
U.S. NAVAL
RESEARCH
LABORATORY
LABORATORY FOR
AUTONOMOUS SYSTEMS RESEARCH
2022
ANNUAL REPORT

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

www.nrl.navy.mil

For more information, visit the NRL website or join the conversation on social media.

The U.S. Naval Research Laboratory is dedicated to research that drives innovative advances for the U.S. Navy and the U.S. Marine Corps from the seafloor to space and in the information domain.

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Petrovic Relieves Vigil as the 41st NRL Commander

Capt. Gregory Petrovic, center, the U.S. Naval Research Laboratory's (NRL) incoming commanding officer, is piped aboard during the NRL change of command in Washington, D.C., on June 25, 2021. Petrovic became the 41st commanding officer of NRL. (U.S. Navy photo by Sarah Peterson)

Capt. Gregory Petrovic relieved Capt. Ricardo Vigil and assumed command as the 41st commanding officer of the U.S. Naval Research Laboratory during a ceremony on June 25, 2021. Petrovic assumed command following his tour of duty as NRL's executive officer.

Chief of Naval Research Rear Adm. Lorin Selby was the guest speaker and presented Vigil with a Legion of Merit award for his service as commanding officer of NRL from June 2019 to June 2021.

"Capt. Vigil led a great team at NRL through some of the most challenging moments, including a pandemic, without missing a beat when it comes to providing our sailors and Marines with the best capabilities in the world," Selby said. "We wish him fair winds and following seas, and I am looking forward to continued outstanding leadership at NRL under Capt. Petrovic."

Vigil reflected on a variety of NRL science and research efforts that one day will support sailors and Marines in the fleet, such as the testing of firefighting foams for use on ships and aircraft, quantum information, and developing and improving ocean atmospheric modeling. He also highlighted advanced laser weapon technology, software-based encryption systems, artificial intelligence, advanced fluid dynamics and hypersonics research aircraft, Scientific Development Squadron (VXS) 1 "Warlocks," predictable space weather, wireless power transfer, and new clock developments for position navigation and timing.

Petrovic is a graduate of the United States Naval Academy and the Eisenhower School of National Security. His prior military assignments include being the division chief for theater anti-submarine warfare and international engagement at the Undersea Warfare Development Center in San Diego, California.

Webb Assumes Command of Warlocks

Cmdr. Jeffrey Webb, the commanding officer of U.S. Naval Research Laboratory's Scientific Development Squadron (VXS) 1, gives his welcoming remarks during a change-of-command ceremony at Naval Air Station Patuxent River in Patuxent River, Maryland, on Jan. 14, 2022. (U.S. Navy photo by Sarah Peterson)

Cmdr. Jeffrey Webb relieved Cmdr. Ian Lilyquist as commander of the U.S. Naval Research Laboratory's Scientific Development Squadron (VXS) 1, the Warlocks, on Jan. 14 during a change-of-command ceremony held at Naval Air Station Patuxent River, Md.

U.S. Naval Research Laboratory Commanding Officer Capt. Gregory Petrovic presented Lilyquist with the Meritorious Service Medal. Lilyquist served as VXS-1's commanding officer from November 2020 to January 2022. Petrovic said Lilyquist's distinguished leadership was instrumental to the squadron's continued record of exceptional support to NRL's airborne mission.

This past year, VXS-1 laid the foundation to transition to the P-8A Poseidon — the Navy's newest maritime patrol platform — retaining the ability for VXS-1 to support heavy-lift, long-endurance airborne research, ensuring the squadron has a fleet-representative platform to demonstrate technology in operational theaters to strengthen the ties between VXS-1 and the maritime patrol-and-reconnaissance community.

"I am deeply honored and eager to lead this talented squadron as its 15th commanding officer," Webb 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."

Webb, a native of Boise, Idaho, graduated from the U.S. Naval Academy in 2003 with a Bachelor of Science degree in Engineering, and he graduated with distinction in receiving his Master of Science in System Engineering from the Naval Postgraduate School in June 2015.

NRL PRAM Mission: One Year and Still Going

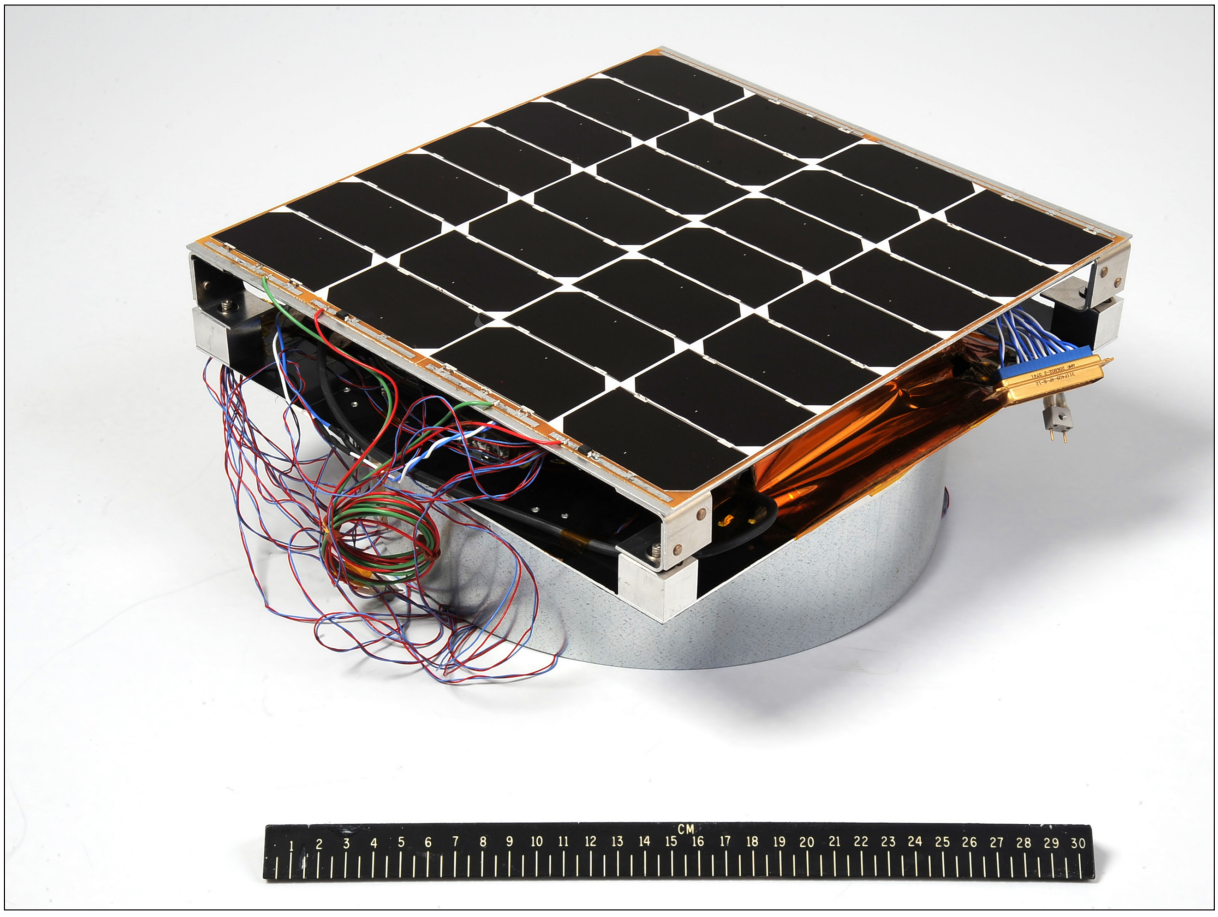
It has been one year since U.S. Naval Research Laboratory engineers launched PRAM, the Photovoltaic Radio-frequency Antenna Module, aboard the Air Force X-37B Orbital Test Vehicle on May 17, 2020.

The mission is part of a comprehensive investigation into prospective terrestrial use of solar energy captured in space.

PRAM is testing functional components of what would be part of a power satellite network that could transmit energy from space to anywhere on Earth. Since the launch, the team has been receiving data regularly.

"The analysis to this point has shown that it has performed as well in orbit and even in some cases exceeded our prelaunch laboratory testing," said Chris DePuma, the PRAM program manager. DePuma went on to say the real wow moment for him was when they received the very first data package from the X-37B Orbital Test Vehicle. "It confirmed all our hard work had paid off, and PRAM was working in orbit and delivering valuable data to advance space solar and power-beaming research."

During the past year, researchers have been collecting and analyzing the data that has been transmitted. Power beaming is an efficient point-to-point transfer of electrical energy across free space by a directed electromagnetic beam. In January 2021, Jaffe and DePuma helped write a paper ("Microwave and Millimeter Wave Power Beaming") led by Chris Rodenbeck, Ph.D., from NRL's Radar Division, that reported data from the first in-orbit flight test of a solar-to-RF "sandwich module."



The Photovoltaic Radio-frequency Antenna Module (PRAM) is shown with a 12-inch ruler for scale. The hardware is the first orbital experiment designed to convert sunlight for microwave power transmission for solar power satellites. (U.S. Navy photo by Jonathan Steffen)

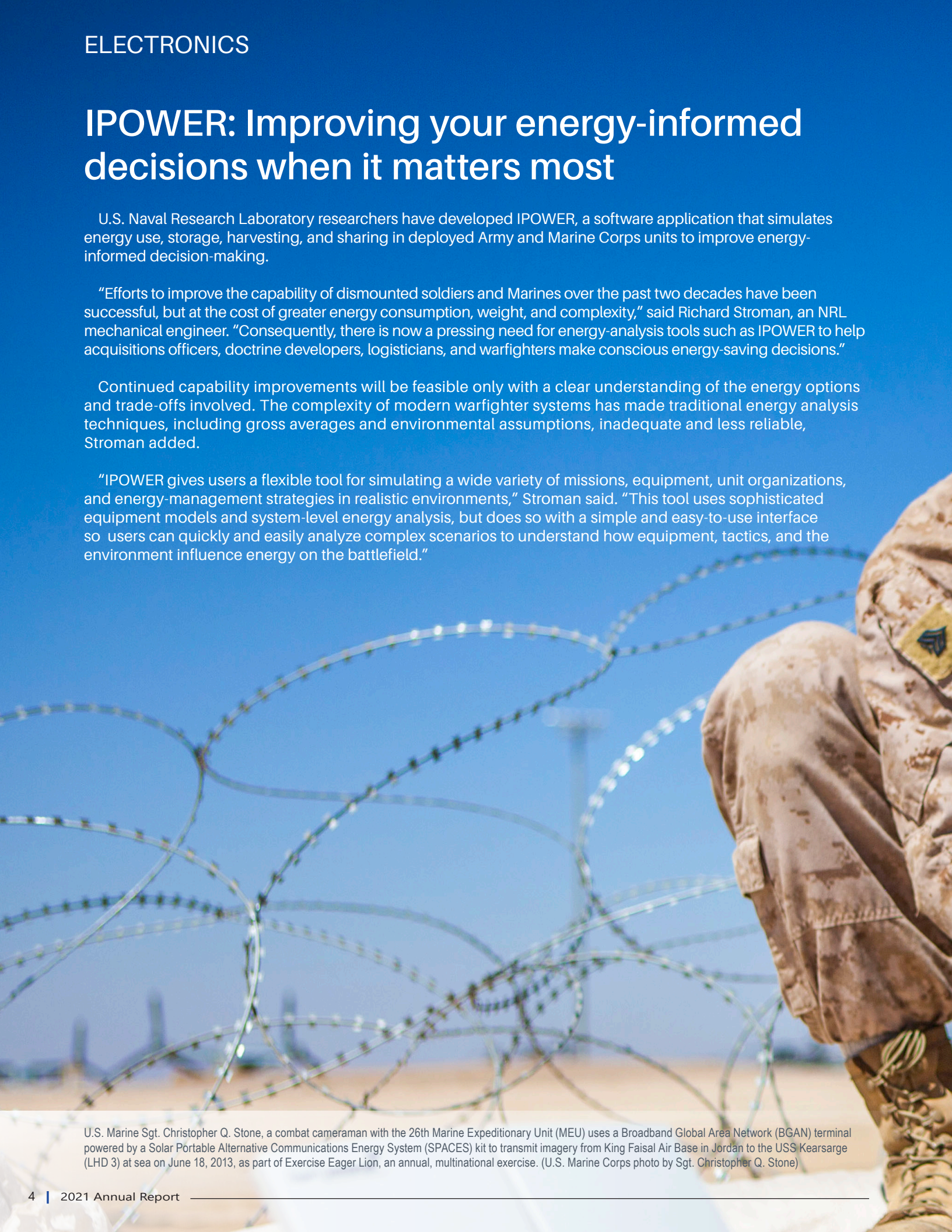
IPOWER: Improving your energy-informed decisions when it matters most

U.S. Naval Research Laboratory researchers have developed IPOWER, a software application that simulates energy use, storage, harvesting, and sharing in deployed Army and Marine Corps units to improve energy-informed decision-making.

"Efforts to improve the capability of dismounted soldiers and Marines over the past two decades have been successful, but at the cost of greater energy consumption, weight, and complexity," said Richard Stroman, an NRL mechanical engineer. "Consequently, there is now a pressing need for energy-analysis tools such as IPOWER to help acquisitions officers, doctrine developers, logisticians, and warfighters make conscious energy-saving decisions."

Continued capability improvements will be feasible only with a clear understanding of the energy options and trade-offs involved. The complexity of modern warfighter systems has made traditional energy analysis techniques, including gross averages and environmental assumptions, inadequate and less reliable, Stroman added.

"IPOWER gives users a flexible tool for simulating a wide variety of missions, equipment, unit organizations, and energy-management strategies in realistic environments," Stroman said. "This tool uses sophisticated equipment models and system-level energy analysis, but does so with a simple and easy-to-use interface so users can quickly and easily analyze complex scenarios to understand how equipment, tactics, and the environment influence energy on the battlefield."



U.S. Marine Sgt. Christopher Q. Stone, a combat cameraman with the 26th Marine Expeditionary Unit (MEU) uses a Broadband Global Area Network (BGAN) terminal powered by a Solar Portable Alternative Communications Energy System (SPACES) kit to transmit imagery from King Faisal Air Base in Jordan to the USS Kearsarge (LHD 3) at sea on June 18, 2013, as part of Exercise Eager Lion, an annual, multinational exercise. (U.S. Marine Corps photo by Sgt. Christopher Q. Stone)

Essentially, the tool uses a climate database to estimate the likely environment, then uses equipment models and mission timelines to compute power flows in the unit. The power flows are used to generate energy metrics, such as the total energy consumed, the number of batteries used, when batteries are swapped, and the amount of fuel consumed. Users can make a deep dive and see details such as a battery's state of charge or harvested solar power as functions of mission time. Results are presented as interactive plots, charts, and other graphics.

NRL Supports Security for Biden's Inauguration with Modeling Capability

Adam Moses, a computer scientist with the U.S. Naval Research Laboratory, mans the D.C. Department of Environment operations center during the 59th Presidential Inauguration ceremony of President Joseph R. Biden Jr. on Jan. 20, 2021. CT-Analyst is a 3D computer-simulated modeling program that can track the release of chemical, biological, and radioactive substances. (U.S. Navy photo)

When seconds matter, or even milliseconds, speed saves lives. That's why Adam Moses, a U.S. Naval Research Laboratory computer scientist, was part of the massive security effort behind the inauguration of President Joe Biden.

Moses deployed a 3D computer-simulated modeling program called Contaminant Transport Analyst, or CT-Analyst, which can track the release of chemical, biological, and radioactive substances that can spread large distances in minutes.

"CT-Analyst aims to be the fastest, most accurate hazardous airborne plume-modeling tool available to both military and civilian first responders," Moses said. "CT-Analyst is easily learned and provides a depth of capability and reporting options that respond well to fast-changing situations."

This was the fourth presidential inauguration the program played a role in, having been used in the 2013 and 2017 inaugurations. NRL hosted the hazmat modeling reach-back center in 2009 and was deployed with the Federal Protective Service for the 2005 inauguration.

In addition, CT-Analyst has supported security for several Super Bowls, the Academy Awards, and other national special security events (NSSEs).

The software was developed by researchers in NRL's Laboratories for Computational Physics and Fluid Dynamics. Continuous improvement of this state-of-the-art modeling software makes it extremely valuable to first responders around the nation.

CT-Analyst also produces information about the effects dangerous chemicals have on people. It uses a rating system called Protective Action Criteria (PAC) values. PAC values give quick reporting on health consequences while inside a plume, from no effects whatsoever to severe incapacitation. In addition, CT-Analyst can quickly indicate the direction of a plume and expected arrival times in increasing intervals, from 5 minutes to an hour.

