at its surface, the duo found that printing one side of the glass slide with a few-micron-diameter aperture carefully aligned to the dial pattern on the other side could work as a tiny sundial. The projected light spot would appear in focus with the dial pattern and is easily read using the standard output of the camera. The duo found that this first prototype with the sun was very promising.

The innovative efforts of NRL civilians like Robinson and Sullivan continue to foster the ongoing advancements in research that are necessary for Department of Defense (DoD) to meet present and future challenges.

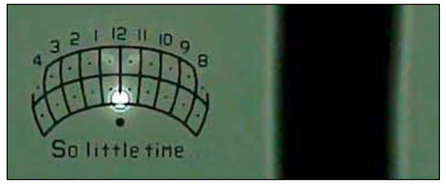
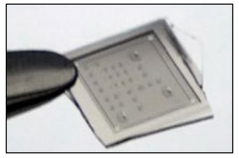


Image captured at solar noon on 10 May 2022, compared to the shadow from a human hair (of width 110 micro-meters) taken at the same time for scale. As is tradition, the motto of the dial is also labeled: "So little time …" (Photo by Jeremy Robinson)



Tweezers hold the MicroDial, on which 30 dial patterns were printed for testing purposes. (Photo by Jeremy Robinson)

NRL Launches Quantum Navy YouTube Series

The U.S. Naval Research Laboratory (NRL), with the help of Defense Media Activity, is launching a three-part series highlighting the importance of quantum research for the 21st century U.S. Navy.

"Quantum Navy" will introduce viewers to the history of quantum research, highlights NRL's key role in the nation's quantum initiative, and previews the future of quantum research and what it means for the Navy.

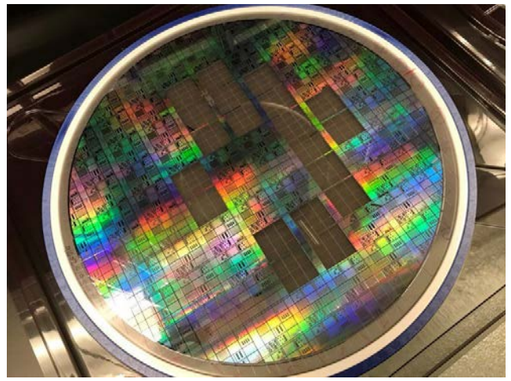
Quantum information science offers vast technological improvements in computing, sensing, and communication, areas of high interest for the Navy. The series features NRL leadership describing researchers' quest for dividends in these areas. Possibilities include solving computer problems in minutes that otherwise could take a lifetime, saving the lives of sailors with more precise locations, or more secure, virtually unhackable communications for our naval forces.

"Quantum networks will be essential to modern, secure communications and to computing, sensor, and precision time enhancements in the 21st century" said Gerald Borsuk, Ph.D., NRL's associate director of research for the systems directorate. "NRL, with along with our DC-QNet partners, will work to advance quantum network capabilities and leadership."

In 2020, NRL was designated as the U.S. Navy's Quantum Information Research Center. This designation allows NRL to engage with public- and private-sector organizations to enhance and accelerate research, development, and deployment of quantum information sciences and QIS-enabled technologies and systems.

"Quantum Navy" premiered on NRL's YouTube channel, with new episodes airing every Wednesday.

NRL Develops Photonic Component Library Implementing First-of-Its-Kind Department of Navy Trade Secret License



A 300 mm photonic integrated circuit (PIC) semiconductor wafer fabricated by AIM Photonics is displayed in Washington D.C., in June 2021. The wafer was fabricated using a new low-optical-loss passive fabrication technique and components developed by the U.S. Naval Research Laboratory Optical Sciences Division in the Nanophotonics Characterization Laboratory. The PIC semiconductor wafer is patterned into 64 identical parts called reticles that are approximately 1 in. by 1 in.; 20 reticles have been removed from the wafer for photonic testing and analysis with functionalities targeting Department of Defense priorities such as quantum information and computing, data remoting, and navigation and timing. (Photo provided by U.S. Naval Research Laboratory Optical Sciences Division)

The U.S. Naval Research Laboratory (NRL) protected and in December 2021 executed a license to a silicon nitride-based photonic component library to The Research Foundation for the State University of New York (RF SUNY), the administrator of AIM Photonics, a Department of Defense (DoD) Manufacturing Innovation Institute, using a novel form of intellectual property protection: trade secret.

By working closely with AIM Photonics's state-of-the-art foundry, NRL's Optical Sciences Division is developing photonic components with functionalities targeting DoD priorities such as analog signal processing, quantum information and computing, data remoting, and navigation and timing.

"Photonic integrated circuits have demonstrated that combining optical sources, modulators, and detectors on semiconductor chips is a winning technology," said Todd Stievater, Ph.D., a research physicist from the Photonics Technology Branch and principal investigator. "They are already integral pieces of today's internet data centers and enable the continued scale-up of the world's flow of digital information."

This success is founded in part on process design kits (PDKs), which include sets of predesigned and preverified functional components for both traditional (electronic) integrated circuits and photonic integrated circuits (PICs).

"The RF SUNY license to NRL's component library will permit AIM Photonics to create a new PDK for internal research and development by AIM Photonics customers," said Nathan Tyndall, a research chemist from the NRL Photonics Technology Branch and co-inventor of the component library.

The Photonic Integrated Circuit Sensors program, which resulted in the creation of this intellectual property, is sponsored by the under secretary of defense for research and engineering as part of the Trusted and Assured Microelectronics: Radio Frequency Optoelectronics portfolio.

The component library is based on years of internal research at NRL focused on developing and processing silicon-nitride waveguides to support PIC applications. This license is an important step toward lowering the costs associated with using PIC technology for DoD applications. Silicon nitride is a glass-like material commonly used in semiconductor fabrication. In NRL's work, optical waveguides are formed in this material, which allow light to be transported across a semiconductor chip.

NRL's intellectual property counsel explored whether the DoN could do the same thing under its existing statutory authorities. "After months of legal analysis, NRL's intellectual property counsel concluded that the Department of Navy could protect and license its inventions as trade secrets, and provided their analysis to counsel, Office of Naval Research, who formally adopted it in March 2021," Walsh said.

NRL's Office of Technology Transfer and Intellectual Property Counsel then built a trade secret program. "The culmination of that effort is this license to RF SUNY," said Amanda Horansky-McKinney, former head of the NRL Office of Technology Transfer. "NRL hopes and expects this is the first of many trade secret licenses."

SIRI-2 to Qualify Technologies for Radiation Detection in Space

U.S. Naval Research Laboratory scientists launched the second Strontium Iodide Radiation Instrument (SIRI-2) instrument in December 2021 aboard Space Test Program (STP) Sat-6. SIRI-2, a gamma ray spectrometer, will demonstrate the performance of europium-doped strontium iodide gamma ray-detection technology with sufficient active area for Department of Defense (DoD) operational needs.

"The technology being demonstrated in SIRI-2 will need to detect small radiation signatures or signals in the highly variable background radiation fields found in space," said Lee Mitchell, Ph.D., an NRL research physicist. "The instrument will also study transient phenomena such as solar flares during the one-year mission."

The DoD has been utilizing scintillation detectors in space since the Vela high-altitude nuclear detection program in the 1960s. Scintillator technology is widely used throughout the scientific community in areas such as astrophysics and solar and earth science. "While we reduced the cost, weight and power for comparable-sized instruments," Mitchell said. "These improvements led to greater sensitivity and, in turn, improve source detection and identification."

One thing that has Mitchell and his team excited is seeing the pickup of solar activity. The solar cycle is an 11-year change in the Sun's activity measured in terms of variations in the number of observed sunspots on the solar surface, and the mission is well aligned with the peak of solar cycle 25.

"While the peak of the solar cycle is expected to occur in 2025, it appears the Sun is showing significant activity earlier than expected," Mitchell said. "Solar flare activity is most active at the peak of the solar cycle, so we hope to not only space-qualify new technology for the DoD, but also make significant contributions to solar physics by studying gamma rays emitted during solar flares."

A follow on to SIRI-2, SIRI-3 will take knowledge gained from the previous missions to develop a large prototype instrument that is expected to launch in late 2025.

A United Launch Alliance Atlas V rocket lifts off December 7, 2021, from Space Launch Complex 41 at Cape Canaveral Space Force Station, Fla. The rocket propelled two Department of Defense Space Test Program satellites into space. (U.S. Space Force photo by Joshua Conti)

NRL Celebrates 99 Years of Innovation, Looks Ahead to Second Century of Discovery

Secretary of the Navy Josephus Daniels breaks ground for NRL's first building on December 6, 1920.

The U.S. Naval Research Laboratory's (NRL) centennial celebration reached its height. with the 100th anniversary of its founding on July 2, 2023. The following months have been an opportunity for the nearly 3,000 NRL employees to highlight past, present, and future scientific achievements and to imagine the technological breakthroughs and innovations in its second 100 years.

