RESEARCH PARTNERSHIPS

A User's Guide

Naval Research Laboratory

This publication is a user's guide for organizations, activities, and individuals, either in government, industry, or academia, who would like to participate in a cooperative research and development (R&D) partnership with the Navy's corporate laboratory—the Naval Research Laboratory (NRL).

NRL has a long history of fruitful relationships with industry and academia, both as collaborators and contractors. The Laboratory welcomes and encourages productive working relationships with both government and nongovernment activities and is always willing to explore new and innovative ways of using the skills of others to enhance the Navy's combat readiness.

This publication describes the wide variety of NRL cooperative research and development opportunities that are available, including Broad Agency Announcements (BAAs), contracts, grants, and formal and informal research agreements.

Additionally, the Laboratory's Technology Transfer Program, including Cooperative Research and Development Agreements (CRADAs); patent licensing; and the role of the NRL Office of Research and Technology Applications (ORTA), focuses on the expeditious transfer of the results of NRL's R&D programs to the private sector and/or state and local governments.

Finally, we describe NRL's interactive visiting scientist and engineer programs and outline NRL's annual intellectual output.

NRL invites your partnership inquiries. For your convenience, a point of contact is listed for each program.

Front cover photos:
Top left: Engineers at the Naval Research Laboratory's Naval Center for Space Technology (NCST) designed, built, and tested the Starshine satellite to meet Space Shuttle Hitchhiker Payload specifications in a period of only four months. Starshine is a passive satellite with no moving parts or electrical components.

Center right: NRL main site, located off Interstate 295 in S.W. Washington, DC, as viewed from the Potomac River.

Bottom: A technician sets a small plastic target in a large vacuum chamber (view is through a side window). Once under high vacuum, the Nike laser will drive the target with 100 terawatts of UV light, accelerating the target to nearly 1/1000 the speed of light (300 km/s) in four billionths of a second. For that moment, it is the fastest moving object on Earth.

CONTENTS

NRL IN THE DEPARTMENT OF THE NAVY

The Naval Research Laboratory (NRL) began operations in 1923, as a result of Thomas Edison's vision for the nation's need of "…a great research laboratory…."

NRL, with major sites in Washington, DC; the Stennis Space Center (SSC), Mississippi; and Monterey (MRY), California, reports to the Chief of Naval Research (CNR), who heads the Office of Naval Research (ONR). As the corporate laboratory of the Navy, NRL is an important component of a continuing effort to maintain the U.S. Navy's technological superiority over potential adversaries.

ONR was established in 1946 to serve as the sponsor of military-relevant research, both in-house (at Navy laboratories) and out-of-house (at colleges and universities). This was in recognition of lessons learned in World War II, when government-sponsored research was first focused on rapidly transitioning the products of both civilian and military research organizations into defense products.

Today, as extremely tight budgets dictate affordability and reduce the specialized defense supplier base, many defense products result from collaboration between Navy scientists and the private sector, leveraging commercial "know-how" and investments for military use. Such collaborations often provide increased access to affordable, leading-edge technology for both military and commercial applications. ONR sponsors research and development (R&D) in naval laboratories and through grants and contracts with universities, industry, and non-profit organizations. ONR also encourages cooperation and collaboration between the Naval laboratories and private sector organizations through cooperative research and development agreements (CRADAs), work for outside party agreements, and other vehicles whereby the Navy and the private sector can work together toward mutu-

The 50-ft dish of the radio telescope was constructed in 1951. Scientists called it the first "accurately figured" radio telescope in the world. It was used extensively in the 1950s and 1960s to search for radiation from particular regions of the galaxy and to pinpoint celestial objects in the heavens and was later used for moon radar. By 1960, other larger dishes, superior in their measurements and accuracy, made the 50-ft dish obsolete. It has become the unofficial symbol of the Naval Research Laboratory.

Artist's concept of bust of Thomas Edison in front of Building 43, NRL's main administration building and home of the NRL research library.

ally beneficial goals consistent with the Navy's mission. As part of its overall mission, ONR annually publishes descriptions of its research priorities and the underlying Naval needs as a guide to potential R&D performers.

NRL is totally supported by reimbursable funding under the Navy Working Capital Fund whereby NRL recovers the full cost of its operations through charges levied on its "customers" (sponsors). As a result, except for the requirement for zero profit, NRL's "business" system is very similar to that employed by private industry.

About one-half of NRL's technical staff is supported by science and technology (S&T) funding from the Department of Defense (budget categories 6.1, 6.2, and 6.3). In some technical areas, NRL focuses largely on basic research and exploratory development and then transitions its R&D products to the Naval Warfare Centers or to industry. In other areas (for example, space systems), NRL is chartered to carry projects into the actual development of operational systems. In these areas, NRL's efforts rely heavily on contractual or other cooperative relationships with outside organizations, such as academia and industry.

The research conducted at NRL, in addition to being subjected to internal critical review and evaluation by ONR and by external scientific and technical peers, is also widely published in refereed journals and reported at national and international scientific conferences (see Intellectual Output, pg. 28). Many of these articles, reports, and papers are coauthored by collaborators from industry and academia. NRL also sponsors extensive interactions with leading scientists from other nations.

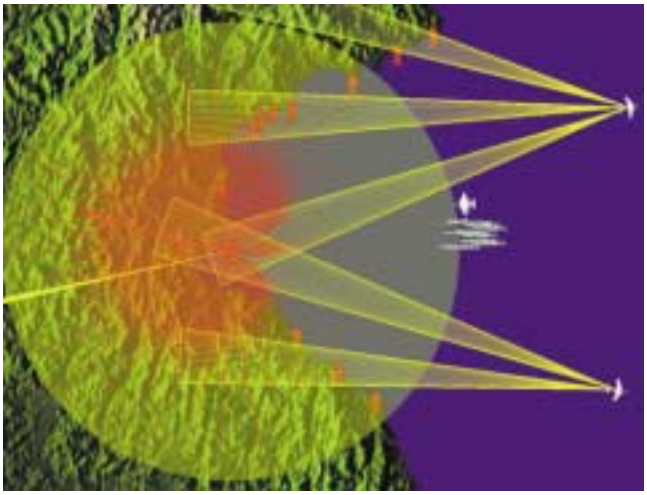
NRL has had long and fruitful relationships with industry, academia, non-profit organizations, and other government laboratories. The Laboratory values these productive relationships and actively solicits new and innovative methods of expanding such joint ventures. Accordingly, NRL serves as an important link in the Navy R&D chain. And through NRL, the Navy has direct and productive relationships with the R&D communities worldwide in industry and academia.