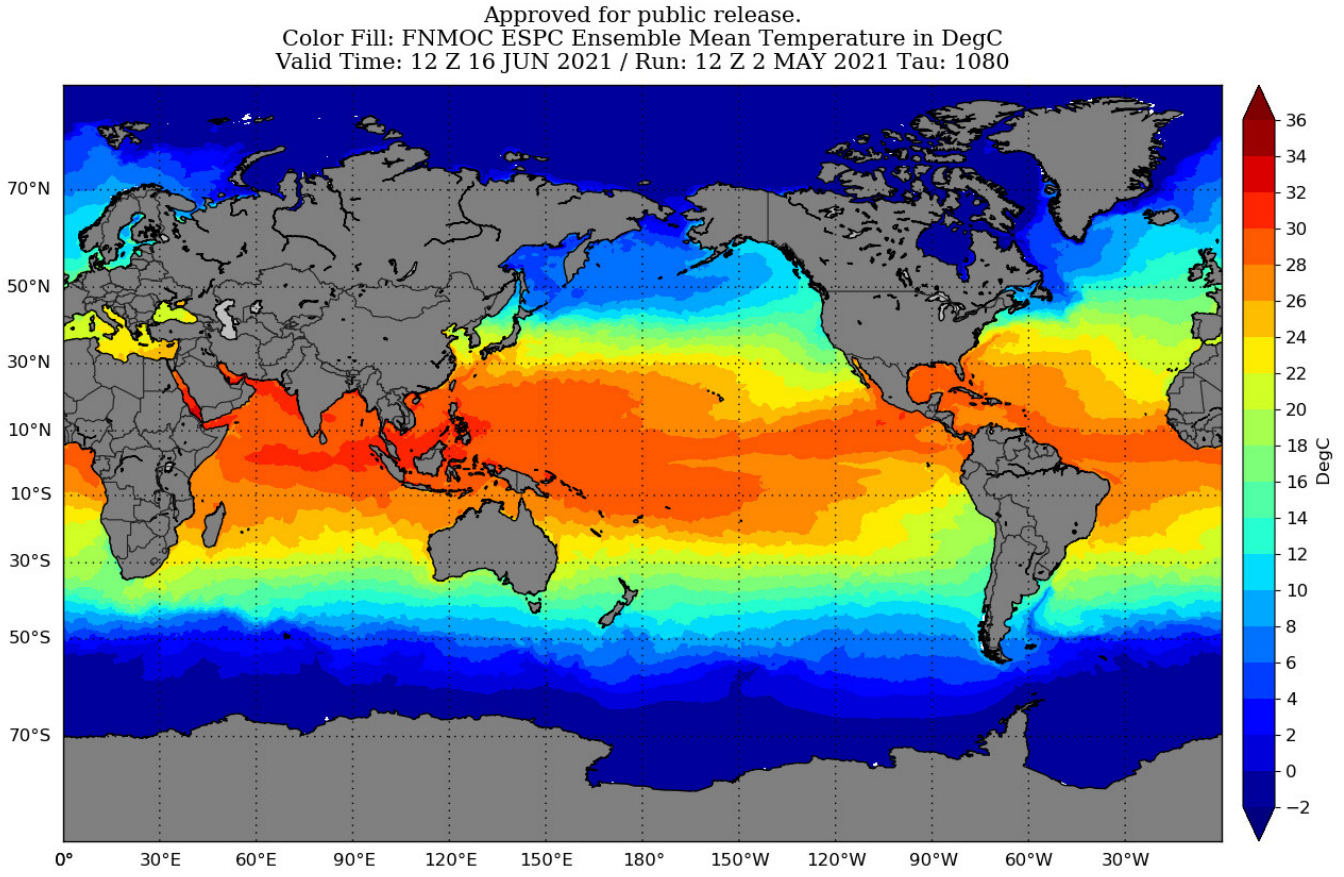
A plume in red on the map shows an example of how the U.S. Naval Research Laboratory's CT-Analyst modeling software can track the release of harmful chemicals or biological agents in a crowded urban area during the 59th Presidential Inauguration ceremony of President Joseph R. Biden Jr. on Jan. 20, 2021. CT-Analyst can track the release of chemical, biological, and radioactive substances that can spread large distances in seconds. (U.S. Navy photo)

Navy Forecasting Provides 45-day Advanced Environmental Predictions

Earth's ocean-navigating environment just got a little less mysterious thanks to the U.S. Naval Research Laboratory-developed Navy Earth System Prediction Capability (ESPC) global forecasting system, which went live in late August.

The Navy ESPC V1 provides the Navy with the first high-resolution ensemble capability for the ocean and sea ice that delivers both ensemble mean forecasts as well as a measure of uncertainty up to 45 days out.

"Atmosphere, ocean and sea-ice conditions affect naval operations," said Carolyn Reynolds, a meteorologist at NRL's Marine Meteorology Division in Monterey, California. "The transition of this new system provides, for the first time, environmental forecast information that fills the gap between weather and climate timescales to advise decision makers."



The Fleet Numerical Meteorological and Oceanography Center (FNMOC) Earth System Prediction Capability (ESPC) ensemble displays mean temperatures in degrees Centigrade. (U.S. Navy photo)

Study Finds Localized Water Release in Upper Mesosphere Enables Polar Mesospheric Cloud Formation

A team of scientists published an observational and modeling study showing that water vapor, a common launch byproduct of space traffic, can actively cool the mesosphere and can induce the formation of mesospheric clouds.

Since the end of the shuttle age in 2011, 17 countries have created their own space agencies, now totaling more than 72, 14 of which have their own launch capabilities. In 2020, there were 104 successful rocket launches globally that potentially released water vapor. But what are the effects it is having on the earth's atmosphere?

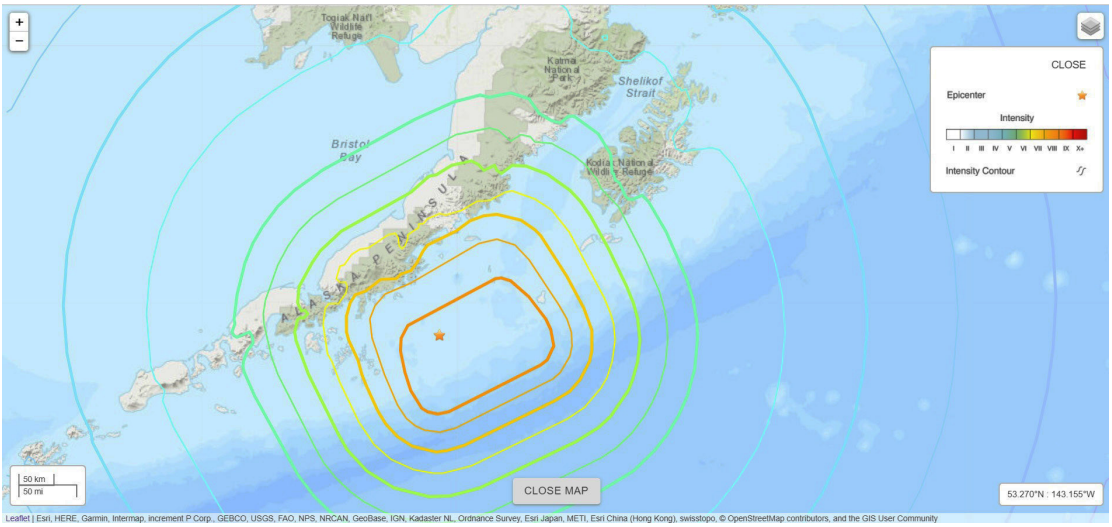
"Nobody knows how much these smaller launches are contributing, not yet, anyway," said Michael Stevens, Ph.D., from the U.S. Naval Research Laboratory's Geospace Science and Technology Branch, who is a co-author of the paper. "If you're using these clouds to measure any small multi-decadal changes, then they can become important. We've shown in this study that they could contribute significantly. But we don't know yet whether they do contribute significantly. This study has advanced our growing understanding of the impact."

Polar mesospheric cloud research at the edge of space serves to test high-altitude weather and climate models of the upper atmosphere that are important for the Navy.

A long-exposure view depicts the NASA "Super Soaker" rocket trail to its destination altitude of 53 miles, along with the light detection and ranging (LIDAR) beam (green) used for temperature measurements and cloud detection, at Poker Flat Research Range in Alaska on Jan. 26, 2018. The rocket experiment was part of a study a conducted by NASA and NRL.

Video captures a 485-pound (220-kilogram) canister of water exploding at 1,000 frames per second as part of the ground testing for the NASA "Super Soaker" experiment on Dec. 16, 2016, at NASA Wallops Flight Facility in Virginia.

NRL Scientist in the Right Place at the Right Time to Record Historic Earthquake



A magnitude 8.2 earthquake struck 50 miles south of the Alaska Peninsula on July 28, 2021, at 10:15 p.m. local time (July 29, 2021, 06:15 UTC). Seismic instruments indicate the earthquake originated at a depth of 20 miles (32.2 kilometers). This USGS map displays the Modified Mercalli Intensity (MMI) Scale, which uses Roman numerals from I (not felt) to X (extreme). Source: Department of the Interior, U.S. Geological Survey

U.S. Naval Research Laboratory (NRL) researcher Ben Phrampus recorded the largest U.S. earthquake in nearly half a century when it hit recently off the coast of southern Alaska. The magnitude 8.2 earthquake went mostly unnoticed because it was almost 20 miles below the ocean floor. However, it briefly sparked evacuations, tsunami warnings, and two aftershocks of magnitudes 6.2 and 5.6, respectively.

Phrampus, a research physicist in NRL's geology and geophysics section, was in the right place at the right time while on watch aboard a research vessel when the earthquake hit July 29, and the crew's instruments recorded the event.

The U.S. academic community's national seismic research vessel Marcus G. Langseth, operated by Lamont-Doherty Earth Observatory's Office of Marine Operations at Columbia University, sat west of an island chain called Haida Gwaii, which is off the northern Pacific coast of Canada. An acoustic receiver known as a hydrophone streamer recorded the noise while it was in the water at the time and showed a massive spike.

Some quick checking revealed it was an earthquake. They confirmed their findings after viewing the U.S. Geological Survey's website, which reported the quake.

After the tsunami warnings went off, coastal residents either scrambled to higher ground or evacuated. The earthquake was the most powerful in North America since a magnitude 9.2 earthquake in Alaska in 1964. Known as the "Great Alaskan earthquake," it spread across south-central Alaska, causing ground fissures, structure collapses, and tsunamis. More than 130 died in the quake, the most powerful recorded in North America. It was the second-largest earthquake ever recorded on Earth.

The more recent earthquake may have caused light to moderate damage and moderate shaking, according to preliminary seismic data. The U.S. National Tsunami Warning Center canceled a tsunami warning issued for parts of Alaska after waves of less than 1 foot arrived at the shore. Tremors extended throughout the Alaska Peninsula and Kodiak.

Phrampus said a rupture offshore went all the way to the seafloor along the continental slope. This produced seismic energy that interacted with the sound fixing and ranging channel, or SOFAR, which is an ocean channel that allows sound to carry great distances, according to the National Ocean Service. The ocean consists of many zones, and sound can travel through a zone for hundreds, and sometimes thousands, of miles. Interacting with the SOFAR converted the energy into acoustic waves, a process called downslope conversion, Phrampus said.

The research cruise ended Aug. 24. Results were to be presented at the American Geophysical Union in New Orleans in December 2021.

NRL Quantum Research Center Celebrates First Year of Research, Collaboration

Jonathan Kwolek, a U.S. Naval Research Laboratory (NRL) research physicist, shows an atom interferometer to Chief of Naval Research Rear Adm. Lorin Selby on Sept. 14, 2020, at NRL facilities in Washington, D.C. Kwolek uses the instrument to measure motion for navigational purposes. NRL is designated as the Navy's Quantum Information Research Center. (U.S. Navy photo by Jonathan Steffen)

The U.S. Naval Research Laboratory celebrated its first anniversary in March 2021 as the Navy's designated Quantum Information Research Center.

"This past year, NRL has lived up to our reputation for being a world-class research institution," said Dr. Bruce Danly, NRL's director of research. "We continue to establish the scientific basis for quantum information science and technologies for sensors applications, precision time and quantum computing applications of importance to the Navy. One major milestone was the establishment of an Educational Partnership Agreement between NRL and the University of Maryland's Quantum Technology Center to identify and pursue opportunities related to quantum technologies; the partnership's anniversary is on Sept. 1. The partners plan to seek avenues to collaborate in developing quantum technologies and in understanding the science that makes them possible.

"These advances will address crucial needs on the battlefield, including better and more secure communications and improved navigation. Advances in quantum sensors and precision clocks will allow the Navy to better operate in GPS-denied and jamming environments" said Gerald M. Borsuk, Ph.D., associate director of research for the Systems Directorate at NRL. "Quantum computers have the potential to address important needs not feasible with traditional high-performance digital supercomputers, including decision-making in complex battlefield environments and the design of novel materials. All of these new capabilities will benefit our sailors, Marines and warfighters, giving them the technological edge in fulfilling the Navy's mission in the global and cyber-warfare environments."

NRL continues to build bridges with industry and maintains close collaborations with academia on quantum technologies. Building on its more than 25 years of quantum research, the first year as the Navy's designated Quantum Information Research Center had boded well for future research and for bringing quantum technologies to reality.

How Science is Finding Ways to Navigate in GPS-Denied Environments

There's no denying that GPS and mapping applications on our mobile phones have dramatically affected society, including the military. Still, even their use has limits on reach and capabilities. Now science is going above and beyond to get to remote locations where GPS has no reach. In late September, the Office of Naval Research (ONR) Global selected and co-funded with the U.S. Army Development Command the winning proposal of its second annual Global-X Challenge, which called for international projects to address capability gaps at high latitudes (polar regions).

The winning project is a team comprising researchers from Japan, the U.K., the U.S., and Finland and led by Dr. Chris Steer from Geoptic Infrastructure Investigations Limited (U.K.), and will seek to show in nine months a proof of concept of an alternative navigation system in the Arctic with precision equal to that of GPS. They will be using a natural source of radiation called cosmic ray muons as an alternative to the satellite-derived GPS signals. The unique aspect of this work is that these subatomic particles pass through rock, buildings and earth — areas where GPS communications cannot be received.

The lead ONR Global science director for this project, Dr. Charles Eddy, said, "The ability to navigate in polar regions will be of increasing importance in the coming decades, as climate change is opening up Arctic waterways to commercial and military activities. This project, which uses cosmic relativistic particles that continuously impinge on the Earth's entire surface, offers an innovative approach to the challenge of navigation at high latitudes with little or no GPS service."

The future is extremely bright for this line of research, given that position-finding is fundamental within many areas of science, engineering and industry. While generally a very positive aspect, "the wide applicability can also be a distracting issue, as often, a focus application is required to make progress," said Steer. "Consequently, the next stage after this project would be to understand the positioning needs of end users, down-selecting to the best fit with our positioning measurement system, and maturing the technology for their needs."

A polar glacier is seen in an undated photo. (Photo courtesy of Kiril Dobrev)

New NRL 3D-Printed Antenna Designs Reduce Cost, Weight, and Size

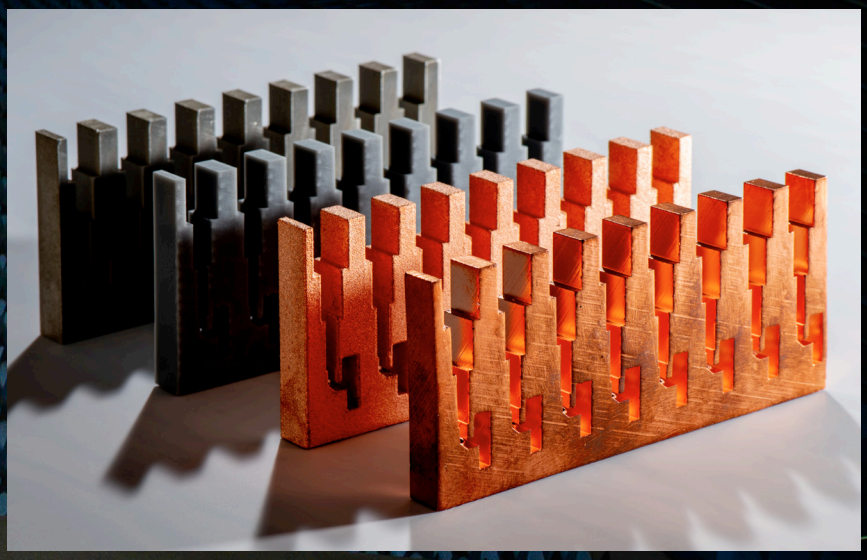
Anna Stumme, a U.S. Naval Research Laboratory electrical engineer, makes adjustments to an array inside the anechoic chamber at the U.S. Naval Research Laboratory in Washington, D.C., on Sept. 5, 2019. Stumme creates and tests prototype parts developed using traditional and 3D-printed methods. (U.S. Navy photo Jonathan Steffen)

U.S. Naval Research Laboratory experts created and tested 3D-printed antennas and arrays to advance radar technology and to enable new applications for the Navy.