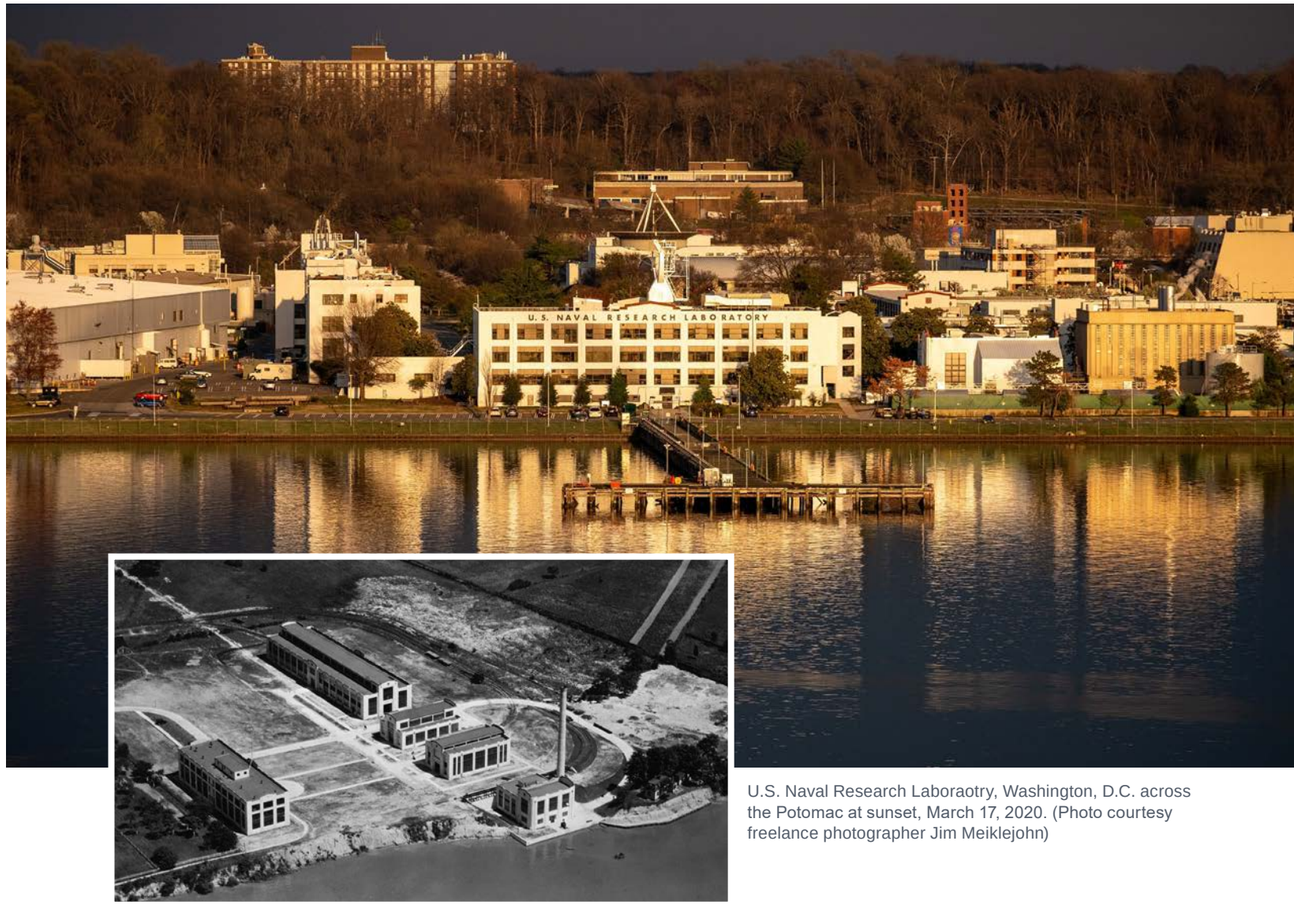
"For a nearly a century, NRL employees have been at the forefront of innovation and research, and we are excited to honor this centennial as we look to the next 100 years," said Peter Matic, Ph.D., NRL's centennial celebration coordinator. "We are planning and coordinating events to celebrate this momentous occasion and share our legacy with a wider audience in the coming year."

NRL is recognized worldwide for its technical leadership in basic and applied research spanning disciplines from the seafloor to outer space.

"The researchers at NRL unravel the impossibilities of today while delivering advanced capabilities to meet tomorrow's challenges," said then-NRL commanding officer Capt. Gregory Petrovic. "The talented men and women at NRL have delivered many firsts for our nation and the Navy. The list of breakthroughs and achievements is already long, and NRL will continue its legacy of delivering innovative capabilities to the fleet and American people in the next century."

In its first century of operation, NRL developed surveillance, meteorological, and GPS satellites, operational radar, and information security used aboard ships. Other notable achievements, among many, include the pilotless first unmanned radio-controlled flight, the concept of using nuclear power for submarines, and more accurate weather modeling and forecast systems.

The lab is also home to numerous award-winning scientists, including Jerome Karle, Ph.D., who was awarded the Nobel Prize for Chemistry in 1985 for his contribution in the development of direct methods for the determination of crystal structure, Roger Easton, who was awarded the National Medal of Technology in 2005 for his extensive pioneering



U.S. Naval Research Laboraotry, Washington, D.C. across the Potomac at sunset, March 17, 2020. (Photo courtesy freelance photographer Jim Meiklejohn)

Aerial photo of NRL taken in 1923. (Navy photo)

achievements in spacecraft tracking, navigation, and timing technology that led to the development of the NAVSTAR-Global Positioning System (GPS), and William Burns, Ph.D., who received the Thurlow Award in 1995 for his contribution to the development of the fiber-optic gyroscope.

Secretary of the Navy Josephus Daniels broke ground and established the U.S. Navy's first modern science-and-technology-research facility on December 6, 1920. Josephus was inspired by American inventor and businessman Thomas Edison when Edison said, "The Government should maintain a great research laboratory, jointly under military and naval and civilian control."

Edison editorialized his idea for a center of innovation that could develop "military and naval progression" to modernize warfighting and to prevent catastrophes in a New York Times Magazine article on the contemporary sinking of RMS Lusitania in 1915.

"For a century, NRL spearheaded research that has not only made our Navy and country stronger, it has also impacted the lives of billions of people, and has lived up to the spirit of what Edison envisioned," said Bruce Danly, Ph.D., NRL's Director of Research. "As we look to our 100th year, the Lab and its scientists continue expanding our knowledge and developing the tools needed for all-domain naval power."

NRL Teams Restore Pollinator Garden for Earth Day 2022

U.S. Naval Research Laboratory's employees participate in a pollinator garden restoration project outside NRL's Laboratory for Autonomous Systems Research facility during an Earth Day celebration on April 22, 2022. (U.S. Navy photo by Petty Officer 1st Class Jeff Troutman)

Lt. Diedrich Harms volunteers during a NRL pollinator garden rival effort outside NRL's Laboratory for Autonomous Systems Research facility during an Earth Day celebration on April 22, 2022. (U.S. Navy photo by Petty Officer 1st Class Jeff Troutman)

The Environmental Section and the Green Team joined together with the NRL workforce for Earth Day on April 22, 2022, to help revive the Pollinator Garden outside of Building 271. To do this, the team converted inactive land into productive, pollinator-friendly habitat, reinvigorating the pollinator area known as "living landscapes" and providing essential services for the ecosystem.

This year's Earth Day theme was "Invest in Our Planet," which encourages those in society to create a prosperous future, to act boldly, to innovate broadly, and to implement equitably to come together to create a sustainable future.

Playground Power Substation Groundbreaking

From left, AIC International vice president Anthony Stewart, Northrop Grumman installation manager Kin Fejeran, NRL customer lead Ryan Sheehan, NRL customer program manager Jeana Hill, AIC International president Henry Stewart, U.S. Navy Cmdr. Brian Christner, who is the public works officer for MCB Camp Blaz, and Anthony Cruz, department head for critical infrastructure support of Naval Facilities Engineering Systems Command Marianas, break ground on NRL's Playground Project at Marine Corps Base Camp Blaz, Guam, on April 7, 2022. (U.S. Marine Corps photo by Gunnery Sgt. Rubin J. Tan.)

A multiagency team led by NRL staff participated in the ground-breaking ceremony for the Naval Research Laboratory's Playground Project held at Marine Corps Base Camp Blaz, Guam, on April 7, 2022. The project will be vital to the Department of Defense's global command, control, communications, computers, and intelligence (C4I) mission to support civilian aviation, GPS navigation, and precise positioning/time distribution techniques.

ROBOTICS

NRL Engineers Ready Innovative Robotic Servicing of Geosynchronous Satellites (RSGS) Payload for Launch

Engineers at the U.S. Naval Research Laboratory's (NRL) Naval Center for Space Technology (NCST) recently completed robotic payload component level testing for the Defense Advanced Research Projects Agency (DARPA) Robotic Servicing of Geosynchronous Satellites (RSGS) program.

Once on orbit, the RSGS robotic servicing vehicle will inspect and service satellites in geosynchronous Earth orbit (GEO), where hundreds of satellites provide communications, weather monitoring, support national security missions, and other vital functions.

"This partnership will enable revolutionary servicing capabilities to commercial and government users for visual diagnostics, upgrades, orbit adjustment, and satellite repairs," said Bernie Kelm, superintendent of the Spacecraft Engineering Division, NCST. "As the robotic payload developer, we designed this innovative set of spaceflight hardware and software that will advance national capabilities in satellite servicing."

The RSGS payload includes flight hardware components, robotic control algorithms, multiple highly customized electronics designs, and flight software running on five single-board computers. NRL also specified and procured two dexterous seven-degree-of-freedom robotic arms, outfitting them with control electronics, cameras, lights, and a robotic tool changer.

Additionally, NRL developed the robotic tool to grapple customer satellites via their standard launch vehicle interface and procured another tool to capture resupply elements that are compatible with DARPA's Payload Orbital Delivery (POD) design standard.

"Our diverse team of NCST engineers has focused their efforts on the robotic payload for the RSGS Program for the last seven years," William Vincent, NRL's RSGS program manager, said. "The Robotic Payload is one of NRL's most complicated payload developments ever."

NRL engineers developed multiple power and control avionics running on a distributed SpaceWire network to support an extended-duration mission to control all the sensors and actuators in a robust and redundant manner. NRL procured panchromatic and color camera and also designing LED lighting units to provide situational awareness during robotic activities.

"Our algorithms team developed machine vision, position control, collision avoidance, and compliance-control algorithms that support robotics control and enable autonomous grapple capabilities," Vincent said. "The algorithms are implemented in flight software, which also provides all of the command-and-control functionality for the payload and provides control interfaces to the spacecraft bus."

Robotic motions require special planning to ensure safe spacecraft operations. NRL has developed the Integrated Robotic Workstation (IRW) to accomplish just that. The IRW supports mission planning for the development of new mission activities. Once a mission is planned, the IRW supports screening activities to prescreen all robotic motion commands in a payload simulator to verify command loads before they are sent.

Finally, using NRL's Neptune® ground control software, the IRW commands all robotic payload activities and displays and trends payload telemetry during operations. To execute this effort, a skilled systems engineering team spent years performing system analyses, documenting requirements and interfaces, and generating a robust verification-and-validation plan.