CURRENT RESEARCH

The following areas represent broad fields of NRL research. Under each, more specific topics that are being investigated for the benefit of the Navy and other sponsoring organizations are listed. Some details of this work are given in the *NRL Review*, which is published annually. More specific details are published in reports on individual projects provided to sponsors and/or presented as papers for professional societies or their journals.

Advanced Radio, Optical, and IR Sensors

Advanced optical sensors
EO/MET sensors
Satellite meteorology
Precise space tracking
Radio/infrared astronomy
Infrared sensors and phenomenology
Middle atmosphere research
Image processing
VLBI/astrometry
Atmospheric effects on low-frequency EM communications
Optical interferometry
Imaging spectrometry
Liquid crystal technology



A top-down graphical assessment of jammer effectiveness

Computer Science and Artificial Intelligence

Standard computer hardware, development environments, operating systems, and run-time support software
Methods of specifying, developing, documenting, and maintaining software
Human-computer interaction
Intelligent systems for resource allocation, signal identification, operational planning, target classification, and robotics
Algorithms and utilization of massively parallel computing systems
Visualization of scientific processes
Highperformance networking
Adaptive systems: Software and devices
Advanced computer networking
Simulation management software for networked highperformance computers
Algorithms for incorporating environment and communication systems performance into simulations
Interactive 3-D visualization tools and applications

Directed Energy Technology

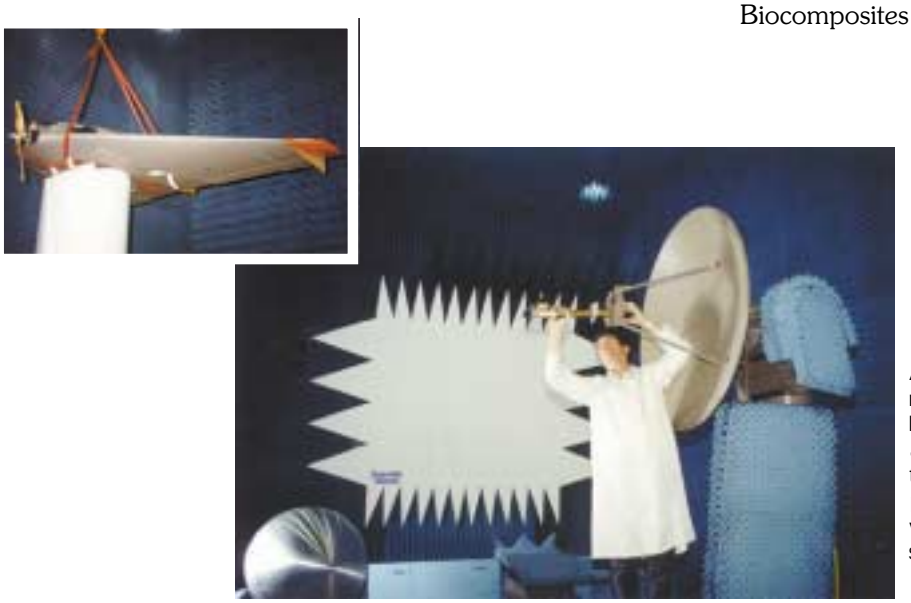
High-energy lasers
Chemical lasers
Laser propagation
High-power microwave sources
Charged-particle devices
Pulse power
DE effects

Electronics and Related Technologies

Nanoelectronics
Microwave/millimeterwave solid-state devices
Reliable and radiation tolerant/hard electronics
Radiation effects
Satellite survivability
Space experiments
Solid-state power devices
Electromagnetic field synthesis and modeling
Vacuum electronics
Infrared sensors
High-temperature, high-voltage devices
Optical solid-state devices and integrated circuits
Plasma processes and devices
Molecular engineering

Electronic Warfare

EW/C2W/IW systems and technology
COMINT/SIGINT technology
EW decision aids, and planning/control systems
Intercept receivers, signal processing, and identification systems
Passive direction finders
Decoys and offboard CM (RF and IR)
Expendable autonomous vehicles
Repeaters/jammers and EO/IR active countermeasures and techniques
Platform signature measurement and management
Threat and EW systems computer modeling and simulations
Visualization and virtual reality
Hardware-in-the-loop and flyable simulators
RF environment simulators
EO/IR multispectral/hyperspectral surveillance
Biocomposites



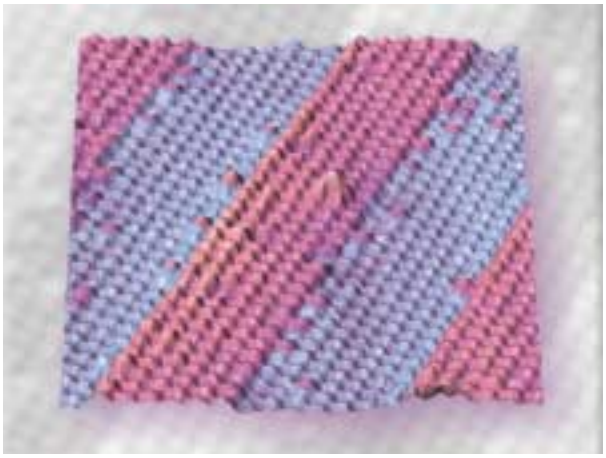
A view of the interior of the compact range, with the primary reflector. The larger photograph shows an antenna assembly being readied for testing on the range positioner, while the inset photo shows a small unmanned aerial vehicle as it undergoes radar-cross-section measurements.