The lightweight and rapid production of 3D-printed parts makes it an attractive alternative to traditional manufacturing, which often requires expensive materials and specialized equipment.

"3D printing is a way to produce rapid prototypes and get through multiple design iterations very quickly with minimal cost," said NRL electrical engineer Anna Stumme. "The light weight of the printed parts also allows us to take technology to new applications where the heavy weight of solid-metal parts used to restrict us."

Radar systems perform critical functions for the Navy and remain an important part of maritime navigation and national defense. Parts for antennas and arrays, which are multiple connected antennas working together as one, may unexpectedly break or wear out, requiring replacement. Traditionally, parts are ordered or intricately machined out of metal, sometimes taking weeks to produce. 3D-printed radar parts, such as cylindrical arrays, which provide 360-degree visibility, can be produced within hours (versus several days using traditional methods) due to the reduced machining and assembly time.



Manufactured column element parts of cylindrical arrays used for testing the viability of additive manufacturing to make cylindrical arrays are displayed at the U.S. Naval Research Laboratory in Washington, D.C. on Sept. 5, 2019. From left are metal 3D print, stereo lithography (SLA) print, selective laser sintering (SLS) nylon print with electroplating, and SLA print with electroplating. (U.S. Navy photo by Jonathan Steffen)

NRL Researchers Search for Critical Ocean Sciences Data with Lidar

A UV-18 Twin Otter carrying U.S. Naval Research Laboratory Scientific Development Squadron (VXS) 1 personnel and Ocean Sciences Division researchers flies over the Chugach Islands on Jan. 31, 2021, to determine ocean bubble fields using the NRL lidar and multiwavelength camera. (U.S. Navy photo by Lt. Alex Christie)

U.S. Naval Research Laboratory researchers from the Ocean and Atmospheric Science and Technology Directorate along with the Scientific Development Squadron (VXS) 1's UV-18 Twin Otter conducted airborne research in Homer, Alaska.

The team's objective was to measure bubbles using lidar, a laser system used in remote sensing. Improved understanding of bubble fields has many applications, including radiance, surface properties, and characterization of the ocean's surface.

"We are characterizing bubble fields to help better predict the ocean environment for Navy operations," said Damien Josset, Ph.D., an NRL oceanographer and principal investigator of the project who conducted the experiments aboard the Twin Otter.

Quantifying the oceanic whitecaps and subsurface bubbles is important to the Navy's oceanographic models to characterize the long-term evolution of the ocean environment because bubbles are the primary way the atmosphere and the oceans exchange heat, momentum, and gas.

Current remote-sensing techniques for ocean research rely primarily on passive observations at different wavelengths, including, visible, infrared, and microwaves, to estimate water-leaving radiance and surface properties, such as sea surface temperature, salinity, and wind.

"Lidar is fundamentally different because visible light penetrates well into the water body and it has the unique capability to provide a vertical profile of ocean properties," Josset said.

NRL's lidar system consists of a self-contained unit installed in a weatherproof enclosure, that is designed to be mounted on the Twin Otter's research compartment with the laser pointed down toward the water.

The project required high surface winds to create bubbles, or breaking waves, and good flying weather.

"It's difficult to characterize the bubbles' vertical properties, especially at global scale, which makes lidar an ideal tool to measure the bubble structure and properties," said Josset.

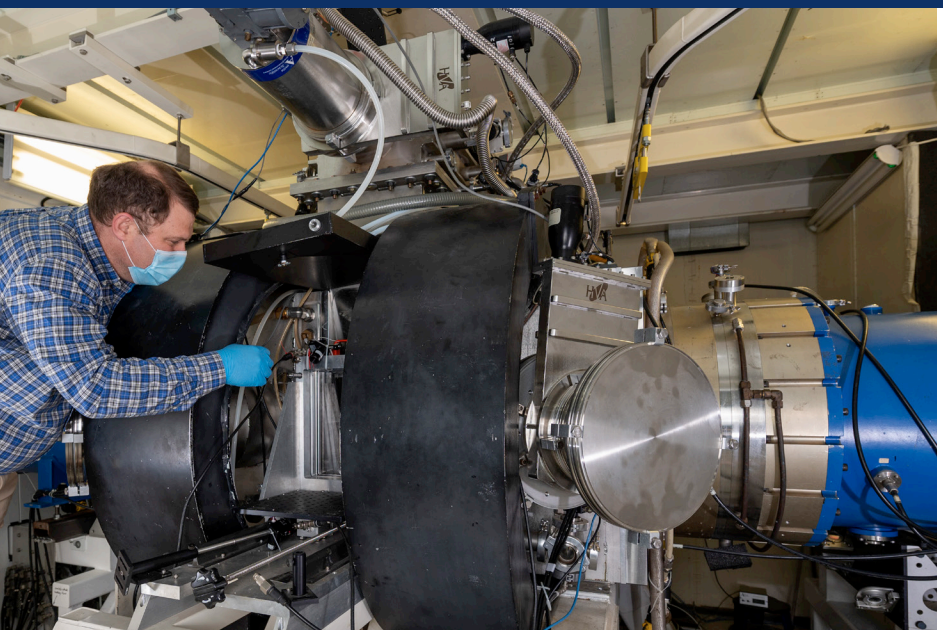
The team deployed two underwater echo sounders and flew over the same area with the new airborne lidar system. The system was built with internal NRL basic research funding and is also a technology demonstrator for Josset's Office of Naval Research CubeSat and the Bureau of Safety and Environmental Enforcement's oil projects.

"The goal is to test a small lidar that can provide high-resolution measurements of the ocean's physical properties and of oil thickness, in case of oil spills," Josset said.

"By improving the ability to characterize bubbly surfaces, improvements to ocean modeling and acoustic simulation can be achieved, as propagation can be significantly impacted by rough, bubbly ocean surfaces," Josset said.

Damien Josset and Stephen Sova from the U.S. Naval Research Laboratory's Ocean Sciences Division integrate NRL's lidar system on Jan. 12, 2021, prior to departing for Homer, Alaska. NRL's lidar is an airborne system designed to be mounted on the Twin Otter's nadir port. (U.S. Navy photo by Damien Josset)

U.S. Naval Research Laboratory researchers Damien Josset, Ph.D., who is an NRL oceanographer, Stephen Sova, and Stephanie Cayula, an NRL physical scientist from the laboratory's Ocean Sciences Division, prepare to conduct airborne lidar research in Homer, Alaska, on Jan. 26, 2021. (U.S. Navy photo by Damien Josset)



The Race Is On: NRL Argon Fluoride Laser to Advance Fusion Energy

Matthew Wolford, a U.S. Naval Research Laboratory research chemist, inspects the Electra argon fluoride (ArF) laser. The ArF laser is the shortest-wavelength laser (193 nm) that can scale to the high energies and power needed for laser fusion. Electra has demonstrated the world's highest-energy ArF laser and is providing the technical and scientific basis for constructing larger systems. (U.S. Navy photo by Jonathan Steffen)

U.S. Naval Research Laboratory experts race toward sustainable clean energy with advances in fusion energy. Steve Obenschain, Ph.D., a research physicist at NRL, said nuclear fusion would be a valuable addition to clean energy sources because it can provide baseload electrical power when the sun does not shine and the wind does not blow. The baseload is the minimum level of demand on an electrical grid over a span of time, for example, one week.

Scientists at NRL, in collaboration with the U.S. Department of Energy, published their argon fluoride (ArF) laser fusion research findings in the Philosophical Transactions of the Royal Society last fall.

The scientific paper, "Direct drive with the argon fluoride laser as a path to high fusion gain with sub-megajoule laser energy," reports ArF is a promising technology for achieving the high-gain inertial fusion implosions needed for energy production. Laser fusion involves the implosion of small capsules to achieve the high densities and temperatures (100 million degrees Celsius) required to initiate the fusion reactions.

If the fusion energy gain is much larger than that required to power the laser, one can use this as a power source. NRL simulations indicate ArF's deep ultraviolet light could enable high gain at much lower laser energy than previously thought feasible.

"The ArF laser could enable development and construction of much smaller, lower-cost fusion power plants," Obenschain said. "This would hasten the deployment of this attractive power source with enough fuel feedstock readily available to last thousands of years."

The NRL result is particularly important because the Lawrence Livermore National Laboratory National Ignition Facility (NIF) announced Aug. 8 it had performed a laser fusion experiment that yielded almost as much fusion energy as that of the laser beams used to drive the implosion. The NIF result yielded 1.3 megajoules of fusion energy, equivalent to one pound of high explosive, thereby demonstrating the basic scientific and technical feasibility of laser fusion.

"The NIF result is impressive and highlights the need to look ahead to what laser technologies will accelerate future progress. The NRL ArF laser technology provides a path to much higher fusion gain and yields," Obenschain said. "These qualities are needed for the National Nuclear Security Administration's stockpile stewardship program and the high gain is needed for fusion power."

High-energy ArF lasers will require a significant investment to reach the performance required for fusion and the energy, repetition rate, precision and billion-shot class reliability necessary for a commercial power plant, Obenschain noted. "Our work so far indicates there is no fundamental obstacle preventing an ArF direct-drive inertial fusion energy system from meeting these requirements," Obenschain said. "The advantages could facilitate the development of modest-size, less-expensive fusion power plant modules operating at laser energies less than 1 megajoule," he said. "That would drastically change the existing view on laser fusion energy being too expensive and power plants being too large."

GaN Wide-Bandgap Semiconductor Enabling 1,200-V-and-Beyond Power Switches Now Commercially Available for 200 mm Large-Scale Manufacturing

Cem Basceri, president and CEO of QROMIS, displays a 200-mm-diameter, 650V, E-mode gallium nitride (GaN) discrete power device wafer on a QST® (QROMIS Substrate Technology) substrate. (Courtesy photo by QROMIS)

The U.S. Naval Research Laboratory's gallium nitride (GaN) wafers, also called large-area engineered substrates, can enable GaN to potentially be a displacement technology for silicon semiconductors used in microelectronics, particularly in power electronics.

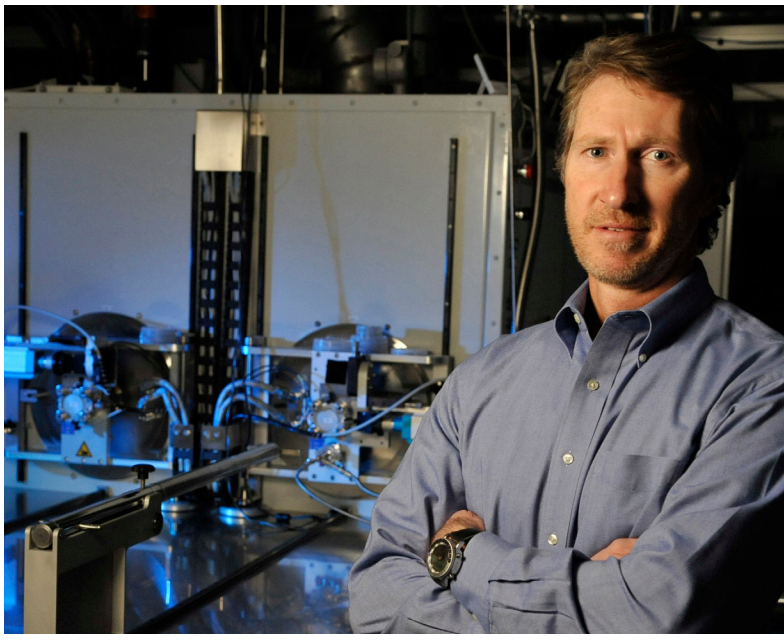
A typical substrate in microelectronics is a thin semiconductor crystalline disk, or wafer. An engineered substrate is a composite structure consisting of polycrystalline and crystalline layers that are optimized for a good thermal expansion and crystalline match to GaN. The excellent thermal expansion match permits thick GaN epitaxial layers, which has enabled 1,200-volts-and-beyond GaN power switches.

Karl Hobart and Francis "Fritz" Kub, both electrical engineers and heads of the High Power Devices Section and the High Power Electronics Branch at the U.S. Naval Research Laboratory, are the lead inventors for GaN engineered substrates.

"What's unique about GaN material is it's a wide-bandgap semiconductor, so it can support higher electric fields," Hobart said. "It is also a useful light emitter and a very fast switch for high-frequency applications, but we're more interested in high-voltage, high-electric-field devices."

The large GaN engineered substrate wafer diameter enables more viable GaN devices to be made per wafer, therefore leading to their manufacture at a lower cost.

The NRL Office of Technology Transfer, led by Amanda Horansky-McKinney and her team, fostered development and commercialization for this particular GaN technology. They were recognized in April with a 2021 Excellence in Technology Transfer Award from the Federal Laboratory Consortium.



Karl Hobart is an electrical engineer with the High Power Devices Section and the High Power Electronics Branch at the U.S. Naval Research Laboratory. (U.S. Navy photo)

Nicole Xu, Ph.D., is a U.S. Naval Research Laboratory Postdoctoral Research Associate from the Laboratories for Computational Physics & Fluid Dynamics.

NRL Designs Faster, More-Energy-Efficient Unpiloted Underwater Vehicles

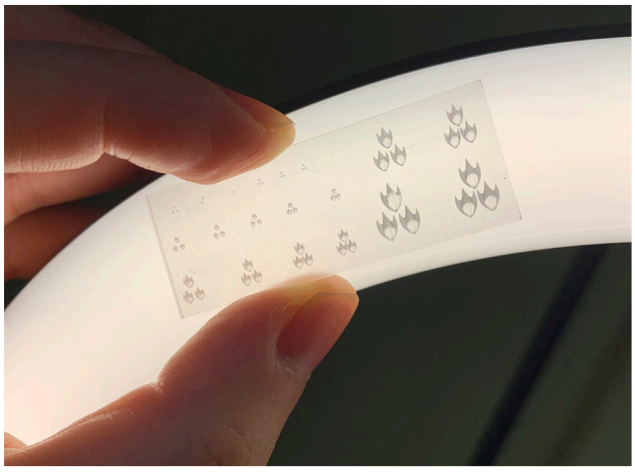
Nicole Xu, Ph.D., a U.S. Naval Research Laboratory (NRL) Postdoctoral Research Associate from the Laboratories for Computational Physics & Fluid Dynamics, designs faster and more-energy-efficient underwater vehicles using bioinspired shark skin-like surfaces.

"Shark skin comprises arrays of teeth-like denticle structures, which contribute to fast and stealthy swimming by turbulent drag reduction," Xu said. She began her NRL postdoctoral associateship in January 2021.

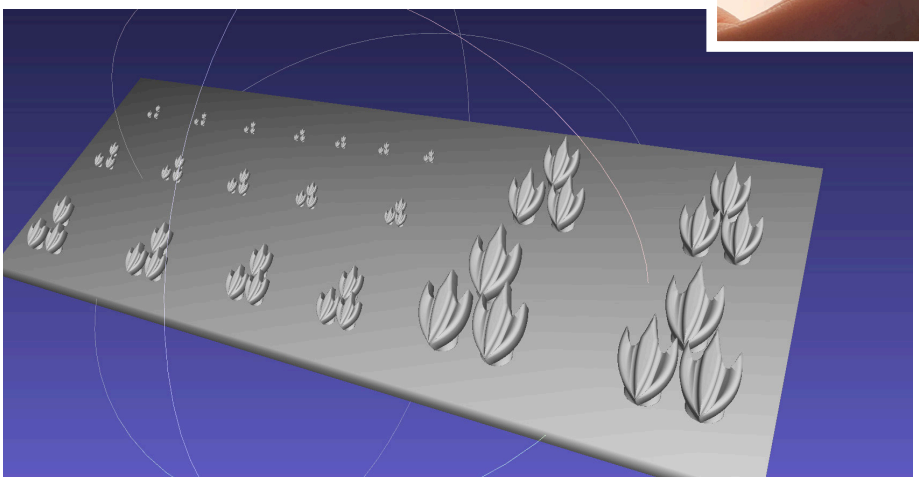
"Xu has demonstrated extraordinary motivation and initiative, as well as technical expertise in the area of unpiloted systems research," said Jason Geder, an NRL aerospace engineer who is Xu's mentor.