The RSGS team recently completed environmental testing of the first of two flight robotic arm systems. This included simulating the launch environment in NRL's vibration lab, simulating both the vacuum and extreme temperature ranges of space in NRL's thermal vacuum (TVAC) chamber, and ensuring electromagnetic interference (EMI) functionality in EMI chamber testing.

During TVAC testing, the robotic arm system demonstrated performance over temperatures representing actual on-orbit conditions. Under the harsh temperature and vacuum conditions of space, the robot arm performed a variety of operations including running preplanned robotic calibration movements, tool actuation, and camera and light functions.

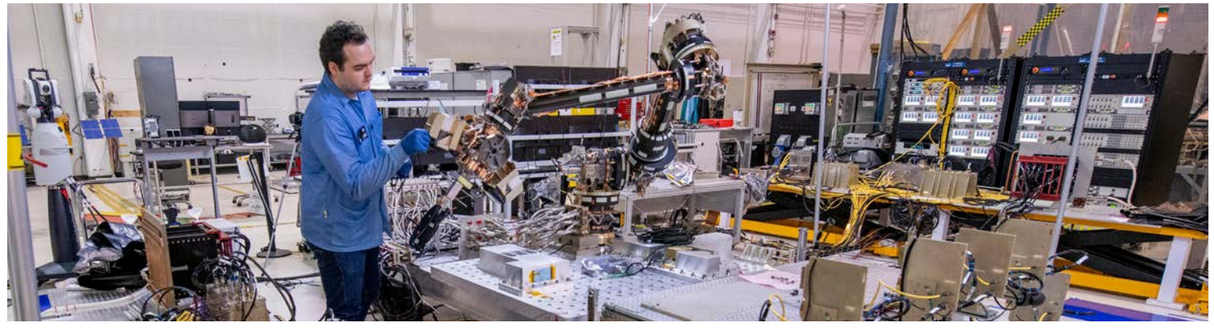
The second robotic arm system is integrated with a separate testbed that has the entire flight avionics suite. It is currently going through motion performance testing. This fall, the second arm system will complete environmental testing. Robotic performance testing to demonstrate and verify robotic algorithms' function is underway in the Robotics Testbed (RTB) at NRL's Space Robotics Laboratory. The RTB consists of a non-spaceflight version of the flight robotic arm system and avionics hardware running flight software. This high-fidelity robotics testbed allows ground verification of many system-level robotic performance characteristics for the RSGS payload.

Compliance control algorithm characterization and Marman ring detector algorithm performance characterization have been completed. Contact dynamics testing in the RTB is underway, which uses a sled floating on a thin layer of air to simulate the arm contacting client space vehicles ranging in mass from 75 to 3,000kg (165–6,613 lbs.). Grapple, articulation, and release testing is scheduled later this summer.

The flight software team is preparing to start qualification testing. Testing takes place in a software testbed with a real-time dynamic simulation that generates simulated robot arm pose inputs for the robotic control algorithms and dynamic imagery for input into machine vision algorithms. This testbed allows the NRL team to test the flight algorithms with realistic control loops to fully verify the system thoroughly before launch.

"The systems engineering and verification efforts required by RSGS are extensive," said Amy Hurley, NRL's lead systems engineer. "It is amazing to see years of systems engineering and a strong verification-and-validation plan come together successfully."

The U.S. Naval Research Laboratory's Robotic Servicing of Geosynchronous Satellites (RSGS) integration and test team analyzes data collected from contact dynamic testing on the robotic test bed in Washington, D.C., on June 16, 2022. Contact dynamic testing allows the team to charaterize how the payload will behave when servicing client spacecraft. (U.S. Navy photo by Sarah Peterson)



John Kinch, a U.S. Naval Research Laboratory robotics engineer, prepares flight Robotic Arm System (RAS) #2 for kinematic calibration in Washington, D.C., on June 23, 2022. The arm is integrated in a testbed with a full suite of flight avionics and flight software. This testing uses a laser tracking system and arm telemetry to calibrate as measured Denavit–Hartenberg parameters of the robotic arm. (U.S. Navy photo by Sarah Peterson)

NRL Fungal Experiment Launches as Artemis I Payload

An experiment prepared by the U.S. Naval Research Laboratory (NRL) was launch as part of NASA's scheduled Artemis I mission to orbit the moon on November 16, 2022.

The NRL experiment planned to use samples of fungi to investigate effects of the deep space radiation environment outside of Earth's protective magnetosphere.

"We're interested in factors that affect eukaryotic survival in space," said Jennifer Yuzon, a postdoctoral scientist for NRL's Laboratory for Biomaterials and Systems. "For our experiment fungus is our model organism, specifically Aspergillus niger, which is found in all human environments, including spacecraft."

The project's experimental setup had four different strains of the fungus. Samples included one wild-type strain and three mutated strains that were genetically engineered in the laboratory. Two of the mutated strains are deficient in DNA repair pathways, while the other mutated strain is defective at melanin production.

"Looking at the impact of melanin and DNA repair pathways in the samples with the effects of both cosmic radiation and microgravity will increase our knowledge for how humans may be impacted at the Moon and beyond as we continue to explore further," said Zheng Wang, an NRL microbiologist and the principal investigator on this project. "We also hope to gain knowledge for the development of new ways to protect astronauts and equipment during space travel. As the fungi adapt to the space environment, they may also produce novel biomolecules that could have therapeutic potentials."

Three samples of Aspergillus niger fungus are shown at different growth durations at the U.S. Naval Research Laboratory (NRL), in Washington, D.C., on August 15, 2022. The fungal biology research team at NRL uses Aspergillus niger to study the roles of melanin and DNA repair on adaptation and survivability of microorganisms in deep space. (U.S. Navy photo by Sarah Peterson)

Tiffany Wong-Stack, Ph.D., a postdoctoral researcher in the U.S. Naval Research Laboratory's (NRL) Laboratory for Biomaterials and Systems, prepares a sample of the fungus Aspergillus niger. Four different strains of the fungus are scheduled to be launched aboard the Artemis I mission as part of a NRL experiment examining the effects of space radiation. (U.S. Navy photo by Sarah Peterson)

While NRL has a long history in space exploration, stretching back to the V-2 rocket test in the late 1940s, this experiment marks a first in space for the Lab. The fungal experiment became the first biological project performed at NRL to be launched to space.

After the Orion spacecraft completed its mission the fungal samples was to be returned to NRL for a thorough analysis.

"The mission is about 42 days in lunar orbit," Yuzon said. "Then we'll process our samples for survival, genomic and metabolic changes."

The NRL experiment is one of four space biology investigations selected for Biological Experiment 01 (BioExpt-01) mission aboard the Orion spacecraft by NASA's Space Biology Program. During the Artemis I mission, the fungal samples was stored in a specialized Biological Research in Canisters system within the crew compartment of NASA's Orion capsule. According to NASA, all of the investigations aim to study DNA damage and protection from radiation; Moon missions experience approximately twice as much radiation exposure as levels on the ISS.

Artemis I was an uncrewed flight test in NASA's mission to extend human presence to the Moon and beyond. The mission was intended to demonstrate the performance of the Space Launch System rocket and to test the Orion spacecraft's capabilities over the course of about six weeks as it traveled about 40,000 miles beyond the Moon and back to Earth.

Borosulfates are a unique class of compounds that are formed when, under special conditions, borates and sulfates are "forced" to form new bonds and lose water in the process of making polymeric anionic chains. Borosulfates are a part the "solid acid" class of compounds that have been leveraged to develop solid acid fuel cells (SAFCs) by SAFCell, Inc., but are different in that the anions in borosulfates are bound together, producing a combination of attractive, new properties. NRL has found that borosulfates that specifically exhibit one-dimentional anionic chains (as seen in the accompanying figure) have very special properties that produce a very low barrier to proton transport within the crystal in combination with relatively high thermal stability and good tolerance for both wet and dry conditions at the target fuel cell operating temperature. This makes one-dimentional borosulfates such as ammonium borosulfate attractive alternatives to current state-of-the-art solid acid electrolytes.

NRL, SAFCell Sign CRADA for Exploration of New Class of Solid Acid Proton Conductors

SAFCell Inc. has signed a Cooperative Research and Development Agreement (CRADA) with the Department of the Navy's U.S. Naval Research Laboratory (NRL).

CRADA is an agreement between a federal laboratory and a nonfederal party to perform collaborative research and development in any area that is consistent with the federal laboratory's mission.

Under the terms and within the scope of the agreement, SAFCell will provide expertise and guidance for the development and testing of a new class of borosulfate solid acid intermediate-temperature proton-conducting materials and will evaluate these experimental electrolytes in electrochemical cells.

"NRL has developed borosulfate proton electrolytes, which are expected to have significant advantages over other existing proton electrolyte technologies used in various electrochemical energy conversion devices," said Holly Ricks-Laskoski, Ph.D., a senior partnership manager in NRL's Technology Transfer Office who is responsible for this CRADA. "This collaboration is expected to further develop fuel cells based upon NRL's borosulfate technology to provide stable, compact, and robust sources of electrical power."

Intermediate-temperature proton-conducting materials offer substantial advantages over other classes. Operating at midrange temperatures around 250 degrees Celsius (482 degrees Fahrenheit), SAFCell's stacks tolerate impurities that pose obstacles for other fuel cell technologies while still using inexpensive metal components and flexible polymer seals.

This unique combination of properties results in a rugged and low-cost stack platform that operates easily on commercially available fuels.

"SAFCell is excited to work with NRL to develop electrochemical devices using NRL's borosulfate electrolytes," said Calum Chisholm, SAFCell's chief executive officer. "These solid-state proton conductors can operate at higher temperatures and without the hydration requirements of our current electrolytes, which equates to more versatile and lower cost solid acid systems."

Chisholm went onto say SAFCell will "apply their decades of experience working with solid acid electrolytes to accelerate the development of this new class of proton conductors into solid state fuel cells, hydrogen generators, and membrane reactors."

For those companies looking to work with NRL, Ricks-Laskoski said, "NRL is open and we are looking forward to working with you."

NRL Conducts Successful Terrestrial Demonstration of Beaming Microwave Power

A team of researchers from the U.S. Naval Research Laboratory recently demonstrated the feasibility of beaming terrestrial microwave power by transmitting 1.6 kilowatts of power over 1 kilometer (km) at the U.S. Army Research Field in Blossom Point, Maryland, the most significant power- beaming demonstration in nearly 50 years.