Enhanced Maintainability, Reliability, and Survivability Technology

- Coatings
- Lubricants and greases
- Water additives and cleaners
- Fire safety
- Laser hardening
- Satellite survivability
- Radiation effects
- Mobility fuels
- Chemical and biological sensors
- Environmental compliance

Environmental Effects on Naval Systems

- Meteorological effects on electromagnetic/electro-optical system performance
- Meteorological effects on weapons, sensors, and platforms
- Air quality in confined spaces
- Electromagnetic background in space
- Radiation effects on spacecraft
- Solar and geomagnetic activity
- Magnetospheric and space plasma effects
- Non-linear science
- Ionospheric behavior
- Oceanographic effects on weapons, sensors, and platforms
- Electromagnetic, electro-optical, and acoustic system performance/optimization
- Environmental hazard assessment
- Biosensors



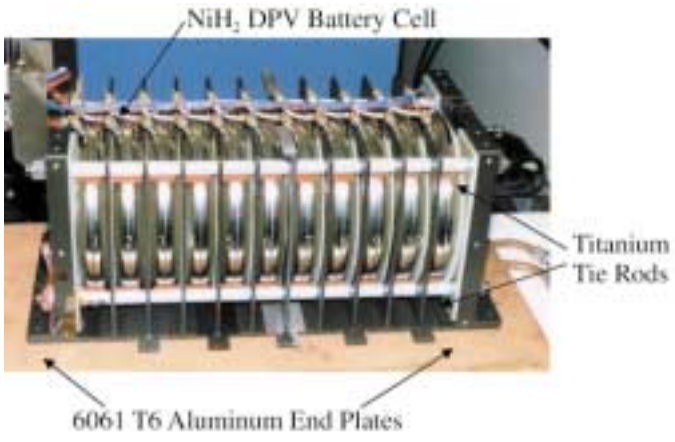
Color-enhanced scanning tunneling microscopy image of a cross section showing the atomic-scale structure at the interfaces between GsSb and InAs superlattice layers

Imaging Research/Systems

- Remotely sensed signatures analysis
- Real-time signal and image processing algorithms/systems
- Image data compression methodology
- Image fusion
- Automatic target recognition
- Scene/sensor noise characterization
- Image enhancement/noise reduction
- Scene classification techniques
- Radar and laser imaging systems studies
- Coherent/incoherent imaging sensor exploitation
- Remote sensing simulation
- Hyperspectral imaging
- Microwave polarimetry

Information Technology

- Antijam communication links
- Next generation, signaled optical network architectures
- Integrated voice and data
- Arctic communication links
- Information security (INFOSEC)
- Voice processing
- High performance computing
- High performance communications
- Requirement specification and analysis
- Real-time computing
- Wireless mobile routing
- Tactical/warfighter's internetworking
- Natural environments for distributed simulation
- Collaborative engineering environments
- Information filtering and fusion
- Integrated internet protocol (IP) and asynchronous transfer mode (ATM) multicasting
- Reliable multicasting

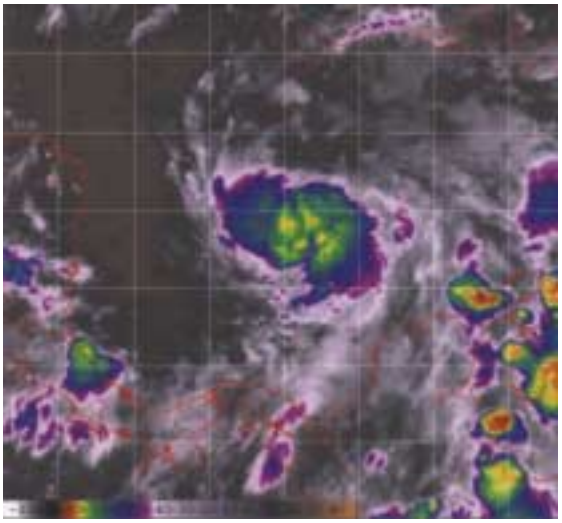


Eleven-cell NiH_2 DPV battery pack

High assurance software
Distributed network-based battle management
Teraflop scalable shared memory, massively parallel computer architectures
Distributed, secure, and mobile information infrastructures
Virtual engineering
Simulation-based virtual reality
Advanced distributed simulation
High-end, progressive HDTV imagery processing and distribution
Defensive information warfare
Augmented reality
Motion science research

Marine Geosciences

Marine seismology, including propagation and noise measurement
Geoacoustic modeling in support of acoustic performance prediction
Geomagnetic modeling in support of non-acoustic system performance prediction
Static potential field measurement and analysis (gravity and magnetic) in support of navigation and geodesy
Geotechnology/sediment dynamics affecting mine warfare and mine countermeasures
Foreshore sediment transport
Mapping and charting, including advanced seafloor mapping, imaging systems, and innovative object-oriented digital mapping models, techniques, and databases



Hurricane Mitch gathers strength in the Caribbean Sea on 24 October 1998 (0118 GMT). This is a false-color IR image designed to reveal colder (higher) clouds.

Materials

Superconductivity
Magnetism
Biological materials
Materials processing
Advanced alloy systems
Solid free form fabrication
Environmental effects
Energetic materials/explosives
Aerogels
Nanoscale materials
Non-destructive evaluation
Ceramics and composite materials
Thin film synthesis and processing
Electronic and piezoelectric ceramics
Thermoelectric materials
Metamorphic materials/smart structures
Computational material science
Paints and coatings
Flammability
Biomimetic materials

NRL's Satellite-Linked Vertical Line Array (SVLA) buoy during a recent ocean deployment. Data from an array of hydrophones are collected and stored within the buoy and simultaneously transmitted, using RF and satellite communications, to both ships in the vicinity and distant shore stations.

Meteorology

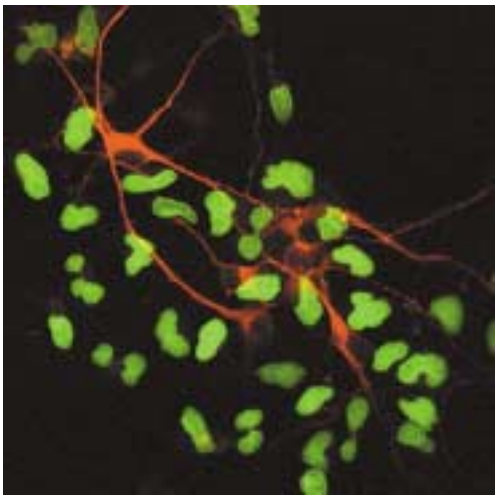
Global, theater, tactical-scale, and on-scene numerical weather prediction
Data assimilation and physical initialization
Atmospheric predictability and adaptive observations
Adjoint applications
Marine boundary layer characterization
Air/sea interaction; process studies
Coupled air/ocean/land model development
Tropical cyclone forecasting aids
Satellite data interpretation, assimilation, and application
Aerosol assimilation and modeling
Meteorological applications of artificial intelligence and expert systems
On-scene environmental support system development
Tactical database development and applications
Meteorological tactical decision aids
Meteorological simulation and visualization
Nowcasting
Tactical weather parameters