Xu's goal is to test these bioinspired surfaces on hydrofoils in flow channels before implementing the skins onto unpiloted underwater vehicles (UUV), such as the NRL-developed WANDA UUV and other traditional underwater vehicles.

"Because the denticles possess complicated microstructures, I am currently testing 3D-printing capabilities and designing the foils to conduct our initial experiments in a water tunnel," Xu said.



Nicole Xu displays 3D-printed shark skin-inspired surfaces comprising various sized denticle structures to conduct initial experiments in a water tunnel.



A computer-aided design (CAD) of a shark skin-inspired surface comprising various sized denticle structures developed by Nicole is displayed. (Drawing provided by NRL Laboratories for Computational Physics & Fluid Dynamics)

NRL's Hybrid Tiger UAV Soars at Demonstration

U.S. Naval Research Laboratory aerospace engineers carry Hybrid Tiger, an electric unmanned aerial vehicle with multiday-endurance flight capability, to the launch location at Aberdeen Proving Ground in Maryland on Nov. 18, 2020. The Hybrid Tiger team is integrating technologies developed in prior NRL power and energy programs into a single UAV to achieve multiday endurance with a Group 2 UAV. (U.S. Navy photo by Jonathan Steffen)

U.S. Naval Research Laboratory engineers recently demonstrated Hybrid Tiger, an electric unmanned aerial vehicle (UAV) with multiday-endurance flight capability, at Aberdeen Proving Ground, Maryland.

The team integrated technologies developed in prior NRL power and energy programs into a single UAV to achieve multiday endurance with a Group 2 UAV. Group 2 UAVs are typically in the 21-to-55-pound weight class and normally operate below 3,500 feet above ground level at speeds less than 250 knots.

This was the first time Hybrid Tiger flew through a complete 24-hour period, its longest flight to date.

"Extrapolating the flight endurance of Hybrid Tiger from the recent flight data suggests it can reach the program goal flight endurance," said Richard Stroman, Ph.D., a mechanical engineer from the NRL Chemistry Division. "The results validated our extensive simulation efforts, because the flight endurance is almost exactly what was predicted by our simulation."

U.S. Naval Research Laboratory aerospace engineers Mike Schuette, Trent Young, and Sam Carter prepare the horizontal tail for the Hybrid Tiger Unmanned Aerial Vehicle flight demonstration at Aberdeen Proving Ground in Maryland on Nov. 18, 2020. (U.S. Navy photo by Jonathan Steffen)

NRL Demonstrating Advanced Distributed Radar Concepts with FlexDAR

The U.S. Naval Research Laboratory (NRL) completed the installation of the Flexible Distributed Array Radar (FlexDAR) earlier this year and began demonstrations with nodes operating at the NRL Chesapeake Bay Detachment in Maryland and at the NASA Wallops Flight Facility in Virginia.

The FlexDAR concept was conceived by NRL to demonstrate new and advanced capabilities enabled by the implementation of every-element digital beamforming (EEDBF) antenna arrays combined with network coordination and precise time synchronization. EEDBF is an emerging technology that provides a huge leap in antenna capabilities that, when combined with network coordination and precise time synchronization, enables new and advanced radar capabilities. This, along with flexible digital processing, offers a number of attractive features well beyond the capabilities of conventional arrays and radar systems.

FlexDAR demonstrates dramatic performance improvements in detection range, tracking accuracy, and electronic protection when operated in a distributed configuration. Each radar incorporates every-element digital transmit and receive beamforming, which enables multiple simultaneous full-gain receive beams within each radar's field of view. Each radar operates at S-band and consists of 1,008 elements.

Both FlexDAR systems are now operational and will allow the full capability of the FlexDAR concept to be developed and demonstrated over the coming months and years. The FlexDAR system represents the state of the art in distributed radar technology.

NRL engineers and scientists led the development of the technical aspects of the FlexDAR program. Requirements for the arrays were developed by the NRL team, and Raytheon Integrated Defense Systems, now known as Raytheon Technologies, won the competition to build the two arrays. NRL personnel designed and implemented the radar signal-processing and tracking algorithms, the network coordination techniques, and an advanced graphical user interface, referred to as the FlexDAR Back-End (FBE).

Raytheon produced, integrated, and tested two phased-array FlexDAR Front-End (FFE) subsystems based on the NRL requirements. The FFE implements EEDBF and is integrated with the FBE using only a few high-speed fiber-optic Ethernet connections and a single analog signal to provide a common clock. The FBE and the FFE are built using open standards and form just one possible configuration of this fully-software-defined platform.

The NRL-and-Raytheon team integrated the systems and have verified many of the key capabilities of FlexDAR including low antenna side lobe levels, multiple simultaneous and independent receive beams, multiple simultaneous subapertures, distributed-radar tracking, and data throughput.

Verification of capabilities is ongoing, and the testbed will support continued development and demonstration of advanced distributed-radar concepts.

The Office of Naval Research sponsored the FlexDAR program as part of the Integrated Topside and Electromagnetic Maneuver Warfare Command and Control Innovative Naval Prototype (INP) programs. ONR INPs develop higher-risk technologies that offer potential leap-ahead capabilities, but do so ahead of formal naval requirements.

The program was a collaboration with the NRL Radar and Information Technology divisions and Raytheon Technologies.

The solar corona is viewed in white light during the total solar eclipse on Aug. 21, 2017, from Mitchell, Oregon. The Moon blocks out the central part of the Sun, allowing the tenuous outer regions to be seen in full detail. The image is courtesy of Benjamin Boe and first was published in "CME-induced Thermodynamic Changes in the Corona as Inferred from Fe XI and Fe XIV Emission Observations during the 2017 August 21 Total Solar Eclipse", Boe, Habbal, Druckmüller, Ding, Hodérova, & Štarha, Astrophysical Journal, 888, 100, (Jan. 10, 2020). (Photo by AAS)

Astrophysicist's 2004 Theory Confirmed Why the Sun's Composition Varies

About 17 years ago, J. Martin Laming, an astrophysicist at the U.S. Naval Research Laboratory, theorized why the chemical composition of the Sun's tenuous outermost layer differs from that lower down. His theory has recently been validated by combined observations of the Sun's magnetic waves from the Earth and from space.

His most recent scientific journal article describes how these magnetic waves modify chemical composition in a process completely new to solar physics or astrophysics, but already known in optical sciences, having been the subject of Nobel Prizes awarded to Steven Chu in 1997 and Arthur Ashkin in 2018.

Laming began exploring these phenomena in the mid-1990s and first published the theory in 2004.

"It's satisfying to learn that the new observations demonstrate what happens "under the hood" in the theory, and that it actually happens for real on the Sun," he said.

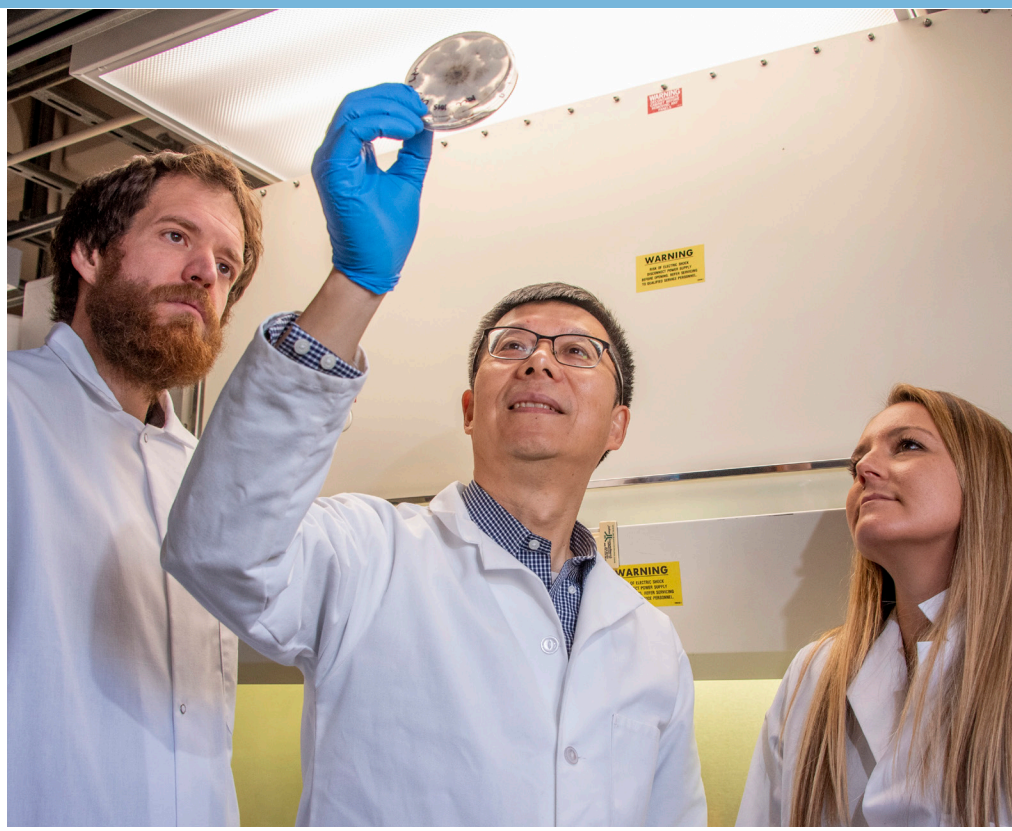
Christoph Englert, head of the U.S. Naval Research Laboratory's Space Science Division, points out the benefits for predicting the Sun's weather and how Laming's theory could help predict changes in our ability to communicate on Earth.

"We estimate that the Sun is 91 percent hydrogen, but the small fraction accounted for by minor ions like iron, silicon, or magnesium dominates the radiative output in ultraviolet and X-rays from the corona," he said. "If the abundance of these ions is changing, the radiative output changes."

"What happens on the Sun has significant effects on the Earth's upper atmosphere, which is important for communication and radar technologies that rely on over-the-horizon or ground-to-space radio frequency propagation," Englert said.

It also has an impact on objects in orbit. The radiation is absorbed in the Earth's upper atmospheric layers, which causes the upper atmosphere to form plasma, and the ionosphere, and to expand and contract, influencing the atmospheric drag on satellites and orbital debris.

Researchers Prepare to Send Fungi for a Ride Around the Moon



From left, Drs. Zachary Schultzhaus, Zheng Wang, and Jillian Romsdahl from the U.S. Naval Research Laboratory's fungal biology research team observe a fungal agar plate in Washington, D.C., on Nov. 13, 2019. The fungus Aspergillus niger and three of its mutant strains were slated to orbit the Moon on NASA's Orion Space Capsule in 2021 so researchers can improve their understanding of the fungi's natural and adapted defenses against radiation. (U.S. Navy photo by Sarah Peterson)

Microbiologists at the U.S. Naval Research Laboratory are preparing experimental samples of fungi to send for a ride around the moon tentatively scheduled for late in 2021 or early 2022.

The experiment aims to provide insight into the fungi's natural defenses against radiation, a phenomenon that could prove useful for future space exploration and sustained life in space.

"During this past year, we successfully completed the scientific verification test to ensure the experiment is working in our lab, which is the first step of this project," said Zheng Wang, an NRL microbiologist who is the principal investigator on this project. "Additionally, since October 2020, we have accomplished an experimental verification test at Kennedy Space Center, which mimics the flight environment for about two months."

Fungi have natural mechanisms to protect against and repair DNA damage caused by radiation. Those mechanisms enable the fungi to withstand several hundred times more radiation than humans. This experiment will study the melanin in fungi (which may assist in protecting them from damage), as well as DNA repair pathways (which repair damage once it occurs). The fungus used for this experiment will be Aspergillus niger, a black mold commonly used in laboratories and industry that also is one of the predominant fungi detected on the International Space Station (ISS).

"We are looking at fungi that are extremely resistant to radiation and trying to figure out why," said Jillian Romsdahl, a microbiologist and NRC postdoctoral fellow on the project. "But we are also looking at a bigger question of how biological systems adapt to deep space, which has implications for people trying to travel to Mars or further."

In the long term, researchers hope to use the knowledge gained to investigate new ways to prevent radiation damage to humans and equipment in space.

The NRL team is investigating these research questions from other angles as well. Wang's research group was recently selected by NASA to study how melanized fungal cells adapt to Mars-like conditions using NASA's Antarctic balloon platform. The team is also collaborating with DoD's Space Testing Program and the ISS National Laboratory to send fungal samples to the ISS to study how microgravity and radiation alter production of beneficial biomaterials and biomolecules.

NRL's work on investigating the roles of melanin and DNA repair on adaptation and survivability of fungi in deep space is funded by NASA and is scheduled to continue through 2022.

Adding Predictability to Fleet Communications During Solar Flares

A U.S. Navy destroyer is operating in the western Pacific Ocean and is impacted by the effects of a massive solar flare. This event has caused a ripple effect across the globe, impacting power grids, destroying electrical infrastructure, and causing havoc to electronic communications. Our ship's captain wonders how long this will last.

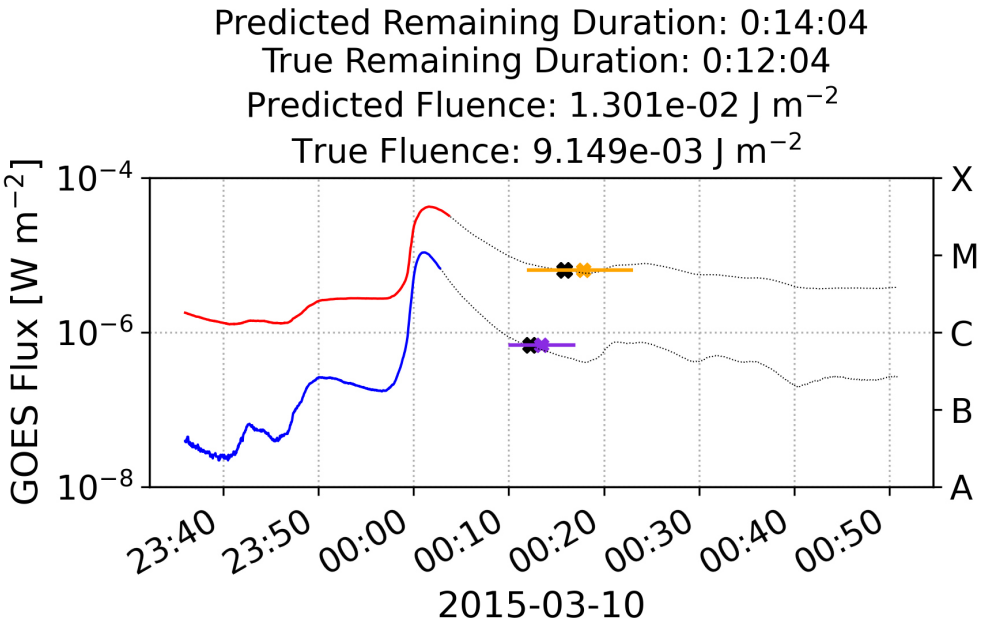
Jeffrey Reep published a paper titled "Forecasting the Remaining Duration of an Ongoing Solar Flare." In this work, Reep developed a method using a machine-learning algorithm that would allow some prediction to the fleet for how long a flare might actually last.

"I study solar flares and I spent my career modeling them," Reep said. "We generally think of flares in terms of their size or their brightness, but we often ignore the part about their duration."

Solar flares, from the Navy's perspective, impact operations due to disturbances in the ionosphere, home to virtually all the charged particles in Earth's atmosphere, right at the edge of space, forming the boundary between Earth's lower atmosphere, where we live and breathe, and the vacuum of space. Ionospheric disturbances change the propagation of radio signals in the upper atmosphere, an effect that is familiar to radio operators around the world.

"This paper itself is a proof of concept. It's not a developed model that can go on a Navy ship right now," Reep said. "The challenge is acquiring all the data in real time so we can have a functional model that's constantly running, and when a flare goes off, it can make a real-time prediction. We still have a few roadblocks to get past."