Beaming microwave power is the efficient, point-to-point transfer of energy across free space by a directed microwave beam. The project, Safe and COntinuous Power bEaming – Microwave (SCOPE-M), was funded by the Office of the Undersecretary of Defense for Research and Engineering's Operational Energy Capability Improvement Fund and was led by the project's principal investigator, Christopher Rodenbeck, Ph.D., head of the Advanced Concepts Group, NRL.

Within 12 months, NRL established the practicality of terrestrial microwave power beaming and beamed 1 kilowatt (kW) of power over a distance of 1 km using a 10 gigahertz (GHz) microwave beam. SCOPE-M demonstrated power beaming at two locations, one at the U.S. Army Research Field at Blossom Point in Maryland and the other at the Haystack Ultrawideband Satellite Imaging Radar (HUSIR) transmitter at the Massachusetts Institute of Technology (MIT) in Massachusetts.

"The reason for setting those targets is to push this technology farther than has been demonstrated before," said power beaming and space solar lead Paul Jaffe Ph.D. "You don't want to use too high a frequency, as it can start losing power to the atmosphere," Rodenbeck said. "10 GHz is a great choice because the component technology out there is cheap and mature. Even in heavy rainfall, loss of power is less than 5 percent."

In Maryland, the team exceeded their target by 60 percent by beaming 1.6 kW just over 1 km. At the Massachusetts site, the team did not have the same peak power, but the average power was much higher, thereby delivering more energy. Jaffe said these demonstrations pave the way for power beaming on Earth, in space, and from space to Earth using power densities within safety limits set by international standards bodies.

Demonstration using the MIT HUSIR transmitter for higher average power. Blossom Point, Maryland – Safe and Continuous Power Beaming Microwave (SCOPE-M) is a U.S. Naval Research Laboratory research project which delivers one kilowatt of electrical power at a distance of a kilometer using a microwave beam. SCOPE-M is built of tens of thousands of x-band antennas. Each of these antennas is connected to a small rectifier diode that diode converts the incident microwave power into DC electrical power. This demonstration paves the way for power beaming on earth in space and power beaming from space to the earth.

"As engineers, we develop systems that will not exceed those safety limits," Jaffe said. "That means it's safe for birds, animals, and people."

Jaffe went on to say that during past experiments with laser power beaming using much higher power densities, the engineers were able to successfully implement interlock systems so if something approached the beam, it would turn off.

Brian Tierney, Ph.D., a SCOPE-M electronics engineer, said the DOD is interested in wireless power-beaming, particularly wireless power beaming from space, and that a similar rectenna (rectifying antenna) array as used for SCOPE-M could be used in space. A rectenna is a special type of receiving antenna for converting electromagnetic energy into direct current electricity in wireless power transmission systems.

"Although SCOPE-M was a terrestrial power-beaming link, it was a good proof of concept for a space power-beaming link," Tierney said. "The main benefit of space-to-Earth power beaming for the DOD is to mitigate the reliance on the fuel supply for troops, which can be vulnerable to attack."

"That is something no other form of clean energy can do today," Rodenbeck said. "From the standpoint of technology readiness level, I feel we are very close to demonstrating a system we can truly deploy and use in a DOD application."

NASA's JWST Takes its First-Ever Direct Image of Distant World

An astrophysicist at the U.S. Naval Research Laboratory (NRL) is part of NASA's James Webb Space Telescope's (JWST) Early Release Science Team for Direct Observations of Exoplanets, which released the observations of a super-Jupiter exoplanet, HIP 65426 b, using JWST's Near-Infrared Camera (NIRCam) and Mid-Infrared Instrument (MIRI) September 1, 2022.

Jordan Stone, Ph.D., an astrophysicist in NRL's Remote Sensing Division, said this early release of the exoplanet imagery was detected using seven of JWST's observational filters, representing the first images of an exoplanet to be obtained by JWST and the first direct detection of an exoplanet at wavelengths beyond 5 microns.

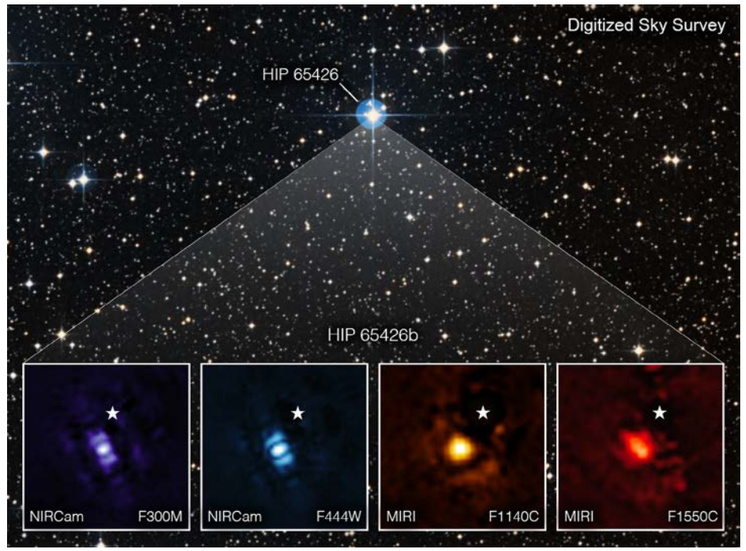
"One of the things we're most excited about is that we now have the ability to measure the brightness of planets at wavelengths longer than 5 microns," Stone said. "So we now have this highly precise machine that's giving us the ability to, to measure light from planet surfaces across a really broad wavelength range. And so this is really going to transform our understanding of giant planets."

An exoplanet is any planet beyond our solar system. HIP 65426 b, is a relatively young exoplanet, about 14 million years old, and is located in the constellation Centaurus, about 349 light-years from Earth.

The JWST NIRCam observes from 0.6 to 5 microns and offers imaging, coronagraphy, and grism slitless spectroscopy; MIRI is a camera and a spectrograph that observes mid- to long-infrared radiation from 5 microns to 28 microns. It also has coronagraphs, especially for observing exoplanets.

HIP 65426 b circles an A type star that is about twice the size of the sun. The planet orbits its star at about 60–100 AU (7.4–9.3 billion miles) distance. That is roughly the double the distance Pluto is from the sun. The exoplanet is seven times the mass and about one and a half times the size of Jupiter.

JWST, launched on Christmas Day 2021, is an international collaboration between NASA, the European Space Agency, and the Canadian Space Agency and is the first large strategic mission of the NASA Astrophysics Division to launch since the 1990s. The infrared observatory is orbiting the Sun about 1 million miles from Earth. Since coming on line, it has produced stunning images and a series of preliminary discoveries.



This image shows the exoplanet HIP 65426 b in different bands of infrared light as seen from the James Webb Space Telescope: purple shows the NIRCam instrument's view at 3.00 micrometers, blue shows the NIRCam instrument's view at 4.44 micrometers, yellow shows the MIRI instrument's view at 11.4 micrometers, and red shows the MIRI instrument's view at 15.5 micrometers. These images look different because of the ways that the different Webb instruments capture light. A set of masks within each instrument, called a coronagraph, blocks out the host star's light so that the planet can be seen. The small, white star in each image marks the location of the host star HIP 65426, which has been subtracted using the coronagraphs and image processing. The bar shapes in the NIRCam images are artifacts of the telescope's optics, not objects in the scene. Credit: NASA/ESA/CSA, A Carter (UCSC), the ERS 1386 team, and A. Pagan (STScI).

NRL Scientist Searches for Gravitational Waves From Monster Black Holes

This visualization shows gravitational waves emitted by two black holes (black spheres) of nearly equal mass as they spiral together and merge. Yellow structures near the black holes illustrate the strong curvature of space-time in the region. Orange ripples represent distortions of space-time caused by the rapidly orbiting masses. These distortions spread out and weaken, ultimately becoming gravitational waves (purple). The merger time scale depends on the masses of the black holes. Space-time distortions radiate away orbital energy and cause the binary to contract quickly. As the two black holes near each other, they merge into a single black hole that settles into its "ringdown" phase, where the final gravitational waves are emitted. For the 2015 LIGO detection, these events played out in little more than a quarter of a second. This simulation was performed on the Pleiades supercomputer at NASA's Ames Research Center. Fixed view. Credit: NASA/Bernard J. Kelly (Goddard and University of Maryland Baltimore County), Chris Henze (Ames) and Tim Sandstrom (CSC Government Solutions LLC)

A U.S. Naval Research Laboratory researcher is leading the way in helping to understand in a new way the gravitational waves generated by supermassive black holes.

Now, astronomers are searching for these waves using gamma rays, the highest-energy region of the electromagnetic spectrum. Matthew Kerr, Ph.D., who works in NRL's High Energy Astrophysics and Applications Section, used 12.5 years of data from the Fermi Gamma-ray Space Telescope to form a gamma-ray pulsar timing array. Fermi is a space observatory used to perform gamma-ray astronomy observations from low Earth orbit and performs an all-sky survey studying astrophysical phenomena such as active galactic nuclei, pulsars, and high-energy sources.

Kerr, who is the paper's co-lead, published the findings, Gamma-ray Pulsar Timing Array Constrains the Nanohertz Gravitational Wave Background, in Science recently.

"Pulsars have been one of the great successes for Fermi," Kerr said. "We've detected more than 100 gamma-ray millisecond pulsars. These are the kind that are used in pulsar timing arrays, so we decided to try to make a gamma-ray pulsar timing array. It turned out to be surprisingly effective. Our results are almost as sensitive as those from radio telescopes, which are the size of football fields!"

Gamma rays offer a key benefit over radio waves. Space is mostly empty, but the pulsars in timing arrays are thousands of light-years distant, and radio waves encounter electrons along the way.

"Just like light is split according to color when it passes through a prism, radio waves at different frequencies arrive at different times after passing through the interstellar medium," Kerr said. "These delays mimic what we would see from gravitational waves, so radio astronomers have to try to remove them from the data, which can be challenging."

Gamma rays are so much more energetic than radio waves that they aren't affected in this way, eliminating any potential error. "And this lets us use the gamma-ray data to check for contamination in the radio data," Kerr said.