Ocean Acoustics

Underwater acoustics, including propagation, noise, and reverberation
Fiberoptic acoustic sensor development
Deep ocean and shallow water environmental acoustic characterization
Undersea warfare system performance modeling, unifying the environment, acoustics, and signal processing
Target reflection, diffraction, and scattering
Acoustic simulations
Tactical decision aids
Sonar transducers
Metrology

Oceanography

Open ocean, littoral, and nearshore oceanographic modeling
Shallow water oceanographic effects on operations
Arctic environmental quality
In-situ oceanographic sensors and data fusion
Bio-optical and fine-scale physical processes
Biocorrosion
Oceanographic simulation and visualization
Waves, tides, and surf prediction
Coupled model development
Coastal and open ocean optical processes
Oceanographic decision aids
Global, theater, and tactical scale modeling
Remote sensing algorithm development



Fluorescence photomicrograph of neural stem cells and stem cell-derived neurons, both of which supply cell elements for a cell-based sensor that can be used to detect toxins.

Immersive visualization of solar magnetic field lines

Space Systems and Technology

Advanced space systems architectures and requirements
Systems engineering and analysis
Mission evaluation and performance assessment
Spacecraft controllers, processors, and signal processing
Astrodynamics, mathematical modeling, and simulations
Surveillance sensing technology and applications
Satellite communications theory and systems
Tactical communications systems
Mobile data collection, processing, and dissemination
Spacecraft electronics design, engineering, and integration
Satellite ground station, tracking, telemetry, and control systems design
Precise time and time interval technology
Navigation satellite technology and frequency standards
Remote sensing, calibration, and research
Spacecraft electrical power and radio frequency systems
Spacecraft survivability and radiation effects

Surveillance and Sensor Technology

Point defense technology
Imaging radars
Surveillance radars
Multifunction RF systems
High-power millimeter-wave radar
Relocatable over-the-horizon radar (ROTHR)
Target classification/identification
High-stability electronics
Airborne geophysical studies
Fiberoptic sensor technology
Undersea target detection/classification
EO/IR multispectral/hyperspectral detection and classification
Sonar transducers
Electromagnetic sensors—gamma ray to RF wavelengths
SQUID for magnetic field detection
Low observables technology
Ultrawideband technology
VHSIC/MIMIC applications
Interferometric imagery
Microsensor systems
Biological sensors

Undersea Technology

Autonomous vehicles
UUV launch dynamics
Bathymetric technology
Anechoic coatings
Acoustic holography

Hands-on experience puts summer students in the middle of research and data collection at NRL Stennis Space Center

NRL's Flight Support Detachment with one of the P-3 aircraft

Major Research Capabilities and Facilities

Acoustics Division

- Large, sandy-bottom, holographic pool facility for investigating echo characteristics of underwater buried/near-bottom targets and sediment acoustics
- Multichannel programmable acoustic signal processing system
- Containerized data processing for acoustic array processing at remote sites and aboard ship
- One million gallon, vibration-isolated underwater holographic/3-D laser vibrometer facility for studying structural acoustic phenomena for submarine, mine countermeasure, and torpedo systems
- In-air structural acoustics facility with high spatial density nearfield acoustic holography and 3-D laser vibrometer measurements and processing systems for diagnosing large structures, including aircraft interiors and rocket payload fairings
- High-powered sound source array
- Moored acoustic array with satellite telemetry
- Multiple towed acoustic arrays with up to 144 acoustic channels
- Twin underwater towers supporting sources and hydrophone arrays to measure high-frequency propagation, volume, and boundary scattering in shallow water
- High-speed maneuverable towed body with MK-50 and synthetic aperture sonars to measure high-frequency boundary scattering and coherence
- Tactical oceanography simulation laboratory
- Digital Acoustic Buoy Systems (DABS), which can autonomously record data from vertical and/or horizontal acoustic arrays

Deployment of high-frequency acoustic tower

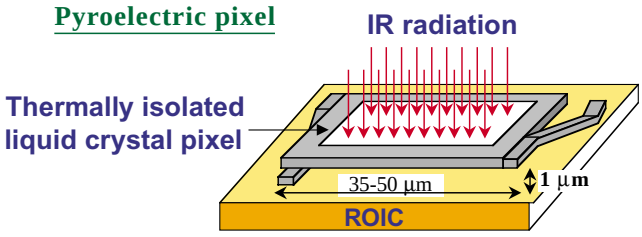
Acoustic Communications Simulation Laboratory
20-ft by 20-ft by 10-ft deep above-ground salt water acoustic tank facility with environmental control and substantial optical access

Center for Bio/Molecular Science and Engineering

Optical equipment
- Confocal fluorescent microscope
- CW fluorimeter and microscope
- Excimer laser projection exposure system
- Dektak surface profilometer
- Optical and fluorescence microscopes
- Photon correlation spectrometer
- Picosecond dye laser system
- Raman spectrometers
- Scanning and transmission electron microscope
- SLM fluorimeter (visible through near IR)
- Time resolved fluorimeter (nanosecond)
- UV-visible absorption spectrophotometers

Analytical instruments
- Atomic force/scanning tunnelling microscope
- Capillary electrophoresis unit
- Contact angle goniometer
- Differential scanning calorimeter
- GC/MASS spectrometer
- DNA synthesizer; DNA sequencer
- HPLC
- Patch clamp microelectrodes
- Potentiometer for electrochemistry

General facilities
- Class 100 clean room
- Cold room for storage and preparation
- Controlled shelf temperature lyophilizer
- Silicon graphics IRIS workstation
- Freeze-fracture apparatus
- High-speed ultracentrifuges
- Inert atmosphere dry box
- Langmuir-Blodgett film balance