The Living With a Star (LWS) program targets specific aspects of the Sun-Earth system that affect life and society. LWS provides a predictive understanding of the Sun-Earth system, linkages among the interconnected systems, and, specifically, space weather conditions at Earth and the interplanetary medium



This is a prediction the model makes for a medium-sized solar flare, predictions for two X-ray pass-bands in orange/violet compared to the true values in black. This modeling could lead to forecasting in real time, providing some prediction to the fleet for how long a flare might actually last. (U.S Navy graphic provided by Jeff Reep, Ph.D., U.S. Naval Research Laboratory)

Peering Through the Clouds of Earth's 'Evil Twin' Surprises NRL Sky Watchers

When flying past Venus in July 2020, Parker Solar Probe's WISPR instrument, short for Wide-field Imager for Parker Solar Probe, detected a bright rim around the edge of the planet that may be nightglow — light emitted by oxygen atoms high in the atmosphere that recombine into molecules in the night side. The prominent, dark feature in the center of the image is Aphrodite Terra, the largest highland region on the Venusian surface. Bright streaks in WISPR, such as the ones seen here, are typically caused by a combination of charged particles — called cosmic rays — sunlight reflected by grains of space dust, and particles of material expelled from the spacecraft's structures after impact with those dust grains. The number of streaks varies along the orbit or when the spacecraft is traveling at different speeds, and scientists are still in discussion about the specific origins of the streaks here. The dark spot appearing on the lower portion of Venus is an artifact from the WISPR instrument. (Photo by NASA/Johns Hopkins APL/Naval Research Laboratory/Guillermo Stenborg and Brendan Gallagher)

U.S. Naval Research Laboratory scientists were left scratching their heads recently over a familiar sight in the sky. Images of Venus are nothing new, but a solar probe surprised the researchers by seeing through the planet's clouds. NRL's Wide-field Imager for Parker Solar Probe (WISPR) took a stunning image of Earth's celestial neighbor last year that left researchers searching for answers as to how what they were seeing was possible. Expecting to see just the featureless Venusian clouds, the NRL WISPR team instead were shocked at what they saw.

"The puzzling part is, we expected to primarily image the Venusian clouds, but instead, WISPR was able to peer through the clouds to image the surface," said Mark Linton, Ph.D., who works in NRL's Heliophysics Theory and Modeling Section. "On the one hand, WISPR is very sensitive to visible light. With visible, we expect only to see clouds; on the other hand, WISPR is much less sensitive to infrared light, but the infrared emission from the surface is readily transferred through the clouds."

Venus, sometimes called Earth's "evil twin," as both planets are about the same size, is beset with a poisonous carbon dioxide atmosphere and a surface temperature of 878 degrees Fahrenheit (470 degrees Celsius), hot enough to melt lead.

WISPR is the only imaging instrument on the NASA Parker Solar Probe mission and was designed at NRL. WISPR records visible light images of the solar corona and the heliosphere, the vast, bubble-like region of space that surrounds and is created by the sun with a pair of overlapping cameras.

The instrument captured the image of the Venus's night side from a distance of 7,693 miles (12,380 kilometers) on July 11, 2020, during the mission's third gravity assist of the hot, hellish, and volcanic planet, whose surface shows up as the light and dark features in this image. The large, dark features are the mountains of Aphrodite Terra, a highland region about half the size of Africa, located near the planet's equator.

In February 2021, WISPR completed its fourth Venus fly-by, a maneuver that uses the planet's gravity to pull the probe closer to the Sun. During its last two orbits around the Sun, its closest approach reached down to 8,400,000 miles above the Sun's surface.

WISPR was set to come even closer to the Sun. Its next close approach was scheduled for April 29, 2021, at which time it was to reach just shy of 6,500,000 miles from the Sun's surface.

SoloHI Imager Captures Rare Shot of Venus, Earth, Mars, and Uranus

The Heliospheric Imager (SoloHI) camera aboard ESA/NASA's Solar Orbiter spacecraft captured four solar system planets. This image from video shows Venus, the brightest object in the video, roughly 30 million miles (48 million kilometers) from Solar Orbiter. The spacecraft was 156 million miles (251 million kilometers) from Earth and 206 million miles (332 million kilometers) from Mars on that day. Uranus was confirmed later at 1.7 billion miles (2.7 billion kilometers) from the orbiter. The Sun is located on the right, outside the video frame.

The European Space Agency's (ESA) and NASA's Solar Orbiter Heliospheric Imager (SoloHI) recorded an image showing three of the four inner rocky planets on Nov. 18, 2020.

The image captured more than the local neighborhood; it also captured the ice giant Uranus, which was more than 1.7 billion miles (2.7 billion kilometers) from the orbiter.

The original video clearly shows Venus, Earth, and Mars moving against the stellar background as the spacecraft and the planets moved along their orbits. It was not until ESA/NASA posted the imagery and the video online that celestial detectives worldwide posed the question of whether Uranus also was captured in the footage.

"We commonly observe multiple planets in NRL's other space-based instruments that are near Earth," said Robin Colaninno, Ph.D., at U.S. Naval Research Laboratory's SoloHI principal investigator. "We did take an image of Earth with the WISPR instrument on the Parker Solar Probe. However, Solar Orbiter is far away from Earth, so it is rare to have a picture with Earth and other planets."

NRL's SoloHI camera is the heliospheric imager for the ESA and NASA Solar Orbiter. The mission provides unique observations of heliospheric plasmas, determining the 3D electron density and the velocity structure of the inner heliosphere and how it spreads out to one astronomical unit (AU), about 93 million miles (150 million kilometers) from the Sun.

"SoloHI is designed to look at the solar wind and coronal mass ejections far away from the Sun," Colaninno said. "We were not expecting to see the planets in this data, so it is a nice surprise."

Solar Orbiter is a collaboration of 20 countries for a payload of 10 scientific instruments. While NASA provided other instrument components, SoloHI is the only wholly American instrument aboard. The heliographic imager, a specialized camera that captured the celestial neighbors, was developed at NRL.

Solar Orbiter was launched in February 2020 and released its first images five months later, the closest-ever pictures of the Sun taken to this date. Currently, as it spirals closer inward, the equipment on board continues to be fine-tuned before beginning routine operations in November 2021. Solar Orbiter was on its way to Venus for its first gravity assist fly-bys when the recording was captured. These fly-bys of Venus and Earth help bring the spacecraft closer to the Sun and tilt its orbit to observe the Sun from different viewpoints.

Kai Noeske, Ph.D., the ESA Science Programme communication officer, summed it up by saying, "It's quite a unique perspective to ride along on a spacecraft on its way through the inner solar system, traveling to never before visited vantage points of the Sun, looking at the different worlds, including the one we call home."

PROTEUS Provides Global Maritime Domain Awareness

The U.S. Naval Research Laboratory launched its PROTEUS pilot project in early June and invited multiple government and private agencies to try the integrated system of maritime domain awareness capabilities. The pilot is scheduled for multiple months.

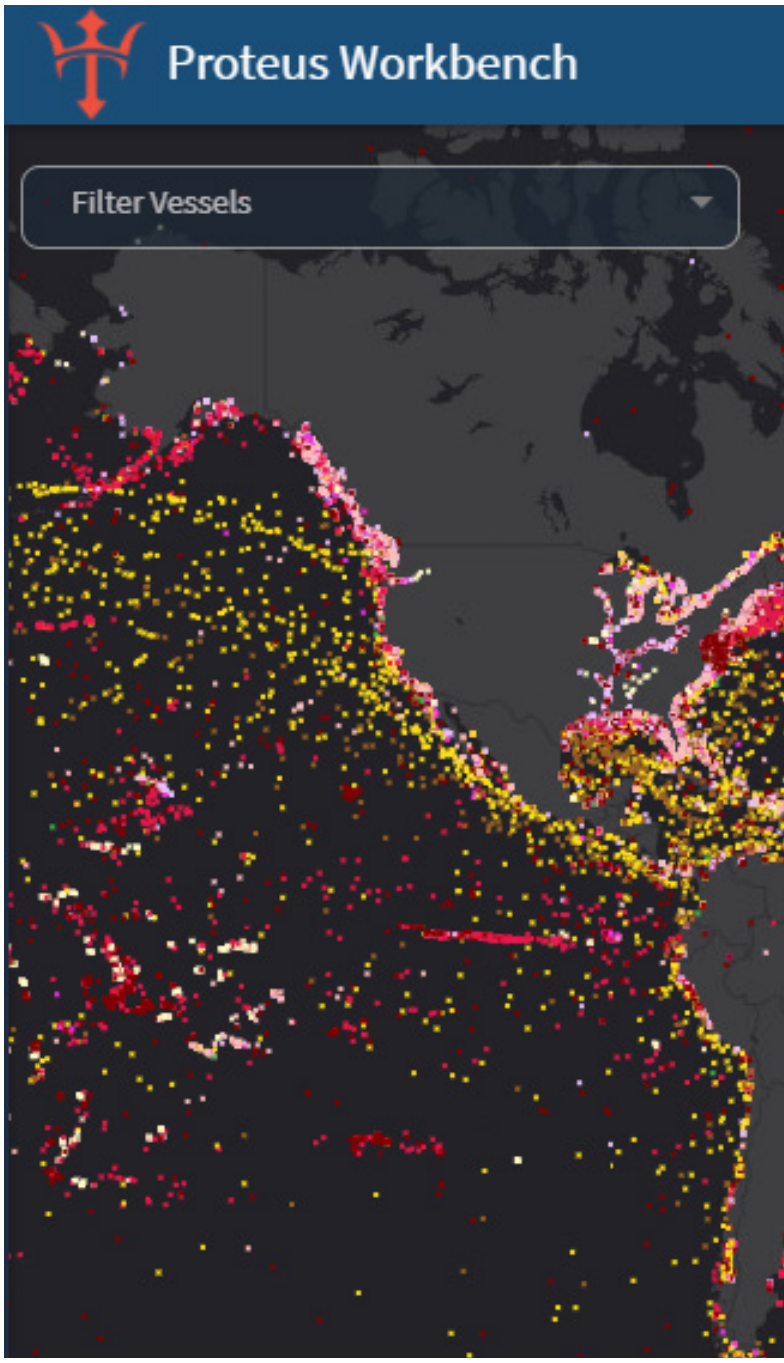
PROTEUS is used to identify, query, and filter maritime vessels based on user-defined criteria and provides near-real-time global maritime situational awareness.

This is accomplished by supplying multisource data-ingestion and -fusion services and automatically generating and maintaining worldwide vessel tracks. The PROTEUS system comprises a data collector and aggregator, a multisource data-fusion engine, a complex event processor, a maritime domain awareness services layer, a web-based common operating picture, and analytic tools.

"Understanding the global maritime domain is a complex and challenging undertaking," said Alan Hope, the PROTEUS program manager at NRL. "PROTEUS is needed to protect our vulnerable maritime borders from illicit activity as to well as support international efforts against illegal fishing and human trafficking."

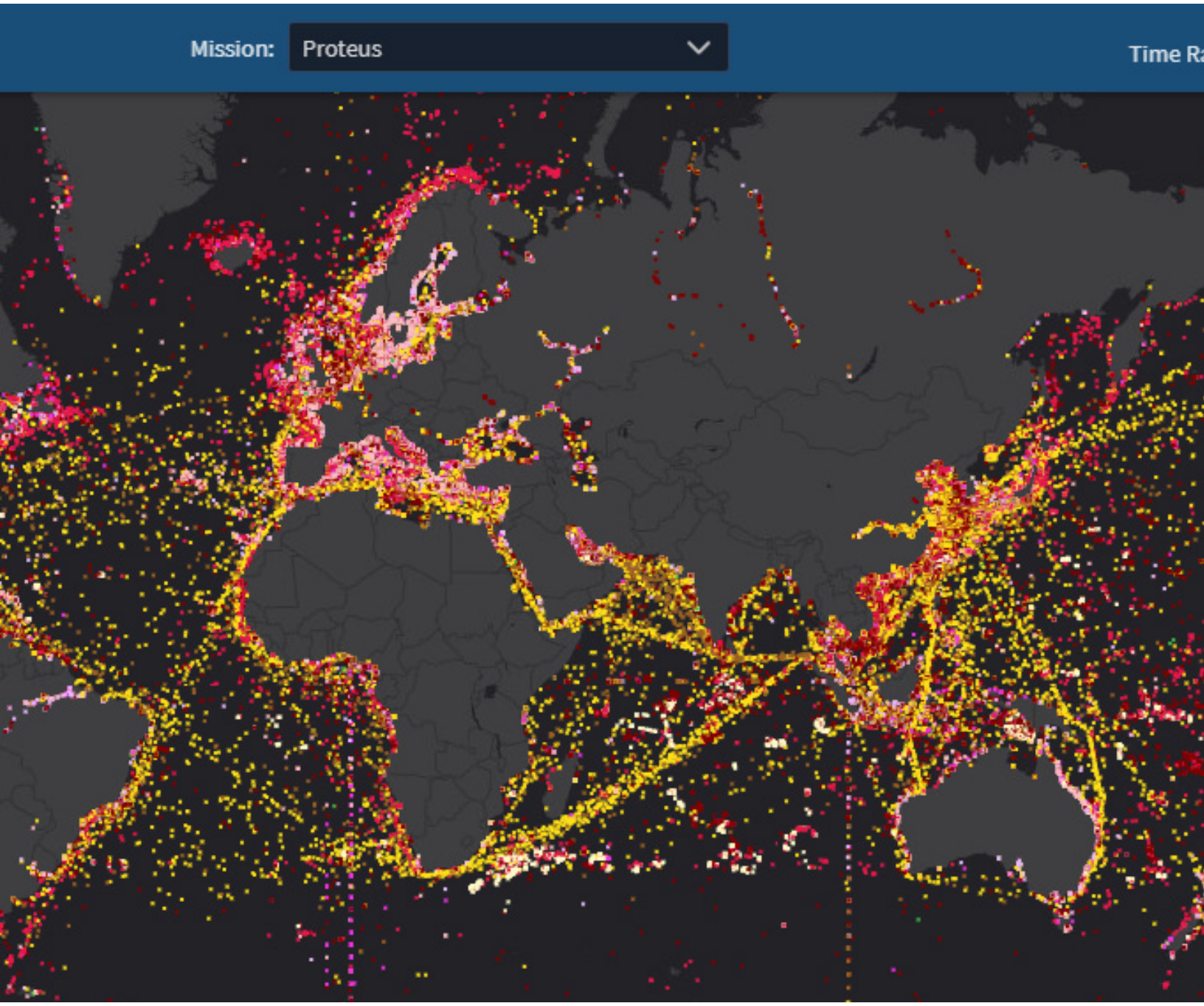
Currently, Customs and Border Protection's Homeland Security Investigations, the US Coast Guard, the Department of Transportation's Maritime Administration, and NOAA's Offices of Law Enforcement and Marine Sanctuaries utilize the PROTEUS pilot program. State and local law enforcement agencies such as the Delaware Information and Analysis Center and the Orange County Intelligence Assessment Center (CA) are also using PROTEUS in support of their work in the maritime domain.

"PROTEUS is an exciting, new U.S. government maritime domain awareness (MDA) system providing a powerful array of MDA information and analysis tools," said Cameron Naron, director of maritime security for the US Maritime Administration. "This system enables MDA stakeholders to collaboratively discover and investigate suspicious and illegal maritime activity throughout the world in ways never before possible."



PROTEUS software monitors sea vessels in real time on July 12, 2021. PROTEUS identifies, queries, and filters vessels based on user-defined criteria and provides near-real-time global maritime situational awareness. (U.S. Navy image)

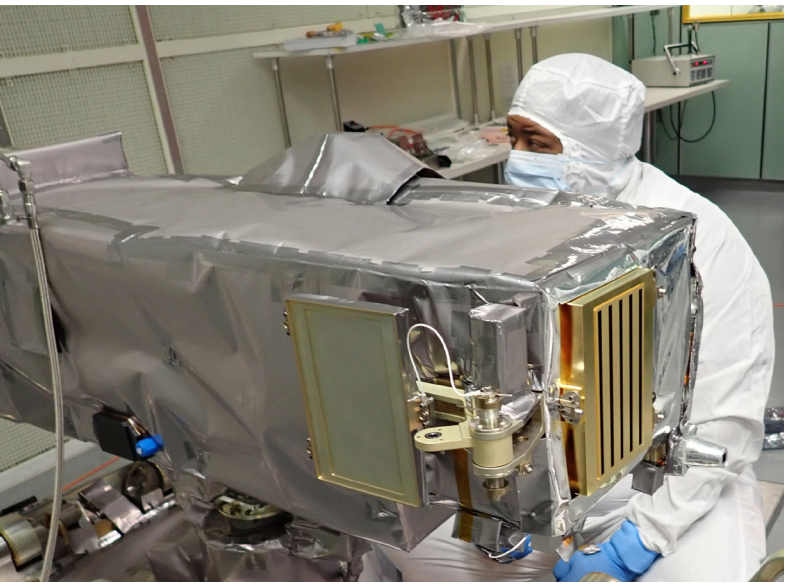
"NRL is pleased to have multiple agencies from the maritime domain using PROTEUS to assist them in their operational mission areas," Hope said. "Moreover, I think there are even more federal, state and local government agencies that can benefit from integrating PROTEUS into their operations."