Pulsars have a long history of providing celestial clocks and have been used in experiments that test the theory of general relativity. They also provide a time scale that can rival the precision of atomic clocks over long time scales. And arrays of pulsars can be used analogously to GPS, enabling navigation in environments where GPS is unavailable, like deep space.

"The gravitational wave background provides an ultimate limit on the observed stability of millisecond pulsars, and so characterizing it is critical to these applications," said Paul Ray, Ph.D., head of NRL's High Energy Astrophysics and Applications Section. "The results are much more impressive than I had anticipated, given the small number of photons detected by Fermi from these pulsars, but even more exciting is how they are expected to improve over the next 5 years as the duration of the dataset is extended."

NRL CIRCE Satellites Delivered, Set for Historic UK Launch

The U.S. Naval Research Laboratory oversaw the delivery and preparation for launch of its twin 6U CubeSat satellites on October 15, 2022, at Spaceport Cornwall in Newquay in the United Kingdom (U.K.).

The Coordinated Ionospheric Reconstruction CubeSat Experiment (CIRCE) satellites were scheduled for manifest aboard Virgin Orbit, which is targeting their first satellite launch later this year. Virgin Orbit's Launcher One rocket takes off horizontally, carried aloft by a modified Boeing 747 jet, pioneering new, lower-cost research opportunities for space access.

CIRCE is a joint NRL-United Kingdom Defence Science and Technology Laboratory (Dstl) experiment designed to measure the Earth's ionosphere and particle radiation environment from a circular orbit at 555 km (344 miles) altitude in a lead/trail formation 300–500 km (186–310 miles) apart in the same orbit plane.

"We are excited and thankful for the international partnership that we have on the CIRCE program. It's been a wonderful experience working with the folks at Dstl and their university and industry partners in the U.K.," said Andrew Nicholas, CIRCE's principal investigator. "We are looking forward to a successful launch and are excited to continue work with our U.K. partners, to start getting real observational data downlinked, and to start the research these observations will enable."

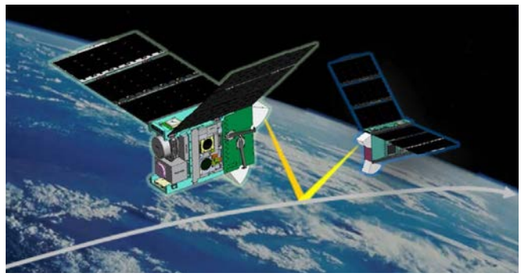
Funded by the Office of Naval Research's Space Weather S&T program with the launch supported by the DoD Space Test Program, the twin satellites push the boundaries of the CubeSat platform technology, challenging the size, weight, and power constraints of the platform as well as integration and complex concepts of operations.

"The CIRCE spacecraft are the size of a cereal box and we've managed to sandwich five sensors in each of them," Nicholas said. "So, they are very compact and heavily laden with technology that is really tightly integrated in there."

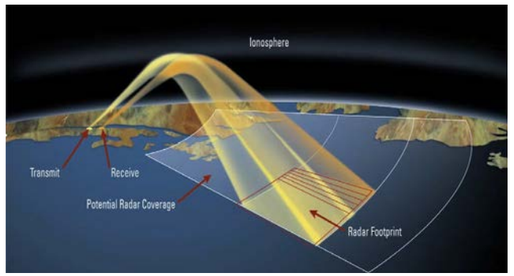
NRL developed the Triple Tiny Ionospheric Photometer (Tri-TIP) to measure nighttime O^+ 135.6nm airglow emissions in the atmosphere. Each CIRCE CubeSat has two Tri-TIPs aboard, configured to look along coordinated lines of sight to perform ionospheric tomography in the orbital plane.

The U.K. contribution to CIRCE is the In situ and Remote Ionospheric Sensing (IRIS) suite, which comprises three highly miniaturized payloads and complements NRL sensors. One IRIS suite will be flown on each satellite and incorporates an ion/neutral mass spectrometer, a tri-band global positioning system receiver for ionospheric remote sensing, and a radiation environment monitor.

During the life of its mission, CIRCE will help researchers better understand how the ionosphere is changing day to day, hour to hour, and even minute to minute, which is important to the Navy, especially for over-the-horizon communications and radar.



CIRCE dual CubeSats will fly in tandem in low Earth orbit to characterize ionospher two 2-dimensional structure (vertical and horizontal) using advanced UV and radio remote sensors and tomographic methods. Miniaturized in-situ sensors provide key insights to the radiation environment and density and composition in the spacecraft environment. (U.S. Navy illustration by U.S. Naval Research Laboratory).



CIRCE will help researchers better understand how the ionosphere is continually changing, which is important to the Navy, especially with over-the-horizon operations (U.S. Navy illustration by U.S. Naval Research Laboratory).

NRL, Aerospace Industry Hosts 18th Annual CanSat Student Challenge

Ivan Galysh, the U.S. Naval Research Laboratory organizer for the American Astronautical Society CanSat Competition, prepares the rockets for launch day on June 11, 2022, in Blacksburg, Virginia. CanSat Competition is an annual student design, build, and launch competition for space-related topics. (U.S. Navy photo by Jonathan Steffen)

After countless hours of preparation, flight testing, and launching, 23 student teams from universities and colleges around the world participated in the CanSat Aerospace Competition at Virginia Polytechnic Institute and State University (Virginia Tech) in Blacksburg, Virginia, on June 11–12, 2022.

Since 2005, the CanSat Competition, organized by the American Astronautical Society (AAS) alongside the U.S. Naval Research Laboratory (NRL), has organized an annual student design-build-launch competition for space-related topics. Although similar competitions exist for other fields of engineering (robots, radio-control airplanes, racing cars, etc.), most space-related competitions are paper design competitions. Over the years, NRL has been devoted to supporting CanSat in its efforts to further students' aerospace exploration through the development of aeronautical exploration and STEM education.

This year's competition tasked teams to design a CanSat consisting of a container and a payload, that teams designed around the structure of a container by a 10-meter long tether. Once the CanSat deployed from the rocket, it was supposed to demonstrate the ability to descend at a rate of 15 m/s using a parachute. During that time, the payload must have maintained the orientation of a video camera pointing in the south direction and 45 degrees downward to ensure terrain was in the frame.

Ivan Galysh, section head of NRL's Digital Signal Processing Section of the Precise Navigation and Timing Branch, CanSat competition director, recounted being impressed by the teams' "documentation provided displaying a very detailed outline of their payload. This truly shows that they have dedicated themselves and their skills to a successful launch."

Throughout the second day of the competition, students gathered around the Kentland Farm of Virginia Tech to put the final touches on their models. On launch day, tensions were high amongst teams as they eagerly anticipated a successful deployment. Tristan McGinnis, leader of the University of Alabama at Huntsville's Team Star Saber, explained his team's desire not only to execute a successful launch, but also to utilize their time at CanSat to enjoy collaborating and learning with one another.

"As a computer science major, I initially came into the competition wanting to engage in programming the payload. But along the way, hurdle after hurdle, I found myself engaging in different forms from aerospace to electrical engineering. It is such a well-rounded project," said McGinnis, who indicated his team is looking forward to participating in the competition again next year.

NRL's continued investment within CanSat is representative of its current and future Department of the Navy workforce, which enhances the Navy and the Marine Corps's ability to meet present and future warfighting challenges. NRL's science, technology, engineering, and mathematics outreach serves to inspire, engage, and educate the next generation of aeronautical scientists and engineers.

A rocket is launched during the American Astronautical Society CanSat Competition on June 11, 2022, in Blacksburg, Virginia. The CanSat Competition is an annual student design, build, and launch competition for space-related topics. (U.S. Navy photo by Jonathan Steffen)

College competitors in the American Astronautical Society CanSat Competition work on their payload on launch day on June 11, 2022, in Blacksburg, Virginia. (U.S. Navy photo by Jonathan Steffen)

Liam Magargal is a Lehigh University doctoral student and U.S. Naval Research Laboratory (NRL) Naval Research Enterprise Intern Program (NREIP) intern. (Photo provided by Liam Magargal)

NRL NREIP Student Helps Generate Cost-Saving Physics Modeling Algorithm

U.S. Naval Research Laboratory (NRL) Naval Research Enterprise Intern Program (NREIP) intern Liam Magargal and a team of NRL scientists and collaborators from the University of Washington (UW) develop novel algorithms to significantly reduce time and costs of simulating the behavior of complex multiphysics systems with machine learning.

These efforts are aimed at enabling efficient, accurate, and low-cost designs of defense systems and applications.

NRL offers undergraduate and graduate students with a strong interest in scientific research an opportunity to learn under the tutelage of professionals through the NREIP.

During the ten-week internship program, students work with mentors at participating Navy laboratories who help hone or further develop their skillsets. Magargal, a Lehigh University doctoral student, helped design and build computational multiphysics models and subsequently used them to generate synthetic data to train algorithms developed by the NRL-and-UW team.

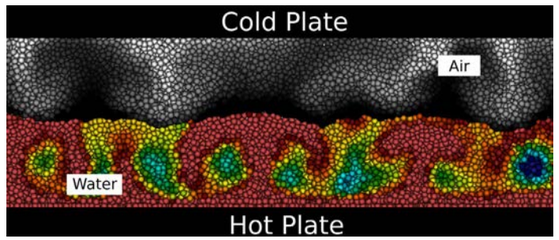
"Computational multiphysics is a field of computational mathematics and physics that enables scientists and engineers to model complex phenomena, such as modeling airflow over an airplane," said Magargal. "While these tools have become indispensable in engineering design, they are often too computationally expensive to be used in many time-critical analyses."

Dr. Steven Rodriguez, an NRL research scientist from the Computational Multiphysics Systems Laboratory who is heading the NRL-and-UW team in this effort, guided Magargal through the development of an in-house code based on numerically modeling the physics of multiphase flow with smoothed-particle hydrodynamics. The tandem composed code that can be customized and user-defined to allow for physical inputs such as conductivity, density, viscosity, and other physical and computational parameters.

Magargal and Rodriguez first focused on generating training data for NRL's algorithms with simple fluid flow often seen in natural convection, such as Rayleigh-Bénard instabilities—a phenomenon that can be seen when you boil water.