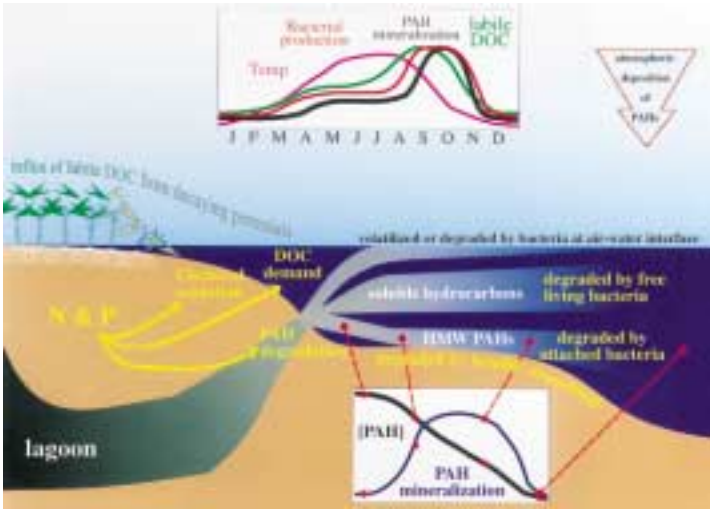
Schematic of thermally isolated pixel structures developed for high IR sensitivity

Chemistry Division

Synthesis/processing facilities
- Paint formulation and coating
- Functional polymers/elastomers and their composites
- Langmuir-Blodgett film
- Surface cleaning/modification
- Thin film deposition/etching with in-situ control
- Aerogel

Characterization facilities
- SOA chemical analysis
- Surface diagnostics
- Nanometer scale composition/structure/properties
- Magnetic resonance
- Mechanical properties–bulk and surface
- Polymer structure/function

Special purpose capability
- Environmental monitoring/remediation
- Synchrotron interfacial spectroscopy/structure
- Combustion and fire research
- Alternate and petroleum-derived fuels
- Simulation/modeling
- Marine Corrosion Facility

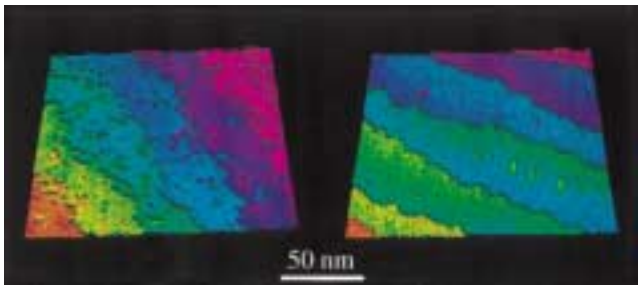


Hydrocarbon contaminant cycling in a complex ecosystem

Electronics Science and Technology Division

- Nano- and microelectronics characterization and processing facilities
- Electron-beam nanowriters
- Femtosecond laser facility
- High-resolution transmission electron microscope
- Scanning tunneling microscopy and electro-optical analysis
- Crystal-growing facilities including bulk growth, molecular beam expitaxy, and organo-metallic chemical vapor deposition

Optical and electrical characterization of materials
Electronic testing and analysis facilities
Vacuum electronics engineering facility



Scanning tunneling microscope images of eight molecular layers of indium arsenide (InAs) on gallium antimonide (GaSb) obtained during the growth of an InAs/GaSb superlattice

Flight Support Detachment

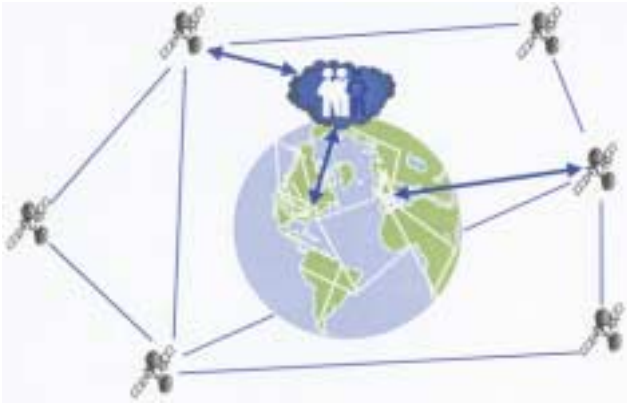
Five research configured NP-3D aircraft
Deployable worldwide
10+ hours endurance
Reconfigurable interior to accommodate a wide variety of projects and their associated equipment
Supports projects from a wide range of areas including meteorology, surveillance and sensor, marine geosciences, optical sciences, radar, remote sensing, and tactical electronic warfare

P-3 airborne research facility

Information Technology Division

Extensive computer facilities
HF modem and channel simulation
Brandywine antenna range
Pomonkey test range
Signal analysis laboratory
Artificial intelligence computer network
Distributed simulation and prototyping test bed
HCI laboratory
Certification and INFOSEC engineering laboratory
Virtual reality laboratory

DoD High Performance Computing Modernization Program (HPCMP) Distributed Center (DC)
Silicon Graphics Onyx II/infinity reality monster (24 processor nodes/4 graphics pipes)
High-speed ATM network (backbone and to the desktop)
Distributed file systems with authentication (Andrew File System/Multi-Resident Andrew File System (AFS/MRAFS))
Silicon Graphics/Cray Origin2000 (128 processor nodes, 24 Gbytes memory)
Sun Ultra HPC (96 processor nodes, 20 Gbytes memory)
ADIC file server (200 terabytes tertiary storage)
Labwide network, NICEnet, providing labwide computer communications, video services, and gateways to networks and computer systems worldwide
Satellite dishes for video and data reception
Microwave antennas receiving ITV from local universities
File server/archiver system for central file storage of labwide data
Visualization laboratory
Labwide ADP training facility

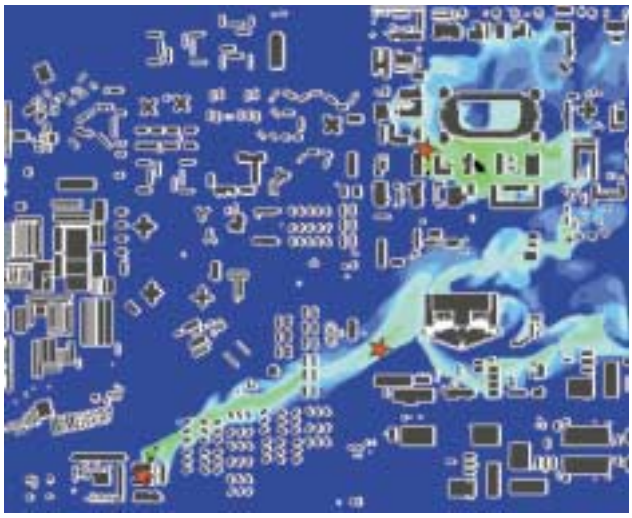


Global information for warfighters

Laboratory for Computational Physics and Fluid Dynamics

Eighteen-processor SGI Power Challenge
Twenty-four processor SGI Origin 2000
Thirty-two processor SGI Origin 2000
Sixty-four processor HP Exemplar
Sixteen-processor HP Exemplar
Three-fourths terabyte RAI Disk Storage Systems
Six-processor SGI Power Onyx workstation
D2 Digital video and animation laboratory
SUN Microsystems 670MP workstation server
Over sixty SUN, SGI, and MACINTOSH workstations