Additional actions supported by PROTEUS include:

- Countering illegal, unreported, and unregulated fishing (IUUF)
- Safeguarding maritime protected areas (MPAs)
- Search and rescue (SAR)
- Critical infrastructure protection
- Environmental protection and response
- Maritime law enforcement
- Countering smuggling (drugs, weapons, money, people)

NRL/NASA Experiment to Study Origins of Solar Energetic Particles



The UltraViolet Spectro-Coronagraph (UVSC) Pathfinder undergoes inspection after the successful completion of its thermal vacuum test at the U.S. Naval Research Laboratory. The front, gold-colored aperture shows the multiple external occulters that will block direct light from the solar disk. The occultation allows the faint solar corona to be observed at Lyman-alpha wavelengths. The UVSC instrument sits on a transport cart that is not part of the flight package. (U.S. Navy Photo)

A joint-U.S. Naval Research Laboratory/NASA experiment prepares to investigate the origins of solar energetic particles (SEPs) that could affect Navy satellites and could harm personnel during future crewed missions to the moon and beyond.

Researchers will use a new instrument, the Ultraviolet Spectro-Coronagraph Pathfinder (UVSC Pathfinder) to try to understand the origins of these particles and how they're generated close into the sun to provide accurate space weather forecasting when these events happen.

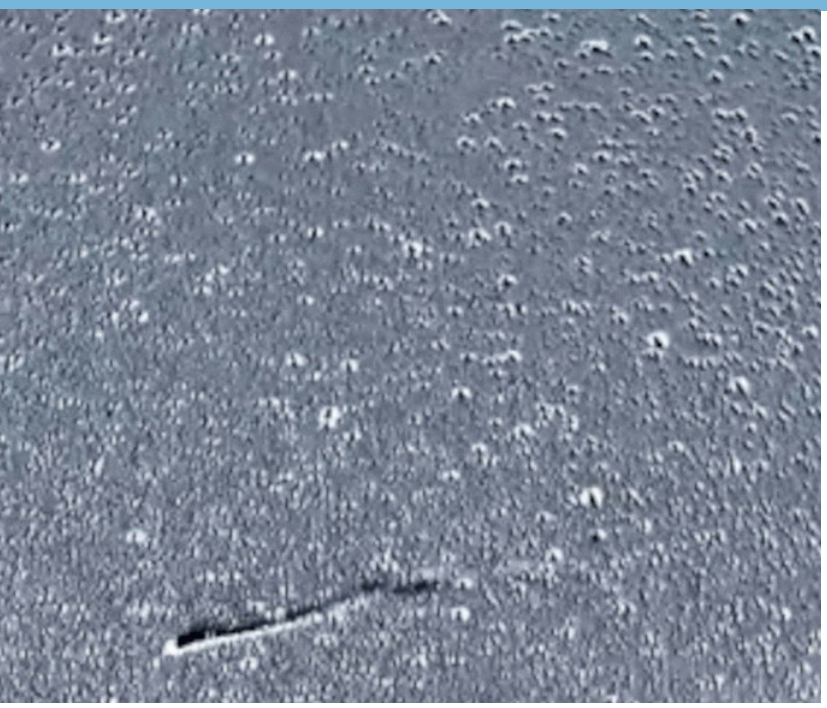
"These SEPs are the Sun's most dangerous form of radiation, and they pose a major challenge to space exploration," said Leonard Strachan Jr., Ph.D., an astrophysicist at NRL, and the mission's principal investigator. "These powerful particles can wreak havoc with spacecraft and expose astronauts to dangerous radiation."

UVSC Pathfinder will ride to space aboard Space Test Program Satellite (STPSat)-6, the primary spacecraft of the Space Test Program (STP)-3 mission for the Department of Defense. STP-3 was scheduled to lift off on Dec. 4, 2021, on a United Launch Alliance Atlas V 551 rocket from Cape Canaveral Space Force Station, Florida.

UVSC Pathfinder, as its name implies, is a pathfinder mission due to the new design of the coronagraph, which uses five separate apertures, each with its own occulter, that greatly improve the signal collected at the lowest regions of the Sun's corona, where the SEPs are first formed.

UVSC Pathfinder was designed and built at the U.S. Naval Research Laboratory and was funded through NASA's Heliophysics Program and the Office of Naval Research. It is managed by the Heliophysics Technology and Instrument Development for Science, or H-TIDeS, program office at NASA Headquarters. The Space Test Program office at Kirtland Air Force Base in Albuquerque, New Mexico, is part of the U.S. Space Force's Space Systems Command, headquartered at Los Angeles Air Force Base in El Segundo, California.

Northrop Grumman personnel examine the U.S. Space Force Space and Missile Systems Center's Space Test Program Satellite 6 (STPSat-6) at its facility in Dulles, Virginia, prior to its shipment to Florida for final launch processing. Seen on the front of the spacecraft is NASA's Laser Communications Relay Demonstration instrument, the first long-duration laser communications mission that will validate advanced relay operations for future missions. (Photo by Northrop Grumman)



NRL's SoloHi Catches Stunning Views of 'Christmas Comet' Leonard Fly-By

Comet Leonard is seen as captured by NASA's Solar Terrestrial Relations Observatory-A (STEREO) spacecraft, HI-2 telescope, which has watched the comet since early November 2021. This animated "difference image" was created by subtracting the current frame from the previous frame to highlight differences between them. Difference images are useful for seeing subtle changes in Leonard's ion tail (the trail of ionized gases streaming from the comet's body, or nucleus), which becomes longer and brighter toward the end of the clip.

Scientists at the U.S. Naval Research Laboratory evaluate early data the ESA/NASA Solar Orbiter spacecraft sent back to Earth as it observes comet Leonard, a mass of space dust, rock and ice just over half a mile (1 kilometer) across as it heads inbound to the Sun.

Imagery captured Dec. 17-19, 2021, by the NRL's Solar Orbiter Heliospheric Imager (SoloHI) aboard the ESA/NASA Solar Orbiter spacecraft shows comet Leonard streaking diagonally across the field of view. Planets Venus and Mercury are also visible in the top right, with Venus appearing brighter and moving from left to right.

"When SoloHI recorded these images, the comet was approximately between the Sun and the spacecraft, with its gas (ion) and dust tails pointing towards the spacecraft," said Karl Battams, Ph.D., a computational scientist in NRL's Heliospheric Physics section. "Toward the end of the image sequence, our view of both of the tails improves as the viewing angle at which we see the comet increases, and SoloHI gets a side-on view of the comet."

"Many folks reported a significant brightening around the 14th (before the SoloHI images), and then a subsequent so-called "outburst" in the past 24 hours, with indeterminate behavior in the meantime," Battams said. "My suspicion is that the comet is increasingly unhappy, and these outbursts could be the beginning of a slow and fatal disruption. But it's too early to say for sure — it could just be letting off steam, so to speak."

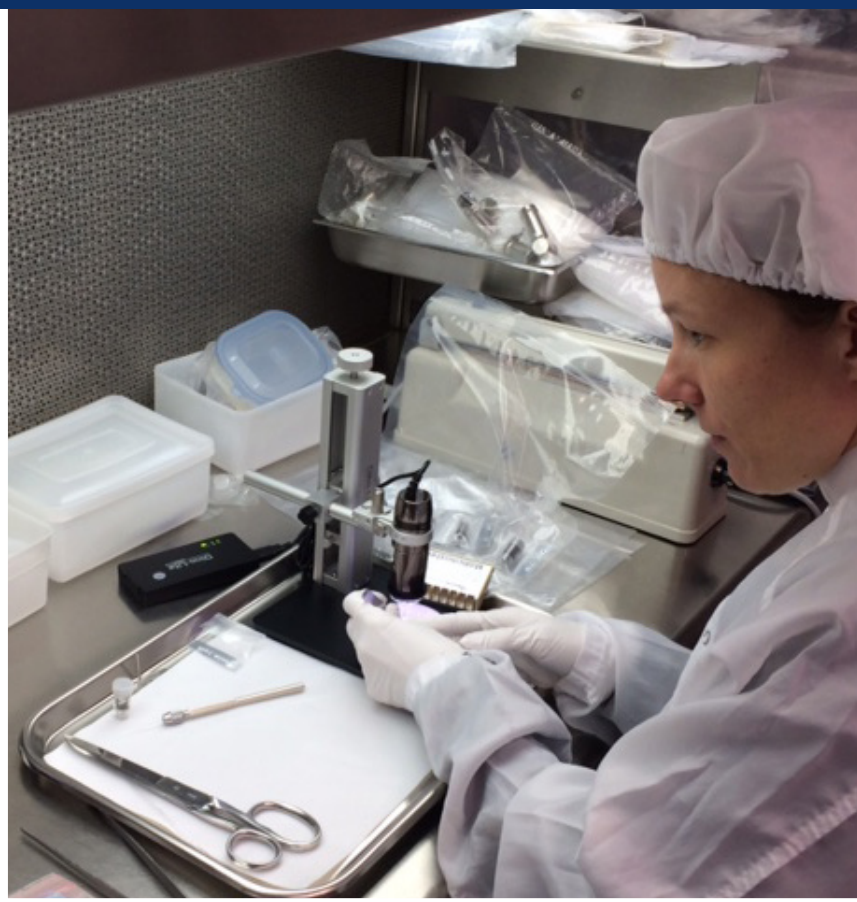
SoloHI was set to continue observing the comet until it leaves SoloHI's field of view on Dec. 22, 2021. Comet Leonard's closest pass on Jan. 3, 2022, will take it within 56 million miles (90 million kilometers) of the Sun, slightly more than half Earth's distance from the Sun. If it does not disintegrate, current calculations show that its path will send it out into interstellar space, never to return to our solar system.

Secrets Revealed in a Grain of Dust from the Moon Lead to Geologist's Award

Scientist-astronaut Harrison Schmitt, the Apollo 17 lunar module pilot, uses an adjustable sampling scoop to retrieve lunar samples while visiting the moon in 1972. U.S. Naval Research Laboratory geologist Kate Burgess used samples from the Apollo 17 mission during her microscopic research of what's inside tiny grains of moon dust. (Photo courtesy of NASA)

When you look at the moon looming over the Earth, especially a rising harvest moon blazing bright orange and red, you don't think about a tiny grain of dust up there.

But Kate Burgess does; she's studied dozens of lunar grains in her work as a geologist at the U.S. Naval Research Laboratory (NRL).



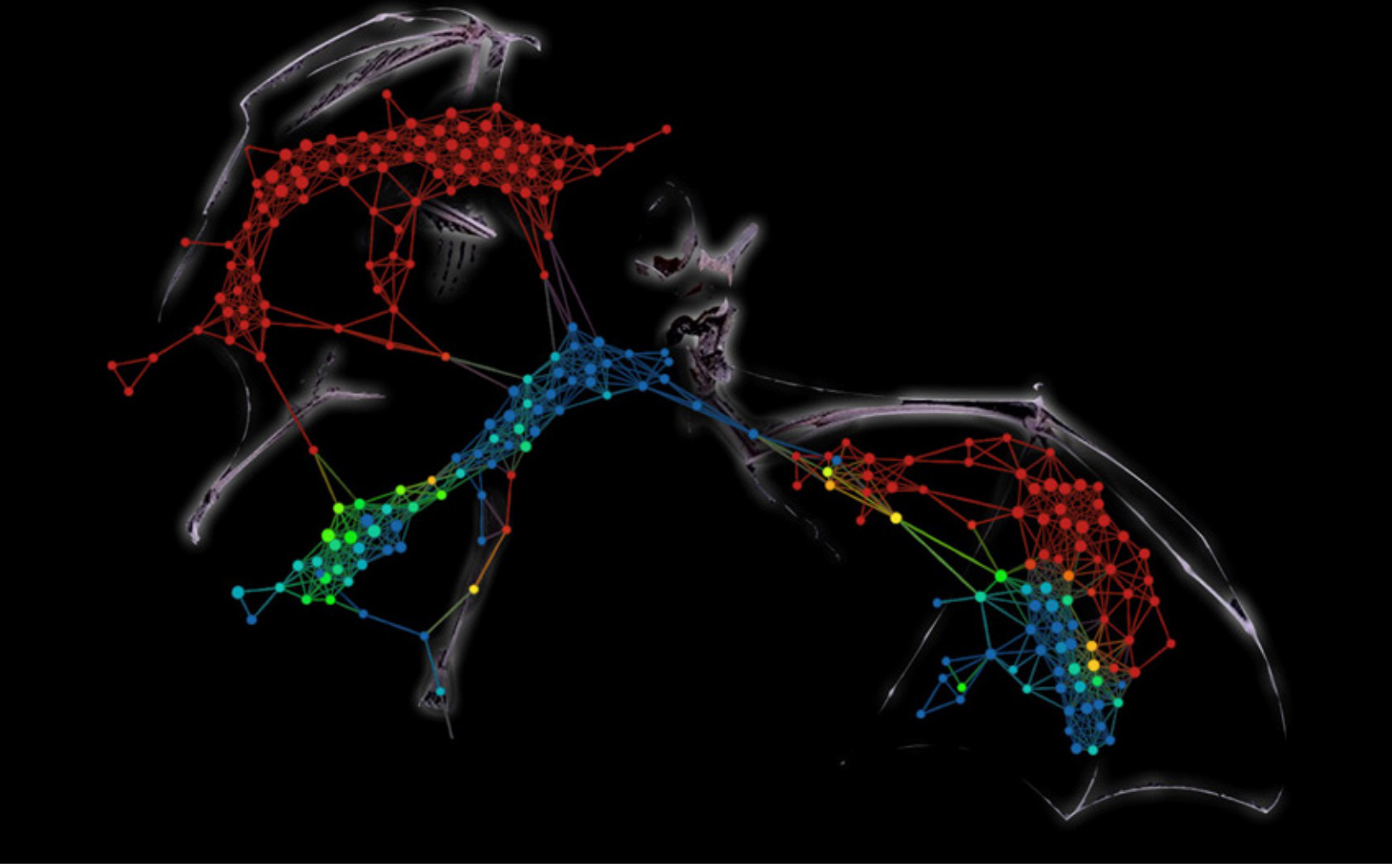
U.S. Naval Research Laboratory geologist Kate Burgess practices the manipulation of lunar samples using a digital microscope in the lab at NASA's Johnson Space Center in Houston. Burgess is receiving the Kurt F.J. Heinrich award from the Microanalysis Society for her work over the past decade. (Photo by Michelle Thompson)

"The idea that you can walk outside and see the moon and think, 'These are little particles of dust that used to be up there, and I get to work with them in my lab,'" Burgess said; "that's pretty cool."

Burgess was surprised to win the Heinrich award, which honors scientists for their work less than 15 years from receiving degrees in their fields and who have made distinguished technical contributions to the field of microanalysis. Burgess earned her doctorate in geology from Brown University in 2012 and began her postdoctoral work at NRL in 2014. She became part of the staff in 2017 and now works in NRL's Nanoscale Materials Section.