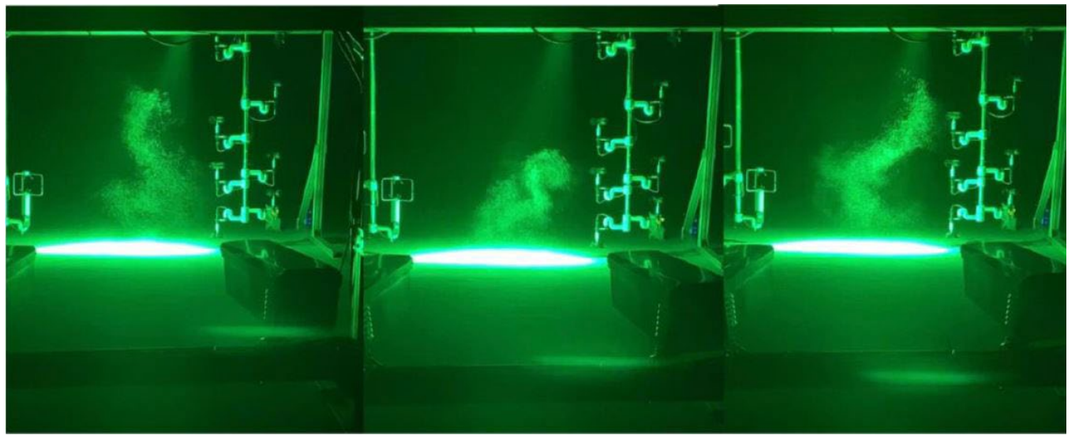
"Liam focused on helping me code up a mathematical technique used to model fluids called the 'Smooth Particle Hydrodynamics Method,' or SPH for short, which was originally developed to model astrophysics," said Rodriguez. "SPH is recognized among the scientific computing community as an effective modeling tool and has shown to be useful for problems involving different types of fluids with different densities — for example, how oil and water interact at room temperature."

This past summer, Magargal learned the mathematical framework of SPH and how to communicate these ideas to a computer to run fluid simulations and study the behavior of intermixing fluids. After modeling the Rayleigh-Bénard convection, Magargal leveraged the code to systematically generate training data for the Projection-Tree Reduced-Order Model (PTROM) — the algorithm developed by the NRL-and-UW team.



U.S. Naval Research Laboratory scientists and an Naval Research Enterprise Internship Program intern collect output data of natural convection between water and air exhibiting Rayleigh-Bénard instabilities to test the power of a novel algorithm that will be employed to compute results of physics models much faster than previously possible, allowing for designs with defense applications to be generated at a lower cost. (Rendering provided by U.S. Naval Research Laboratory Center for Computational Materials Science)

Seeing the Wind: A Close-Up of How Wind Influences Beach Environments



Frames of the particle tracking velocimetry system capturing turbulence on a beach at NASA Wallops Flight Facility. (Photo provided by Madeline Kelley)

On a dark, windy evening on Wallops Island, Virginia, this past fall, Maddy Kelley, an employee in the Ocean Sciences Division at NRL's Stennis Space Center in Mississippi, stood on the beach and watched wind and sand pulse along the beach, driven by eddies and illuminated by neon green lasers.

Kelley, a Ph.D. student in Arizona State University's School of Geographical Sciences and Urban Planning and a geomorphologist who works to quantify and predict the movement of sediment, was part of an international team of scientists and engineers led by Christy Swann, Ph.D., also from the U.S. Naval Research Laboratory's Ocean Sciences Division, conducting research to better understand the natural processes of sandy beach environments.

The researchers aim to use the new images to unravel new understanding of the physics of turbulence and how sediment travels by wind. Ultimately, the research is expected to provide valuable information for models on what may need to be done to preserve beach environments in the future.

The data was collected using a particle tracking velocimetry (PTV) system that the team developed. The 4-m-by-3-m metal-framed apparatus consisted of lasers, high-speed cameras, and traditional sensors measuring turbulence and windblown sand.

Current models studying how wind moves sand, or aeolian sediment transport, historically have performed poorly due in part to limitations of available instrumentation that can measure and incorporate natural boundary layer turbulence.

The newly captured wind turbulence data provides key information at a resolution not previously available that researchers hope to use to better predict future environmental changes and to improve current modeling techniques.

"We're trying to better understand the physics of windblown sand, and for the first time, we can visualize and quantify the relationship between turbulence and transport," Kelley said. "We've proven that (our instrumentation) can work, we can get these high-resolution images in such a harsh environment, but there's still much more to do.

NRL Tech Transfer Continues Forging Partnerships With Sherwin-Williams

A CH-53 Super Stallion from Marine Heavy Helicopter Squadron (HMH) 366 lands on the flight deck of the amphibious assault ship USS Bataan (LHD 5) on April 27, 2022, in the Atlantic Ocean. (U.S. Navy photo by Petty Officer 3rd Class Matthew F. Brown)

The U.S. Naval Research Laboratory's (NRL) Technology Transfer Office plays an important role in demonstrating NRL as a leader in technology innovation. Recently, NRL entered into a Limited Government Purpose License (GPL) with The Sherwin-Williams Company.

NRL has developed polysiloxane nonskid coatings with extended durability. Sherwin-Williams requested a Limited Government Purpose License to make, use, and sell the invention directly and solely to shipyards or contractors performing maintenance, repair, or new construction of vessels owned by the U.S. Government.

"The polysiloxane nonskid coating developed by NRL represents a significant advancement in technology over standard products available on the market today," Mark Schultz, business development manager for Sherwin-Williams Protective & Marine said. "This novel solution with extended durability and excellent color retention, the polysiloxane nonskid coating doesn't chalk, discolor, or fade, and can be rolled or spray-applied, helping minimize waste, increasing efficiencies in the coatings maintenance process, and reducing overcoating for aesthetic purposes. This combination of benefits has been well received by the U.S. Navy."

A key part of NRL's mission is the development and transition of technologies to support the Navy, and more broadly, the warfighter. NRL's intellectual property can be used to support tthose and other U.S. Government-specific efforts. NRL offers no-cost GPLs to any of our over 1,200 patented or patent-pending technologies and protected software.

TECH TRANSFER

The aircraft carrier USS Dwight D. Eisenhower leads a line of ships across the water during a training exercise in the Atlantic Ocean on September 28, 2019.

"NRL's wide breadth of intellectual property is available for use at no cost by the private sector in performance of awarded U.S. Government contracts," said Holly Ricks-Laskoski, Ph.D., senior partnership manager of NRL's Technology Transfer Office. "Leveraging NRL's intellectual property in this way is an opportunity for cost savings for our government contractor partners."

NRL partners with a wide variety of organizations including industry, academia and other government organizations to accelerate the development and transition of new and innovative technologies for the warfighter.

"We are very appreciative of our long-standing partnership with NRL. The innovation, testing and evaluation of forward-looking technologies has produced tangible results for our customers in terms of lowering total ownership cost and effectively maintaining ship schedules," said Bryan Draga, global vice president of marketing for Sherwin-Williams Protective & Marine. "Sherwin-Williams has been uniquely qualified to bring the MIL-SPEC products and technologies to the market thanks to our quality manufacturing processes and MIL-SPEC controls."

Sherwin-Williams's formulation was submitted for the Department of Defense Qualified Products Database evaluation and was under military specification MIL-PRF-24667 for a Type V non-skid coating.

For those companies looking to work with NRL, Ricks-Laskoski said, "NRL is open and we are looking forward to working with you."

The polysiloxane non-skid coating is described and claimed in U.S. Patent Nos. 9,006,307 and 9,034,946 issued April 14, 2015, and May 19, 2015, respectively.

NRL Researcher John Michopoulos Receives ASME Lifetime Achievement Award

John Michopoulos, Ph.D., receives the American Society of Mechanical Engineers (ASME) Computers and Information in Engineering (CIE) Lifetime Achievement Award on August 15, 2022, during a ceremony at the International Design Engineering Technical Conferences and CIE Conference in St. Louis, Missouri. (Photo provided by John Michopoulos)

John Michopoulos, Ph.D., head of the U.S. Naval Research Laboratory's (NRL) Computational Multiphysics Systems Laboratory, received the American Society of Mechanical Engineers (ASME) Computers and Information in Engineering (CIE) Lifetime Achievement Award.

The highest award bestowed by the ASME CIE division, it was presented on August 15, 2022, during a ceremony at the International Design Engineering Technical Conferences and CIE Conference in St. Louis. The award's commendation is "In recognition of outstanding lifetime achievements in advancing the discipline of computers and information in engineering.

"Dr. Michopoulos has been a vital part of NRL's mission since 1986," said Virginia DeGiorgi, Ph.D., superintendent of NRL's Materials Science and Technology Division." He has always been willing to address new and emerging problems, never satisfied to rest on his laurels."

Among the many accomplishments credited to Michopoulos is the development of the first autonomous recursive six-degrees-of-freedom (6-DoF) robotic testing system. This system was designed to generate all the necessary material response data for physics-based machine learning to characterize their response and test materials under loading emulating in-service conditions.

At NRL, ongoing extensions of this technology enable studying multiaxial and multiphysics fatigue of materials. Michopoulos and his group also created forward and inverse multiphysics and multiscale theories and machine learning models, along with the associated computational tools and methodologies to generate digital twins for the characterization, performance prediction, qualification, and certification of many material systems and platforms, including those produced by the additive manufacturing processes in the spirit of integrated computational materials engineering principles.

"As an example, our group [the Computational Multiphysics Systems Laboratory] has developed technology that performs multiscale morphology optimization," Michopoulos said. "This determines the shape of structures that is the best possible for performing multiple functions. It allows us to tailor the shape and morphology of a part for maximizing a desired performance."

"In addition to his technical accomplishments, he has used his skills as a teacher, mentor, and collaborator to develop the next generation of scientific leaders for NRL," DeGiorgi said.

Other notable achievements in the course of Michopoulos's career are the publication of four books, 15 peer-reviewed book chapters, 91 peer-reviewed journal publications, 259 peer-reviewed conference papers, and 10 patents.