All computers and workstations have network connections to NICENET and ATDNET allowing access to the NRL CCS facilities (including the DoD HPC resources) and many other computer resources both internal and external to NRL



Snapshot of contaminant distributions predicted by FAST3D-CT, 2 meters above ground level after being driven by 2.5 meter-per-second winds from the southwest for 7.5 minutes. The three release points are denoted in red.

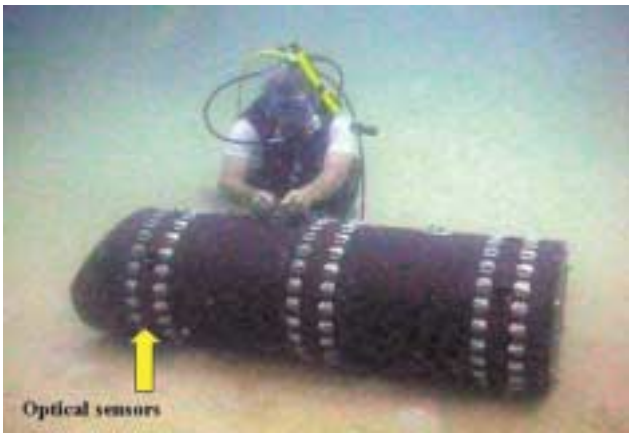
Laboratory for Structure of Matter

Two area detector systems
Two X-ray diffractometers
Zymark robotics
Four silicon graphics IRIS workstations
Protein and peptide chromatography
Atomic force microscope
High-intensity X-ray diffractometer associated with a charge-coupled recording device

Crystal structure of the opioid peptide DPDPE. The three unique peptide molecules (white, red, and yellow) surround a disordered water channel (green).

Marine Geosciences Division

Airborne gravimetry, magnetics, and topographic measurement suite coupled with differential GPS yielding position accuracies of <1.0 meter
100 and 500 kHz sidescan sonar with 2-12 kHz chirp profiler and Cs magnetometer for seafloor characterization/imaging and shallow subbottom profiling
Deep-towed acoustic geophysical system operating at 250-650 Hz characterizes subseafloor structure including gas clathrate accumulations and dissociation of methane hydrates
Acoustic seafloor classification system operating at 15-50 kHz provides underway, real-time prediction of sediment type and consistency
Seafloor probes for measuring sediment pore water pressures, permeability, electrical resistivity, and acoustic compressional and shear wave velocities and attenuations



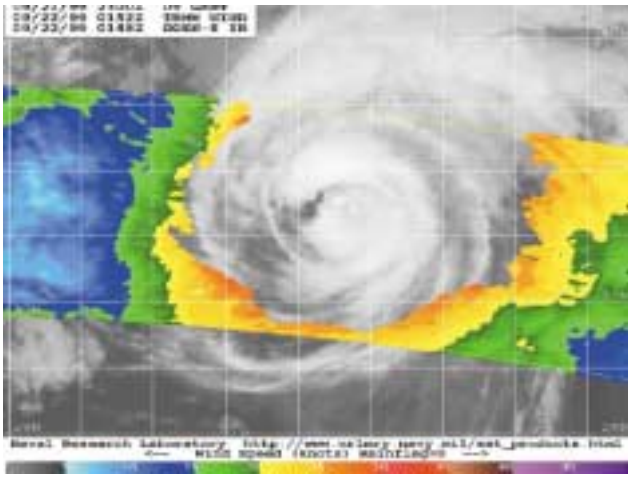
An instrumented mine has been developed by NRL to study burial at impact and subsequent burial by bedform migration, scour, and liquefaction. This instrument mine provides a tool for continuous monitoring of the movement of the mine (heading, pitch, and roll) as well as the percentage of the surface area of the mine actually buried.

100 and kV transmission electron microscopes with environmental cell for study of sediment fabric, especially impact of organic matter
Object-oriented digital cartographic modeling techniques and databases with Internet access
Map data formatting facility compresses map information onto compact disk-read only memory media for masters for use in aircraft digital moving map systems
Magnetic observatory conducts measurements of ambient field and other magnetic phenomena
Comprehensive geotechnical and geoacoustics laboratory capability
Airborne electromagnetic (AEM) bathymetry system

Ocean bottom magnetometer system
3-D, multispectral, subbottom swath imaging system
Ocean Bottom Seismographs (OBS)
In-Situ Sediment Acoustic Measurement System (ISSAMS)
Instrumental mine shape to measure rates and depths of scour burial
Hydrothermal plume imaging data acquisition and analysis system
Integrated digital databases analysis and display system for bathymetric, meteorological, oceanographic, geoacoustic, and acoustic data
Stereometric video image processing system for use in foreshore morphology measurement
Sediment gas-content sampler
Acoustic tomographic probes for surf zone sands and grassy muds