U.S. Naval Research Laboratory geologist Kate Burgess looks through a microscope at a meteorite sample at NASA's Johnson Space Center in Houston. (Photo by Michelle Thompson)

SAVVi NRL Research Team Receives Science & Technology Cooperation Commendation

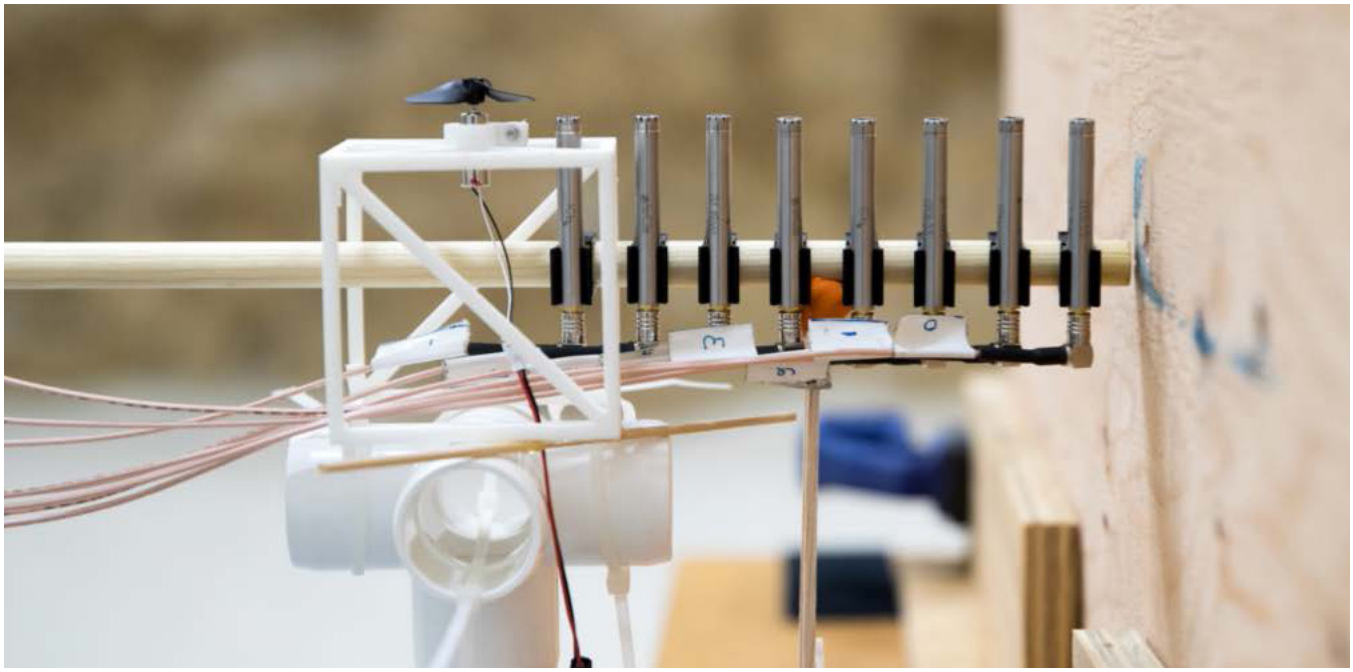


U.S. Naval Research Laboratory researchers characterize topological data analysis-based clustering of acoustic percepts for wall and door detection. NRL's Bio-inspired Adapted Techniques for Sensing, Actuation and Vocalization using Vibro-acoustics (BATSAVVi) project aims to apply passive echolocation to unmanned vehicles, utilizing self-generated vibration to allow bio-inspired communication, localization, and situational awareness. (Courtesy image from the U.S. Air Force Research Laboratory).

A team of researchers from the U.S. Naval Research Laboratory (NRL) received a United States and United Kingdom Science and Technology Cooperation Commendation from the Office of the Under Secretary of Defense for Research and Engineering on Dec. 4, 2020.

The NRL team of experts with the Bio-inspired Adapted Techniques for Sensing, Actuation and Vocalization using Vibro-acoustics (BATSAVVi) program were commended for establishing bilateral collaboration between the U.S. Navy, the U.S. Air Force Research Laboratory, and the Defence Science and Technology Laboratory.

The NRL team, led by **Don Sofge** and **Jason Geder,** along with **Joseph Lingevitch, Ph.D., Matthew Kelly, Daniel Lofaro, Ph.D., Loy McGuire,** and **Luke Calkins** addressed research challenges in small, unmanned vehicle navigation and communication. They successfully proved novel, bio-inspired acoustic approaches to obstacle detection and avoidance within the program.



The U.S. Naval Research Laboratory's Bio-inspired Adapted Techniques for Sensing, Actuation and Vocalization using Vibro-acoustics (BATSAVVi) team conducts experimental setup in the Laboratory for Autonomous Systems Research Desert High Bay for wall/distance estimation experimentation using a linear array of microphones on Aug. 16, 2019. (Photo by U.S. Naval Research Laboratory)

Donald Sofge, computer scientist and roboticist, U.S. Naval Research Laboratory

Jason Geder, aerospace engineer, U.S. Naval Research Laboratory

Joseph Lingevitch, Ph.D., research physicist, U.S. Naval Research Laboratory

Matthew Kelly, researcher, U.S. Naval Research Laboratory

Daniel Lofaro, roboticist, electrical engineer, computer scientist, U.S. Naval Research Laboratory

Loy McGuire, swarm robotics researcher, U.S. Naval Research Laboratory

NRL Physicist Awarded 2020 AAAS Newcomb Cleveland Prize

Matthew Kerr, Ph.D., a research physicist at the U.S. Naval Research Laboratory, was part of an international team of astronomers and astrophysicists recognized by the 2020 American Association for the Advancement of Science Cleveland Prize for a discovery that improved the understanding of FRBs in distant galaxies. The team detected and localized FRBs using the Australian Square Kilometre Array Pathfinder, a radio telescope located in Western Australia. (Photo courtesy of Matthew Kerr)

In 2007, a team of scientists found the first fast radio burst (FRB), then described as a Lorimer bursts, after combing through archived data from the Parkes Observatory in New South Wales, Australia, from July 24, 2001. This extremely energetic burst originated in the Small Magellanic Cloud, about 200,000 light-years away, and at that time was thought of as a one-off event. Since then, scientists worldwide have detected hundreds of FRBs, with one identified within a galaxy approximately 3 billion light-years away. Scientists estimate there are about 5,000 bursts happening all the time, just like sirens in a large city.

Fast forward to 2019: Matthew Kerr, Ph.D., a research physicist at the U.S. Naval Research Laboratory, was part of an international team of astronomers and astrophysicists. The team was led by Keith Bannister, a research engineer at the Commonwealth Scientific and Industrial Research Organisation, Australia's national science agency. They detected and localized FRBs using the Australian Square Kilometre Array Pathfinder (ASKAP), a radio telescope located in Western Australia.

"ASKAP has a new technology called a phased-array feed, which has a tremendous field of view. And because it's an interferometer instead of a single dish, it has an excellent angular resolution," Kerr said. "So for the first time, more than just saying, 'Well, it kind of came from over there,' we knew which galaxy the FRB came from exactly. We could say for the first time it's not terrestrial, it's not coming from our solar system or galaxy, it's extragalactic."

For their research, Kerr and the team were recognized by the 2020 American Association for the Advancement of Science Newcomb Cleveland Prize for a discovery that improved the understanding of FRBs in distant galaxies.

The winning study, "A single fast radio burst localized to a massive galaxy at cosmological distance," published in the Aug. 9, 2019, issue of Science, can be found at https://science.sciencemag.org/content/365/6453/565.

NRL Scientists, Researchers Win 2021 Dr. Delores Etter Award

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 2021 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.

In the Individual Scientist category, research physicist Adam Black, Ph.D., solved a major technical challenge facing the atomic interferometry research community and performed experimental and theoretical development of a new architecture for practical, high-sensitivity quantum accelerometers and gyroscopes for inertial navigation. His accomplishments directly address Navy and NRL goals for alternatives to GPS for position, navigation, and timing that are required in the face of growing adversarial anti-access/area-denial capabilities.

In the Individual Engineer category, mechanical engineer Jesse Maxwell, Ph.D., invented key technologies that comprise the Surface Morphing and Adaptive Structures for Hypersonics technology portfolio leading to the development of the multiphysics HOTSHOT simulation code and the establishment of NRL' s Hypersonic Aerodynamics and Propulsion Laboratory, which features a variable-speed hypersonic wind tunnel.

In the group category, the Optical Nanomaterials Section developed non-infectious fluorescent nanoparticle probes designed to mimic the physiological interactions of the SARS-CoV-2 virus with receptor proteins on human cells. The probes are being transitioned for use in diagnostic tests to rapidly identify presymptomatic COVID-19 infection in point-of-care settings. This research will assist in rapid identification and treatment of infection to mitigate the effects of the COVID-19 pandemic on Navy and Marine Corps warfighters.

Group Catergory, Optical Nanomaterials Section:

Eunkeu Oh, Ph.D., research biophysicist
Mason Wolak, Ph.D., research chemist, acting head, Optical Nanomaterials Section

Individual Scientist Category: **Adam Black,** Ph.D., research physicist

Individual Engineer Category: **Jesse Maxwell**, Ph.D, mechanical engineer

Eunkeu Oh, Ph.D., research biophysicist, U.S. Naval Research Laboratory

Mason Wolak, Ph.D., research chemist, U.S. Naval Research Laboratory

Adam Black, Ph.D., research physicist, U.S. Naval Research Laboratory

2021 Postdoctoral Research and 2020 Sigma Xi Aawards

It's official! The U.S. Naval Research Laboratory Sigma Xi –Edison Chapter has announced the winners of their Sigma Xi and Postdoctoral Mini-seminar awards.

Sigma Xi is a scientific research society that actively promotes the promise of science and technology. The society's goals are to foster interaction among science, technology, and society, to encourage appreciation and support of original work in science and technology, and to honor scientific research accomplishments, according to the Edison chapter's website.

Congratulations to the following for their accomplishment and professional achievement:

Kristina Nyland, Ph.D., from the Remote Sensing Division at Naval Research Laboratory

2021 Postdoctoral Research Awards

Best Mini-Talk: Kristina Nyland, Code 7213

For the Talk: Newborn Jets Launched by Supermassive Black Holes

Best Mini-talk: Matthew Thum, Ph.D., Code 6124

For the Talk: Azobenzene-Doped Liquid Crystals in Electrospun Nanofibrous Mats for Photochemical Phase Control

2020 Sigma Xi Awards

Young Investigator: Joel Grimm, Ph.D.

Citation: For developing a scalable technique for tuning the optical frequencies of a network of semiconductor quantum dots.

Applied Science: John G. Michopoulos, Ph.D., Code 6394

Citation: For contributions to mechatronic testing for characterization of materials systems and for multiphysics modeling and simulation of their design and qualification.

Pure Science: Igor Medintz, Ph.D., Code 6907

Citation: For groundbreaking work in hybrid organic-inorganic bionano-materials, nanoscale DNA-based light-harvesting devices, and nanoparticle enzyme scaffolds for efficient "channeled" synthetic systems for biosynthesis.

Igor Medintz, Ph.D., research biologist at the U.S. Naval Research Laboratory

NRL Chesapeake Bay Detachment Fire Science Researcher Receives Top Honors

U.S. Naval Research Laboratory Chesapeake Bay Detachment fire protection researcher John Farley received the 2020 Fire Protection Research Foundation Medal Award. The award was received in partnership with Gerard G. Back from Jensen Hughes Inc. for their work in evaluating the fire protective effectiveness of new fluorine-free firefighting foams (F3s).

The award-winning project, "Evaluation of the fire protection effectiveness of fluorine-free firefighting foams," informs end users about alternatives by evaluating the firefighting capabilities of fluorine-free, Class B firefighting foams on fires involving hydrocarbon and alcohol fuels. More than 165 fire tests were conducted to determine foam application rates and foam discharge densities as a function of a range of test parameters.

The study highlighted the importance of following the listed parameters while applying F3s, according to the Fire Protection Research Foundation experts. The study's objectives were to determine the firefighting capabilities of four F3s and one baseline short-chain C6 aqueous film-forming foam formulation. Capabilities under examination included control, extinguishment, and burn-back times as a function of application rate and discharge density for a range of test parameters including fuel type, water type, and fuel temperature.

John Farley, director of fire test operations at the U.S. Naval Research Laboratory (NRL), conducts a National Fire Protection Association (NFPA) Research Foundation fluorine-free foam "Standard for Safety Foam Equipment and Liquid Concentrates" (UL-162) 50 ft^2 fire test, which was one of the 165 fire test series conducted for the NFPA at the NRL Chesapeake Bay Detachment in Chesapeake Beach, Md., in June 2019. The fire testing was conducted in calendar year 2019 and the final report, "Evaluation of the fire protection effectiveness of fluorine-free foams," was published in January 2020. (Photo courtesy Jensen Hughes Inc.)

Syed B. Qadri, Ph.D., Recongnized With the 2021 Excellence in Research Award in Materials Science and Technology by the Washington Academy of Sciences

Syed B. Qadri, Ph.D., is a research physicist in the Multifunctional Materials Branch of the Materials Science and Technology Division at the Naval Research Laboratory.

Congratulations to Syed B. Qadri, Ph.D., a research physicist in the Multifunctional Materials Branch of the Materials Science and Technology Division. For "major contributions to the development and understanding of advanced materials," Qadri is being recongnized with the 2021 Excellence in Research Award in Materials Science and Technology by the Washington Academy of Sciences. An excerpt from Qadri's nomination letter reads, his "research has focused on the optical, transport and magnetic properties of low-dimensional semiconductor structures, including structural properties and phase transformations of nanocrystals, nanorods, and nanowires, high-pressure phase transformations in semiconductors using synchrotron radiation, and diamond anvil cell. Size and shape-controlled tunability of the electronic, optical, and transport properties of nanoscale semiconductors, combined with the ability to chemically and physically manipulate these 'freestanding' nanostructures with nanometer precision, opens exciting new opportunities for the development of novel functional materials." With more than 40 years as a workng scientist — including 32 years at NRL — his list of personal achievements and major technical accomplishments is both numerous and impressive. Kudos for this well-deserved honor!

Small Business Office Lauded for 'Consistent Support'

The U.S. Naval Research Laboratory has been at the forefront of military and industrial innovation and research for nearly 100 years. Running like a well-oiled machine, each part of the Navy's primary research organization works in unison to achieve the mission, no single part more important than any other. NRL's Small Business Office (SBO) recently received recognition for their contributions to the success of the Naval Research Enterprise.

In a letter dated June 30 addressed to Chief of Naval Research Rear Adm. Lorin Selby, the Department of the Navy Office of Small Business Programs (OSBP) acknowledged NRL's SBO for their "consistent support of the Office of Naval Research small business achievements, [and] serving as an integral part of ONR's acquisition planning, process and mission objectives of 2020 to provide small business subcontracting opportunities to continue creating a competitive prime industrial base."

"As the DoN's corporate laboratory, NRL is principal in the Navy's effort to meet its science and technology responsibilities. NRL's SBO has direct ties with sources of innovative ideas in the small business and academic communities," said Andrew Chappell, deputy director of NRL's Office of Small Business Programs.

"Small businesses create efficient integration of mature solutions and, at the same time, influence methodical research initiatives that address the DON's most critical gaps and capability shortfalls," Chappell continued.

DON small businesses actively work to drive the speed of technology and are in sync with the Navy's ambition for rapid change within the marketplace. NRL's SBO office was applauded for monitoring and analyzing open source security-related data sources. This solution allows DON the situational awareness, timely course of action advisory, and risk assessment to protect our naval fleet, personnel, remote assets, including naval bases, and ports at home and abroad.

NRL Preserves Navy's Chesapeake Bay Workspace

The Navy's TWR-6, known as the "Devil Ray," is docked June 15, 2021, at Chesapeake Beach, Maryland, where the NRL Oyster Bay Restoration Volunteer Project was in progess. The ship will serve as NRL's new research vessel once repairs have been completed. (U.S. Navy photo by Jonathan Steffen)

The U.S. Naval Research Laboratory Green Team hosted the second half of an oyster restoration project at the boat dock at NRL's Chesapeake Bay Detachment in Maryland and helped increase the Chesapeake Bay oyster population by more than 8,000 with the help of a few dozen NRL volunteers.

Each year, through a partnership with the Chesapeake Beach Oyster Cultivation Society (CBOCS), NRL hosts the two-part project to grow and release mature oyster spat in the bay. Spat is oyster larvae attached to a surface, in this case, an oyster shell surface. In the fall, NRL receives the oyster spat to sink on its docks. The subsequent summer, volunteers hoist the oyster cages out of the water, count the spat, and then deliver the oysters to spread onto a reef.

"This event is an opportunity to engage citizen scientists with environmental stewardship and conservation," said Sutton, who leads the program annually. "It's exciting to get people outside of their daily 9-to-5 and participate in hands-on projects. It's great to be part of something bigger than myself. I find it rewarding to get a larger reach into the community to better then environment."