DoN HBCU/MI Research Program Selects Dr. Atoyebi as Inaugural Postdoctoral Research Fellow at NRL

U.S. Naval Research Laboratory (NRL) chemist Olufolasade Atoyebi, Ph.D., is the Department of the Navy (DoN) Historically Black Colleges and Universities/Minority Institution (HBCU/MI) Program's inaugural Postdoctoral Research Fellow.

This program enables recent postdoctoral science, technology, engineering, and math (STEM) graduates from HBCU/MIs to pursue challenging research problems that address the future needs of the Department of Defense.

"I am honored. The DoN-HBCU/MI Postdoctoral program is a terrific way to learn and collaborate on innovative research supporting the Navy while receiving hand-in-glove mentorship from renowned senior researchers," said Atoyebi, who currently works in NRL's Chemistry Division.

"The projects I'm working on at NRL are in developing or improving materials used on hypersonic vehicles, weaponry on ships and submarines, antimicrobial dressings and other advanced biomaterials — helping to further the Navy's mission of protecting and defending sailors, Marines, and its allies' interests," she said.

NRL HBCU/MI director Paul Charles lauds Atoyebi as a "wonderful addition" to the program. "As the inaugural selection for the DoN HBCU/MI Postdoctoral research program, I am extremely proud of what she has accomplished so far as a professional. She is an excellent example of how diversity and inclusion can be an asset and a strength for any organization."

Atoyebi earned a Bachelor of Science in chemistry and a minor in Hispanic studies from Carnegie Mellon University (CMU) in 2012 and a doctorate in chemistry from Howard University in 2021.

Atoyebi credits her father and brother for her interest in pursuing a career in STEM. "My dad, Kayode Atoyebi, was a pharmacist and my brother, Jide Atoyebi, is a programmer [who] took a lot of chemistry, physics, and math classes," she said. "So, when I was younger, there was a lot of science talk around the table or in the car, which I think is what sparked my curiosity and led me to this path ... thank you!"

Olufolasade Atoyebi, U.S. Naval Research Laboratory postdoctoral researcher

Through the program, Atoyebi has been inspired to highlight its benefits for the next generation of scientists through mentorship. When working with undergraduate or graduate researchers, Atoyebi tries to put herself in their shoes. "Once I have an idea of their background — educationally and personally — I try to teach or mentor from that perspective," she said.

The DON HBCU/MI research program provides workshops and professional development modules, encourages team-building and networking, research, and educational partnerships with HBCU/MIs, and more importantly, contributes in building a strong, diverse future STEM workforce. Through continued support from the DON HBCU/MI program office, under the direction of Mr. Anthony C. Smith Sr., the postdoctoral fellowship continues to blossom to advance science and technology.

NRL Materials Research Engineer Named 2022 Black Engineer of the Year

Brandice Weathers, a materials research engineer at the U.S. Naval Research Laboratory's (NRL) Chemistry Division, has been named Black Engineer of the Year and was set to receive the Professional Achievement in Government Award at the 2022 Black Engineer of the Year (BEYA) Science, Technology, Engineering, and Math (STEM) Global Competitiveness Conference.

Brandice Weathers, Ph.D., a materials research engineer at the U.S. Naval Research Laboratory's (NRL) Chemistry Division was set to receive the Professional Achievement in Government Award at the 2022 Black Engineer of the Year (BEYA) Science, Technology, Engineering, and Math (STEM) Global Competitiveness Conference, which was held February 17–19, 2022.

Prior to her current position, she was a graduate student at the University of Tennessee, Knoxville, and studied localized corrosion of zirconium-based amorphous alloys. After completing her doctoral degree, Weathers joined NRL as a support contractor at NRL Key West where she focused on material performance in marine environments and cathodic protection design.

The BEYA Professional Achievement in Government Award recognizes a highly experienced, midcareer STEM professional who has made significant discoveries and important advances in their chosen STEM career path and is acknowledged as a leader of large STEM initiatives.

"I am excited to receive the BEYA award and honored that my contributions to the research efforts of NRL's Center for Corrosion Science and Engineering are valued and were deemed worthy of nomination," Weathers said.

Since beginning her career with NRL, Weathers' research focus has centered on cathodic protection design for submarines.

"In her 12 years of government service, Dr. Weathers has established herself as an important resource for corrosion control of the U.S. Navy fleet, making important contributions in both technical innovation and in the design of current and future U.S. Navy ships," said John Russell, Ph.D., superintendent of NRL's Chemistry Division. "In particular, she showed significant leadership in the development of a new design manual for corrosion control that will impact Navy ship design for decades to come."

A pivotal career moment was Weathers's first shipyard visit, where she was able to go aboard the USS OAK HILL (LSD-51) and the USS SAN ANTONIO (LPD-17) to perform corrosion inspections. Weathers now coordinates inspections on Virginia-class submarines (SSN-774).

The most exciting recent project Weathers has been working on is the new Naval Sea Systems Command (NAVSEA) document — Ships Corrosion Control Design Practice Criteria (CCDPC) Manual (T9070-B1-DPC-010/630-1). This document represents a 3-year effort to document and codify essential corrosion control design requirements and recommendations for the design of naval sea platforms.

The Center for Corrosion Science and Engineering (CCSE) conducts broad scientific and engineering programs to understand and reduce the effects of the marine environment on naval systems. Within the CCSE, the Corrosion and Marine Engineering Section conducts basic and applied research to synthesize and produce advanced, multifunctional marine coatings technology for all naval environments, including immersion and alternate immersion and atmospheric exposures typical of Navy and Marine Corps platforms. To address corrosion and marine fouling challenges, a Marine Corrosion Facility is located in Key West, Florida. This laboratory resides in an unparalleled site for natural seawater exposure testing and marine-related materials evaluation.

NRL Scientists, Researchers Win 2022 Dr. Delores Etter Award

Individual Emergent Scientist category, experimental electrical engineer Stephanie Tomasulo, Ph.D,

Individual Emergent Scientist category, computer scientist David M. Sidoti, Ph.D

Team category, materials research engineers Scott Olig and Cameron Moser

Group category, Brilliant Effects Employment Shadow (BEES) Joint Capability Technology Demonstration (JCTD) team

BEES JCTD team members are: head, Intelligence, Surveillance, and Reconnaissance Systems Section Thomas J. Walls, Ph.D.; director, Center for Computational Science Basil A. Decina; branch senior staff Michael L. Wilson, Ph.D.; head, Applied Optics Branch Dale C. Linne von Berg.

Across Naval Research and Development Establishment group category, Nickel Aluminum Bronze (NAB) Alloying for Large Propulsor Castings team

NAB team members are: NRL's materials research engineers Derek Horton, Ph.D., and Mary Parker, Ph.D., Naval Foundry and Propeller Center mechanical engineer Trevor Thayer, materials engineering supervisor Sarah Byrnes, and engineering manager for Naval Sea Systems Command 05P3 Submarine Propeller and Propulsor technical warrant holder Meredith Wells.

A group of U.S. Naval Research Laboratory scientists recently won the Assistant Secretary of the Navy Research, Development and Acquisition (RD&A) Dr. Delores M. Etter Top Scientists and Engineers for the Year 2022 Award in individual and team categories.

Presented annually in June, this prestigious Navy award recognizes technical superiority, innovation, technical merit, operational impact and applicability to assistant secretary of the Navy RD&A priorities.

"Our winners represent the very best of professionalism, ingenuity, and achievement among their peers," said NRL's director of research, Bruce Danly, Ph.D. "These awards recognize the excellence of the highest-performing scientists and engineers that we as an organization have been fostering for nearly 100 years. Their efforts and the recognition of their efforts reflect well on the relevance of NRL to the naval forces."

In the Individual Emergent Scientist category, experimental electrical engineer Stephanie Tomasulo, Ph.D, developed materials for infrared detectors and emitters that provide critical Department of Defense (DoD) capabilities, including chemical sensing, infrared search and track, and large-format infrared imaging. These advances will directly impact the naval warfighters by enabling and improving new devices that provide enhanced situational awareness and infrared spectrum dominance.

In the Across Naval Research and Development Establishment group category, the Nickel Aluminum Bronze (NAB) Alloying for Large Propulsor Castings team developed and implemented an innovative alloying method for large, slow cooled castings of nickel aluminum bronze. This alloying method was shown to greatly improve mechanical properties in both laboratory experiments and full-scale foundry production, directly impacting submarine construction programs and its ability to meet performance and schedule requirements

The award — sponsored by the assistant secretary of the Navy for Research, Development and Acquisition — is named for the Honorable Delores M. Etter, Ph.D., who served as U.S. deputy undersecretary of Defense for Science and Technology from 1998 to 2001 and ASN RD&A from 2005 to 2007.

NRL Team Earns ESTCP 2021 Project of the Year Award for Munitions Response

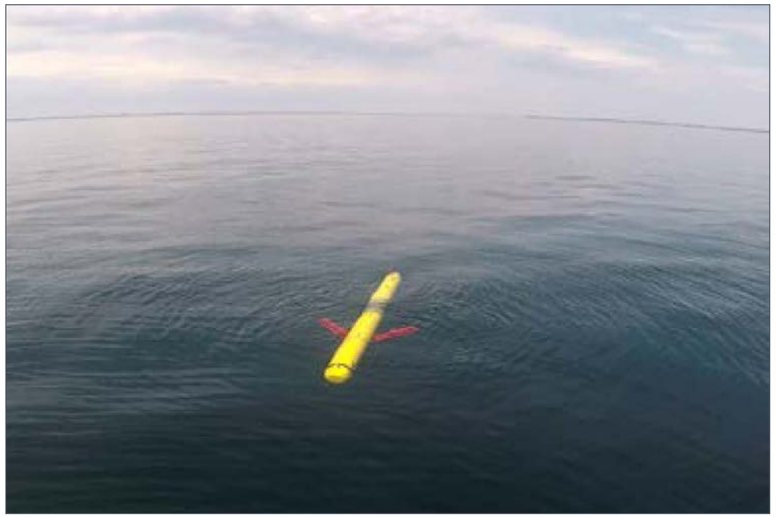
Research scientists from the NRL Acoustics Division recieved The Department of Defense Environmental Security Technology Certification Program (ESTCP) 2021 Project of the Year Award for Munitions Response. ESTCP is DoD's environmental technology demonstration and validation program.