Marine Meteorology Division

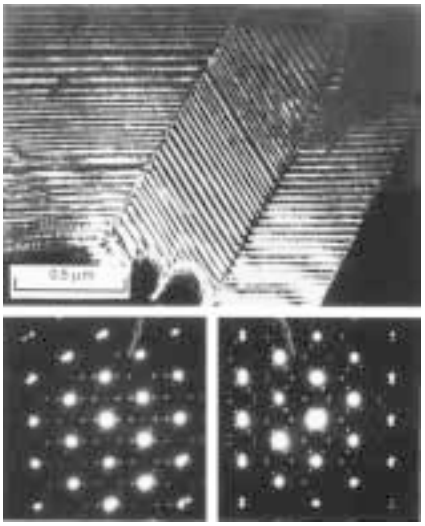
Tactical Environmental Support System (TESS) for fielding regional and shipboard METOC applications
SMQ-11 shipboard antenna system for retrieving polar-orbiting satellite data
Geostationary satellite data direct readout and processing center
Super-workstations for numerical weather prediction systems development
Master Environmental Library (MEL) implemented on super-workstations for archiving and distributing real-time and historical atmosphere/ocean databases
Data visualization center for developing shipboard briefing tools, displaying observations and model output, and integrating meteorological parameters into tactical simulations
The Naval Operational Global Analysis and Prediction System (NOGAPS) for global scale atmospheric simulations, prediction, and data assimilation experimentation
The Coupled Ocean Atmosphere Modeling and Prediction System (COAMPS), a multiscale, totally relocatable nested analysis and prediction system for coupled atmosphere-ocean simulation and prediction experimentation
The Tactical Atmospheric Modeling System/Real-Time; a workstation-based version of COAMPS that utilizes a user-friendly Graphical User Interface that allows the user to easily define the grid domain, size, and resolution; control the model output; and visualize the results



A multisensor satellite product for Hurricane Gert (21 September 1999) showing wind speed from the Tropical Rainfall Measuring Mission (TRMM) microwave imager, falsely colored every 5 knots, superimposed on coincident geostationary infrared data from GOES-8

Materials Science and Technology Division

Ultrasonic gas atomizer
Hot isostatic press
Cold isostatic press
High-energy, dispersive X-ray analytical system
Electron microprobe, SEM, SAM, and STEM systems
Quantitative metallography
Computer-controlled multiaxial loading and SCC measurement systems
Computer-interactive, non-linear, multimode fracture measurement system
Computer-aided, experimental stress analysis
Crystallite Orientation Distribution Function (CODF)
Thermoelectric parametric measurement system
Class 1000 clean room; processing metallic film



A transmission electron microscope image of twinning in a tantalum-ruthenium alloy, one of a new class of high-temperature shape memory alloys discovered at NRL, with electron diffraction patterns of the different twin variants

Elevated temperature and structural characterization laboratory
Non-destructive evaluation laboratory
Closed-loop, low- and high-cycle fatigue systems
Metallic film deposition systems
Magnetometry
Mossbauer spectroscopy
Cryogenic facilities
High-field magnets
Marine corrosion facility
High-resolution analytical electron microscope
Isothermal heat treating facility
Vacuum arc melting facility
Vacuum induction melting facility
3-MeV tandem Van de Graaff accelerator
200-keV ion-implantation facility
Synchrotron radiation beam lines (at NSLS, Brookhaven, NY)
Microwave test facility

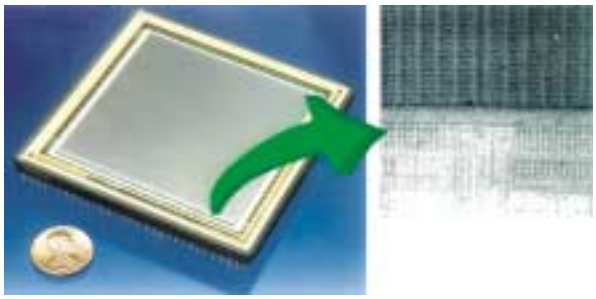
Oceanography Division

Towed sensor and advanced microstructure profiler systems for studying upper ocean fine and microstructure
Integrated absorption cavity and optical profiler systems for studying ocean optical characteristics
Environmental scanning electron microscope and confocal laser scanning microscope for detailed studies of biocorrosion in naval materials
Self-contained, bottom-mounted, upward-looking acoustic profilers for measuring ocean variability
Acoustic doppler profiler for determining ocean currents while under way
Remotely operated underwater vehicle (ROV)
Bottom-mounted acoustic doppler profilers
Towed hyperspectra optical array

Advanced microstructure profiler system for studying upper ocean fine structures

Optical Sciences Division

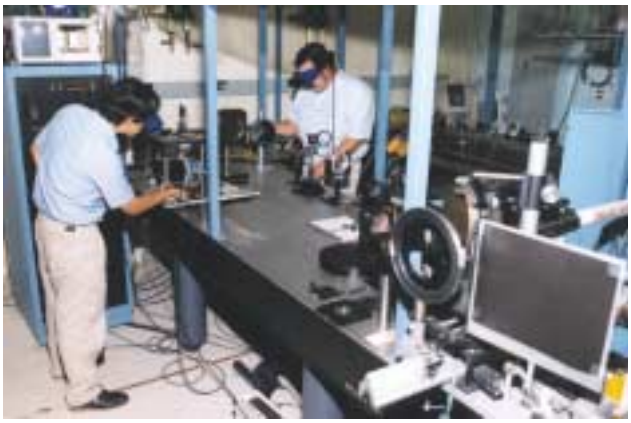
Electron-beam, electron-beam sustained, X-ray, and UV preionized laser devices with spectroscopic and other diagnostic equipment
Short-pulse excitation apparatus for kinetic mechanisms investigations
IR laser facility for optical characterization of semiconducters
Mobile, high-precision optical tracker
Facilities for synthesis and characterization of optical glass compositions and for the fabrication of optical fibers
Optical and digital image processing facilities
Silica and IR fluoride/chalcogenide fiber fabrication facilities
Facilities for fabricating and testing integrated optical devices
Optical probes laboratory to study viscoelastic, structural, and transport properties of molecular systems
Computer IR/EO technology/systems simulation center
High-energy pulsed chemical laser laboratory
Laser diode pumped 10 W 2 μm solid state lasers
Field-qualified EO/IR measurements devices
Focal plane array evaluation facility
Mid-IR, low-phonon crystal growth facility
Onyx-based multispectral image processing facility
Indoor IR test range
NRL P-3 aircraft sensor pallet
EO/IR high-resolution sensors
IRCM
Common data link
Infrared countermeasure techniques laboratory
Multi- and hyperspectral sensors and processing



Twenty-five million pixel EO focal plane array transitioned to several naval reconnaissance programs

Plasma Physics Division

PAWN, 1-MJ compact inductive storage facility
Gamble II, high-voltage, pulsed-power generators
HAWK, 1 MA inductive storage facility
PHAROS III, three-beam, neodymium glass laser and target facility
Table-Top-Terawatt (T^3) laser system
NIKE krypton fluoride laser facility
Large-volume space chamber (2 m × 5 m)
Microwave facility for processing of advanced materials (2.45, 35, 94, and 60-120 GHz)
Large-area plasma processing system