An oyster's value is often understated. They provide habitat and nursery grounds to marine species of the bay. Oyster reefs also serve as breakwaters against the erosive damage of storms. Perhaps the most valuable attribute of oysters is their ability to filter water and to improve water quality. One adult oyster can filter 30 gallons of water per day, making

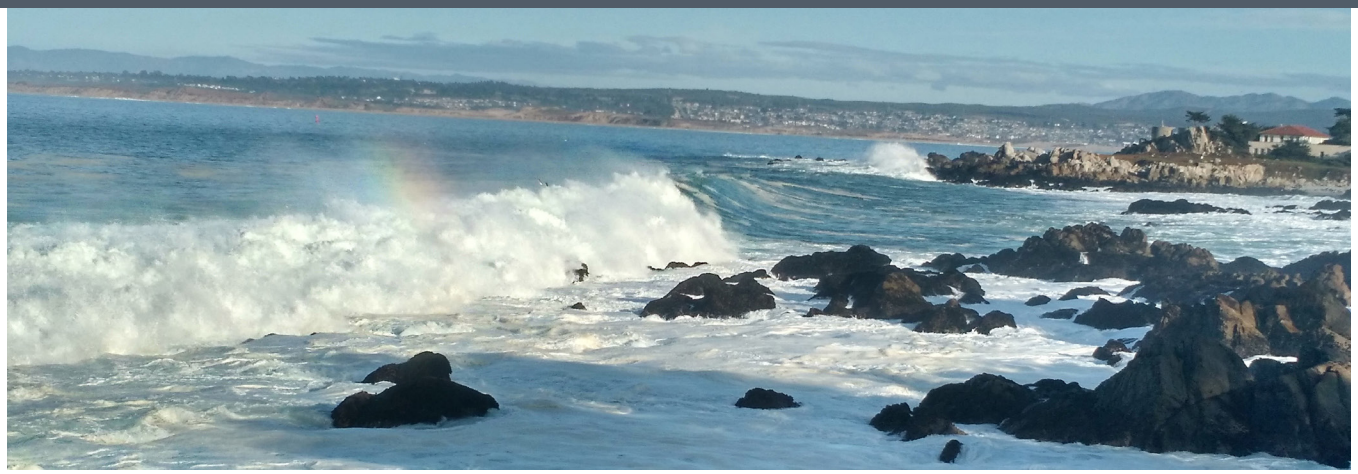
Daniel Shy and Kaylie Hammersbog, volunteers from the U.S. Naval Research Laboratory (NRL), count oyster spat during an Oyster Bay Restoration Volunteer Project in Chesapeake Beach, Maryland, on June 15, 2021. The NRL-organized event brought volunteers together to count oyster larvae, also known as spat, and to return the larvae to the Chesapeake Bay as part of an effort to repopulate the bay with oysters. (U.S. Navy photo by Jonathan Steffen)

them a vital part of the bay. It is important that military, environmental, and agricultural efforts align when tackling restoration on the bay. As a Navy organization specifically, NRL has an obligation to maintain the Navy's workspace and does so through hosting countless research projects in the bay every year, each benefiting from the cleanliness of the ecosystem.

As a waterman, or one who works or lives on the water, William "Bill" Drury operates the boat that takes the oysters to the reef from the pier. Drury has fond memories of his time on the waterways and supports projects like the oyster restoration in Chesapeake Bay to give back. "I have been a waterman since I was 13. I have taken from the bay as well as given back to it. I have great passion in maintaining nature's balance," said Drury, of NRL's Research and Development Services Division at Chesapeake Bay Detachment.

The NRL Green Team is a voluntary organization consisting of NRL employees who promote sustainability in the workplace. The group works closely with NRL's Environmental Section on a variety of projects championing environmental initiatives.

Buckets contain oyster larvae, also known as "spat," that were grown as part of the U.S. Naval Research Laboratory's (NRL) Oyster Bay Restoration Volunteer Project in Chesapeake Beach, Maryland, on June 15, 2021. (U.S. Navy photo by Jonathan Steffen)



James Doyle of the U.S. Naval Research Laboratory (NRL) took this amazing photo in Monterey Bay, California, while participating in his directorate's effort to beat the COVID-19 blues. With researchers spread across the nation, NRL's Ocean and Atmosphere Science and Technology Directorate, whose code is 7000, fulfilled a challenge to collect 7,000 miles by walking, running, bicycling, and a variety of other activities. Big waves are a natural part of the scenery in this neck of the woods. (Photo courtesy of James Doyle, NRL)

From Sea to Shining Sea: Combating the Pandemic One Mile at a Time

When COVID-19 began to spread more than a year ago, few people could have imagined the drastic, far-reaching changes in our lives — both socially and professionally. But in a year's time, the pandemic has turned the world upside down.

Folks at NRL's Ocean and Atmosphere Science and Technology Directorate, or Code 7000, as it's known internally at the lab, didn't take the pandemic lying down. In fact, they decided to escape home-bound isolation by walking or running 7,000 miles. It was a way to combat the blues that come with being cooped up.

"We had a discussion among the 7000 division heads that it would be a good idea to do something to boost morale," said Dr. Christoph Englert, superintendent of NRL's Space Science Division, "especially during the winter, when the days are short and some people have to deal with hardships and loss."

They nicknamed the challenge "7,000 Miles for Code 7000."

Driving didn't count, but Wade Duvall, a research physicist at NRL in D.C., hadn't had a vacation in a year. He felt like flying wasn't safe during the pandemic, so he drove more than halfway across the country, nearly 2,000 miles, to Big Bend National Park in southwestern Texas, near the border with Mexico.

Duvall went a long way to hike, he said, but more importantly, he wanted to do some running. He found himself along the south rim of the Chisos Mountains, where the elevation reaches more than 7,000 feet. He did a shortened version of the 17-mile trail.

"There is a place in far West Texas where the night skies are dark as coal and rivers carve temple-like canyons in ancient limestone," says the National Park Service website about Big Bend. "Here, at the end of the road, hundreds of bird species take refuge in a solitary mountain range surrounded by weather-beaten desert. Tenacious cactus bloom in sublime southwestern sun, and diversity of species is the best in the country."

Who wouldn't want to visit this "magical place," right? And so, spurred on by the challenge, Duvall did, and his spirit was better for it.

With divisions from California to Washington, D.C., and points in between, it was truly a sea-to-shining-sea challenge. The directorate's participants began taking pictures while they were outside, logging miles, then posted them on Teams.

Even though the challenge is over, people are still logging in hours, Englert said.

"I thought it was a great success because people were really into it," he said. "That's pretty cool. It was a fun thing that lifted morale."

Lavina Backman is a materials engineer in the Spacecraft Engineering Division at the U.S. Naval Research Laboratory (NRL). (Courtesy photo by Karen Walker)

Dr. Lavina Backman Celebrates Her Heritage and STEM Career

For Lavina Backman, a materials engineer in the Spacecraft Engineering Division at the U.S. Naval Research Laboratory (NRL), her Asian American and Pacific Islander (AAPI) heritage has served as the driving force for her desire to work within a diverse community.

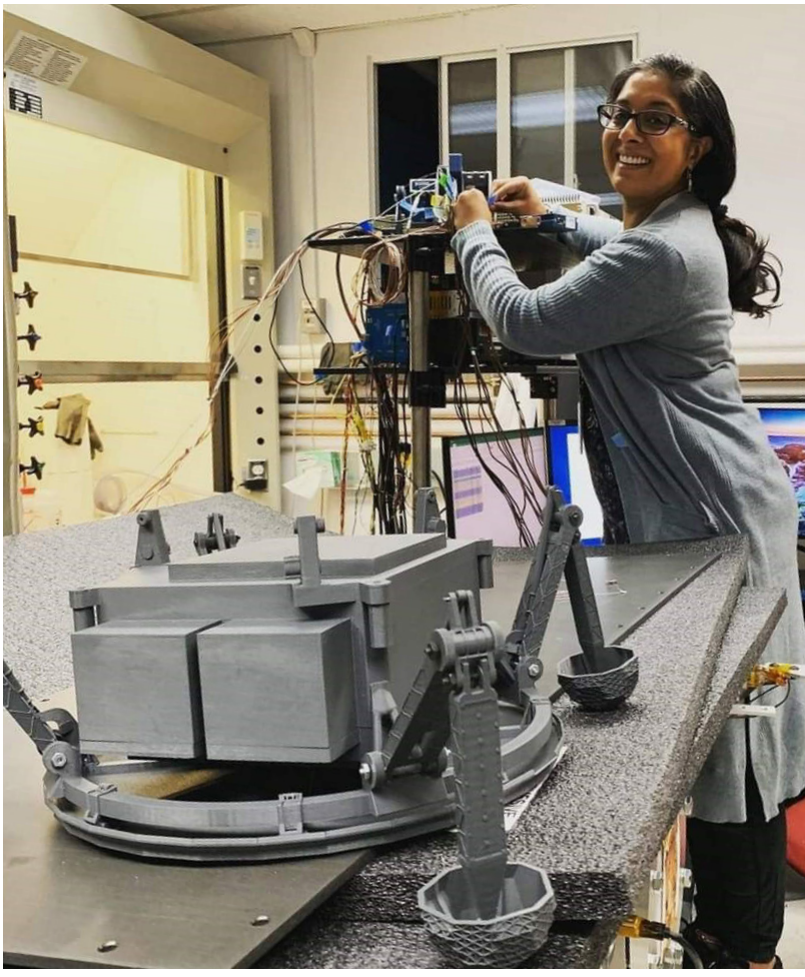
As an Indian woman who grew up in the Philippines, Backman was surrounded by a plethora of cultures, attitudes, income levels, belief systems and values.

"Growing up in that environment gave me my sense of the importance of community, networks and family, but also the value of hard work," Backman said. "The interconnectedness of my upbringing has shaped my perspective on the value of good networks, both personally and professionally. My heritage continues to enrich my life in various ways on a daily basis as well through music, art, stories, and food, among other things."

Backman collaborates closely with NRL's Materials Science and Technology Division's Multifunctional Materials Branch and the Optical Sciences Division to develop and test these materials. Her research requires specialized equipment to fabricate and characterize the materials developed. The research divisions have provided both access to their facilities and resources, and importantly, their longtime expertise in fabricating and characterizing ceramic materials.

"The combined feedback and discussion from both the MSTD and OSD divisions help me to continuously refine my research approach," Backman said "The work I do requires a cross-disciplinary approach and benefits from such teamwork."

"The importance of community in both the Filipino and Indian cultures has played a large part in my motivation to continue volunteering for science, technology, engineering, and math (STEM) educational outreach, which has greatly impacted my career as a materials engineer at NRL and the opportunity to inspire the researchers of tomorrow," Backman said. "I absolutely credit being a part of the Filipino and Indian cultures for this perspective and being in a position to promote diversity and inclusion throughout the laboratory."



Lavina Backman, a materials engineer in the Spacecraft Engineering Division at the U.S. Naval Research Laboratory (NRL), works on setting up the sensor connections for a planetary analog experiment to the Labview module used to collect data during her internship at NASA Jet Propulsion Laboratory in Pasadena, California. (Courtesy photo by Dr. Kevin Hand)

Building STEM Connections Brick by Brick

This robot built by the Cosmic Cougars, the FIRST Lego League (FLL) team mentored by Richard Espinola, got first place in robot performance division 2 in a recent FLL RePLAY Regional Qualifier in Alexandria, Va. Espinola is an electronics engineer at the U.S. Naval Research Laboratory in Washington, D.C. (Photo provided by Richard Espinola)

Richard Espinola, Ph.D., an electronics engineer at the U.S. Naval Research Laboratory in Washington, D.C., spends his spare time mentoring a local FIRST® Lego® League (FLL) team.

It may sound like child's play, but FLL participants are serious about building science, technology, engineering, and mathematics (STEM) connections brick by brick. FLL is a hands-on robotics competition that introduces students to STEM concepts in a fun way. The program is now a global competition with more than 670,000 participants. As team mentor, Espinola helps his team understand the year's challenge and guides them in their problem-solving process. He also applies for DoD STEM grants on behalf of the team.

It all started when Espinola talked to neighbors and they realized that while their children were interested in a robotics team, there was none in their area. So along with another parent, he set out to start one.

"Fortunately, the FIRST program still had a virtual option, so we were able to participate," Espinola said. "It was different from the typical school day during the pandemic because they could interact with their friends and work together. I think my son and his friends enjoyed it. They really made the best of it."

While teams get a break over summer, the start of the school year signals the start of a new challenge. Challenges follow a theme and require each team to develop a novel solution to a problem using robotics. Past challenges have included addressing real-world topics like climate and quality of life for the handicapped population.

"It's not just some abstract idea or science fiction," Espinola said. "It's factually relevant to today's problems. They show how using robotics and technology can address real-world problems."

"My favorite part of FLL is collaborating with my group to find solutions to real-world problems," said Stephan Lugovoy, an FLL team member.

Without mentors like Espinola, a program like FLL cannot function. He encourages other scientists and engineers to consider being a STEM mentors. "If you can manage the time required and you're willing to be patient with young learners, it's very rewarding," Espinola said.

NRL-Led Virtual Cyber Week Provides Students Access to Experts, Peek Into Future

Samina Mondal, a public affairs intern at the U.S. Naval Research Laboratory, hosted a virtual Cyber Week event for the week of July 19, 2021. Cyber Week is an educational seminar on cybersecurity topics that was targeted at students in grades 7-12. Two of the days were devoted to NRL personnel's sharing of their own experiences in cyberspace career fields and internships. The panels provided an opportunity for students to directly pose questions to experts in the field.

The STEM outreach program at NRL is a flexible, week-long curriculum geared toward high school and junior high school students to detect online threats, to gain a better understanding of how the internet works, and to work alongside DoD STEM and the Defense STEM Education Consortium (DSEC) to spark interest in technology-based careers of the future.

Samina Mondal is a public affairs intern at the U.S. Naval Research Laboratory.

Samina Mondal, a public affairs intern at the U.S. Naval Research Laboratory, takes part in an online panel discussion for Cyber Week while hosting the virtual event for the week of July 19, 2021.

FY2021 PERSONNEL

Total FTP Personnel: 1,702

Social Science	1
Psychology	10
Program Management	1
General Natural Resources Management and Biological Sciences	30
Microbiology	2
General Engineering	14
Safety Engineering	1
Fire Protection Engineering	1
Materials Engineering	62
Architecture	1
Civil Engineering	8
Environmental Engineering	4
Mechanical Engineering	128
Electrical Engineering	73
Computer Engineering	61
Electronics Engineering	332
Aerospace Engineering	79
Chemical Engineering	16
General Physical Science	53
Health Physics	9
Physics	350
Geophysics	8
Chemistry	96
Metallurgy	5
Astronomy and Space Science	28
Meteorology	52
Geology	4
Oceanography	52
Operations Research	7
Mathematics	34
Computer Science	180

Highest Academic Degrees Held by Civilian Full-Time Permanent Employees

Bachelor	6,341
Master	483
Doctorate	905

Brett Huhman, a U.S. Naval Research Laboratory senior research engineer, aligns a linear array of six photodetectors co-located with ultraviolet (UV) dosimeters and a single spectrometer during testing of a pulsed xenon gas lamp source in Washington, D.C., on May 8, 2020. Huhman was testing a variety of commercial UV light sources that might have niche applications against COVID-19 for Navy and Marine Corps environments. (U.S. Navy photo by Jonathan Steffen)

FY 2021 Source of New Funds (Actual)

	Total ($M)
Office of Naval Research (ONR)	344.8
Naval Engineering Logistics Office (NELO)	90.0
Naval Sea Systems Command (NAVSEA)	58.5
Naval Air Systems Command (NAVAIR)	31.4
Other Navy	71.9
All Other	507.5
Total Funds	1,104.1

FY 2021 Distribution of Funds

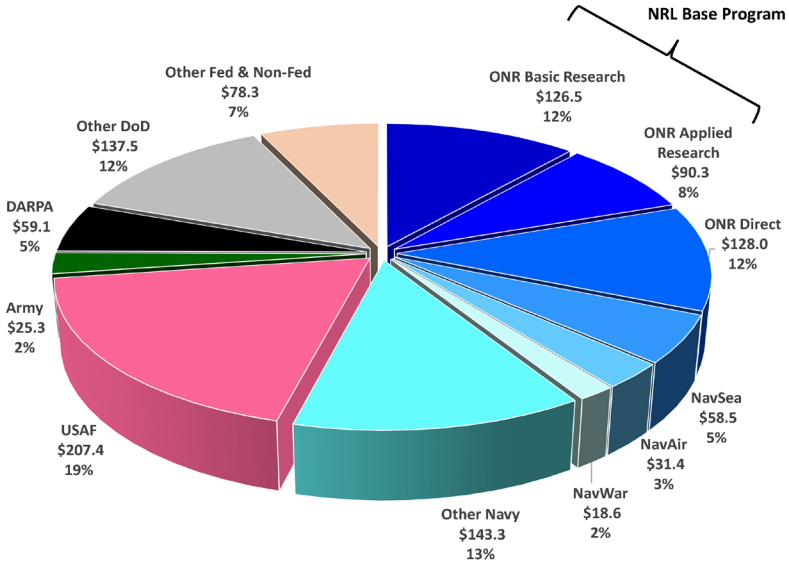
	Total ($M)
Direct Labor	316.9
General Overhead	134.6
Production Overhead	136.6
Direct Material, Travel and Other	151.2
Direct Contracts	387.0
Total Costs	1126.3

FY 2021 Distribution of Funds

RESEARCH FUNDING

*Costs based on CFO statements; direct contracts include costs for reimbursable-funded contracts and obligations for direct site-funded contracts.

All data as of September 30, 2022



Reviewed and Approved
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Commanding Officer
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