The Strategic Environmental Research and Development Program (SERDP) is DoD's environmental science and technology program, planned and executed in partnership with the Department of Energy and the Environmental Protection Agency, with participation by numerous other federal and nonfederal organizations. SERDP invests across a broad spectrum of basic and applied research, as well as advanced development.

Many active and former military installations have ordnance ranges and training areas with adjacent waters in which unexploded ordnance (UXO) now exist due to wartime activities, dumping, and accidents. Researchers have exploited low-frequency sonars that experience lower absorption in the sediment and can detect buried objects.

Headed by Joseph Bucaro, Ph.D. (Code 7130) and Brian Houston, Ph.D. (Code 7100), the project team's first goal was to demonstrate the ability of autonomous underwater vehicle (AUV)-based sonars to detect and classify proud and buried UXO in a shallow-water area. The second goal was to assess the cost and performance of this technology.

In previous SERDP projects (MR-1513) and (MR-2103), the project team explored and successfully developed the sonar technology for detection and classification of underwater proud and buried UXO. A principal innovation introduced in these efforts was the exploitation of acoustic color to support target classification. The team's improved system (the Skyfish) was designed to add to this imaging capability the ability to generate high-quality acoustic color maps to support feature-based target identification. The Skyfish was demonstrated in Boston Harbor scanning three blind target fields.



NRL Internal Awards

NRL Commanding Officer Capt. Gregory Petrovic awards NRL Space Systems Development Division Superintendent Chris Dwyer the Navy Superior Civilian Service Award, the highest honorary award the chief of naval operations or the commandant of the Marine Corps may bestow on a civilian employee in the Department of the Navy, and the highest award granted at the major claimant level. (U.S. Navy photo by Petty Officer1st Class Jeff Troutman)

Jennifer Hartman, a U.S. Naval Research Laboratory (NRL) human resources specialist, receives the NRL Award for Excellence in Mission Support from Capt. Jesse Black, NRL's executive officer, in Washington, D.C., on October 10, 2022. (U.S. Navy photos by Sarah Peterson)

The U.S. Naval Research Laboratory's (NRL) Human Resources Office receives the 2021 NRL Award of Merit for Group Achievement from Capt. Jesse Black, NRL's executive officer, in Washington, D.C., on October 10, 2022.

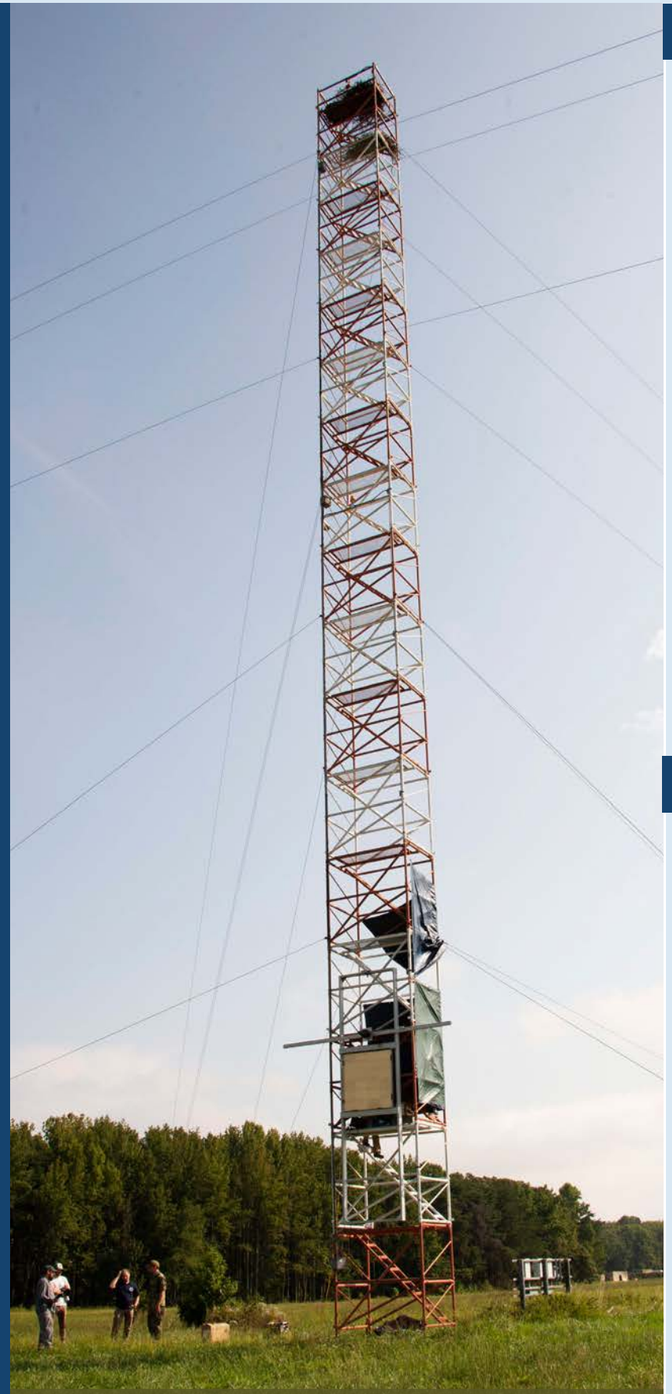
FY2023 PERSONNEL

Total FTP Personnel: 2,459

Social Science	1
Psychology	10
Program Management	1
General Natural Resources Management and Biological Sciences	32
Microbiology	2
General Engineering	15
Fire Protection Engineering	1
Materials Engineering	73
Architecture	1
Civil Engineering	7
Environmental Engineering	4
Mechanical Engineering	121
Nuclear Engineering	1
Electrical Engineering	78
Computer Engineering	61
Electronics Engineering	303
Aerospace Engineering	88
Chemical Engineering	15
General Physical Science	50
Health Physics	9
Physics	317
Geophysics	10
Chemistry	91
Metallurgy	4
Astronomy and Space Science	29
Meteorology	51
Geology	3
Oceanography	51
Operations Research	7
Mathematics	30
Computer Science	186
Data Science	1

Highest Academic Degrees Held by Civilian Full-Time Permanent Employees

Bachelor	**660**
Master	**483**
Doctorate	**877**



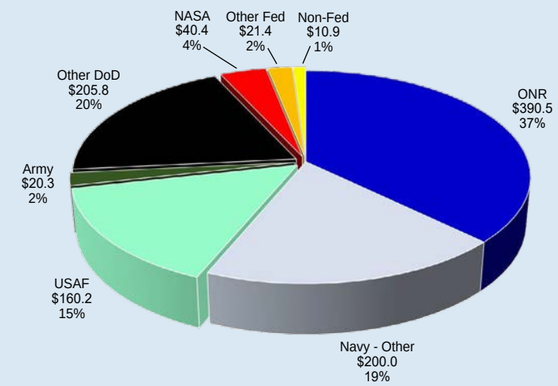
Microwave (SCOPE-M) demonstration at Army Blossom Point Research Field, Maryland, September 21, 2021. U.S. Naval Research Laboratory developed the rectifying antenna, “rectenna”, to convert an x-band microwave beam to 1 kilowatts of DC power at a range of 1 kilometer.

PERSONNEL AND FINANCIALS

FY 2022 Source of New Funds

	Total ($M)
Office of Naval Research	$390.5
Other Navy	200.0
U.S. Air Force	160.2
U.S. Army	20.3
Other DoD agencies	205.8
NASA	40.4
Other Federal agencies	21.4
Non-Federal customers	10.9
Total Funds	$1,049.5

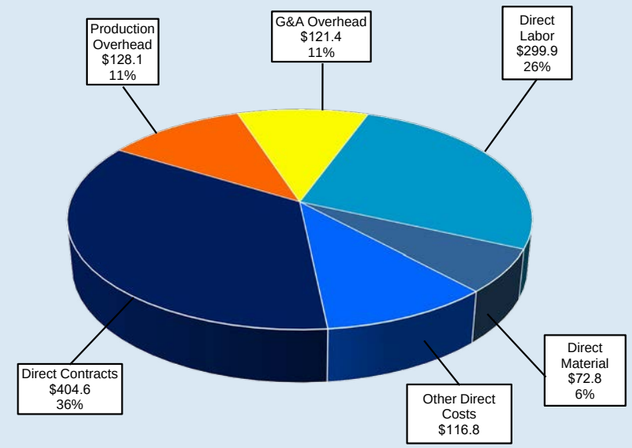
($ in Millions)



FY 2022 Expenditure of Funds

	Total ($M)
Direct Labor	$299.9
General and Administrative Overhead	121.4
Production Overhead	128.1
Direct Materials	72.8
Other Direct Costs	116.8
Direct Contracts	404.6
Total Costs	$1,143.6

($ in Millions)



All data as of September 30, 2022

ABOUT NRL

The U.S. Naval Research Laboratory (UIC N00173) has major facilities on the banks of the Potomac River in southeastern Washington, D.C., at the Stennis Space Center in Mississippi, in Key West, Florida, and in Monterey, California. NRL employs approximately 2,700 civilian scientists, engineers, and support personnel. NRL was dedicated on July 2, 1923, and is the Navy and the Marine Corps's corporate laboratory charged with the mission of conducting basic and applied research in a broad, multidisciplinary program to advance science and technological development for the National Defense Strategy.

NRL AND ITS FIELD SITES

Naval Research Laboratory
Washington, DC

Ocean Sciences Division
Stennis Space Center, MS

Marine Meteorology Division
Monterey, CA

Blossom Pt Tracking Facility
Welcome, MD

Chesapeake Bay Detachment
Chesapeake Beach, MD

Scientific Development Squadron (VXS) 1
NAS Patuxent River, MD

Midway Research Center
Quantico, VA

Free Space Antenna Range
Pomonkey, MD

Marine Corrosion Facility
Key West, FL

Multiple Research Site
Tilghman Island, MD

U.S. NAVAL RESEARCH LABORATORY

Reviewed and Approved
NRL/PU/1000--23-675
IR-1034-24-1-U
April 2024
CAPT Jesse Black, USN
Commanding Officer
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