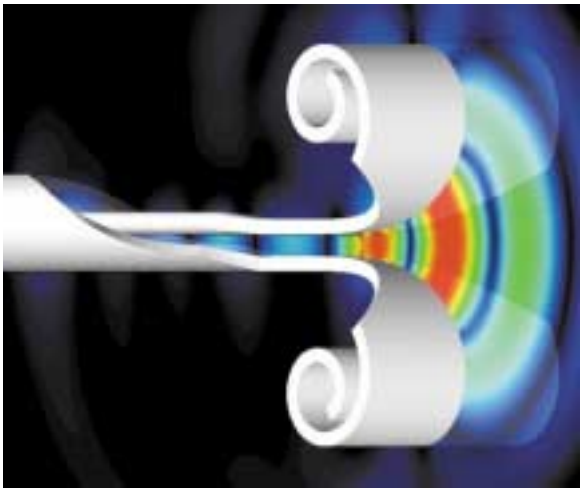


The NRL Table-Top-Terrawatt (T^3) Laser Facility. The T^3 laser currently operates at 0.4 ps, 2.5 TW, and 5×10^{18} W/cm^2 and provides a facility to conduct research in intense laser-plasma interactions, intense laser-electron beam interactions, and intense laser-matter interactions.

Radar Division

Shipboard radar research and development test beds:
- Senrad wideband air surveillance radar facility
- AN/SPQ-9B ADM
- Ship self-defense engagement system
- AN/SPS-49

Electromagnetic numerical computation facility
Airborne radar research facility, including advanced profile, high-resolution imaging radar and P-3 (1998) with APS-145 Group 2 and CEC
High-power 94 GHz radar system
Ultrahigh resolution radar system (microwave microscope)
Ship radar-cross-section computer prediction facility
Compact range antenna measurement laboratory and nearfield scanner
Experimental mode-stirred chamber for electromagnetic compatibility qualification
Space-time adaptive processing (STAP) laboratory
Electronic computer-aided design facility
Clutter research radar
Jet Engine Modulation (JEM) laboratory
Microwave and RF instrumentation laboratory
Cryogenic microwave and RF measurement facility
High-bandwidth, high-capacity data recording system



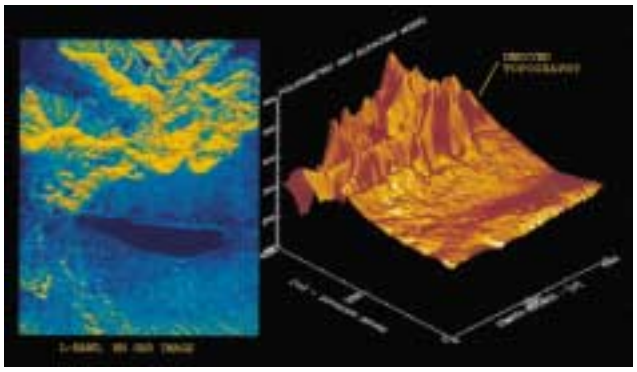
Radar Division and NRL High Performance Computing supercomputers were employed to design this ultra-wideband flared horn antenna that was awarded a U.S. patent. The Radar Division currently has dedicated access to two large memory multiprocessor supercomputers for electromagnetic calculations including ship scattering, antenna array design, and antenna isolation.

Remote Sensing Division

Polar ozone and aerosol monitor space sensor
Ground-based stratospheric water-vapor monitoring system
SAR processing facility
SCI processing facility
- SEALAB
- NASE LAB

Hyperspectral imaging, sensor, and processing
Navy prototype optical interferometer
WVMS NDSC instrument
Free surface hydrodynamics laboratory
Optical remote sensing calibration lab/facility
IRIS system and processor
SSM/I processing facility
STEMS-II boat
STEMS system
Lidar field system
Aerosol and field measurement facility
NRL RP-3A aircraft sensors
Airborne Lidar
MMW imagers (35,90,140, and 220 GHz)
DMSP SSM/I simulator
LFMR SST simulator
PRT-5 IR radiometer
Imaging real-aperture radar (RAR)
Precision altimeters

Rotating scatterometer
Tri-frequency-agile radar (TRIFAR)
X-band interferometer
AXBT
Flight-level meteorological sensors
Hyperspectral sensor system (PHILLS)
Ultra wideband SAR



Topography derived from polarimetric SAR image data using an NRL developed technique. Drinkwater Lake (dry) and a portion of the Tiefort Mountain Range (Ft. Irwin, CA) are shown.

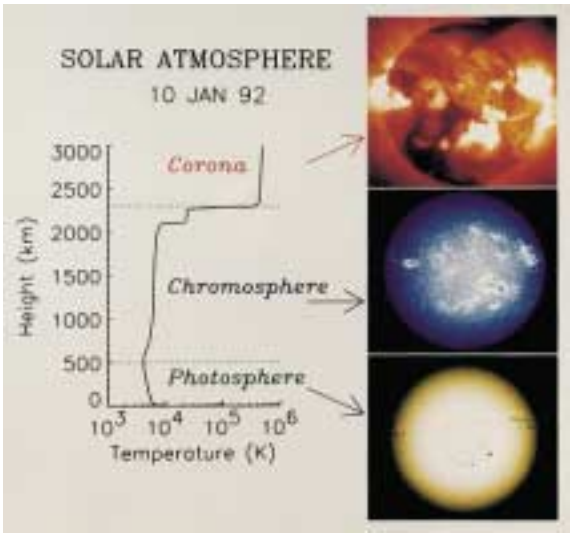
Spacecraft Engineering Department

Thermal-vacuum chambers
Acoustic reverberation chamber
Shock and vibration test facility
Clean-room facilities
Spacecraft-fabrication and assembly facility
Fuels test facility
CAD/CAM facility
Automatic welding facility
Static loads test facility
Spacecraft spin balance facility
Modal analysis facility

Spacecraft Robotics Engineering and Controls Laboratory, the world's largest dual platform dynamic motion simulator, supports research in space robotics: autonomous rendezvous and capture, servicing, remote assembly, and machine learning

Space Science Division

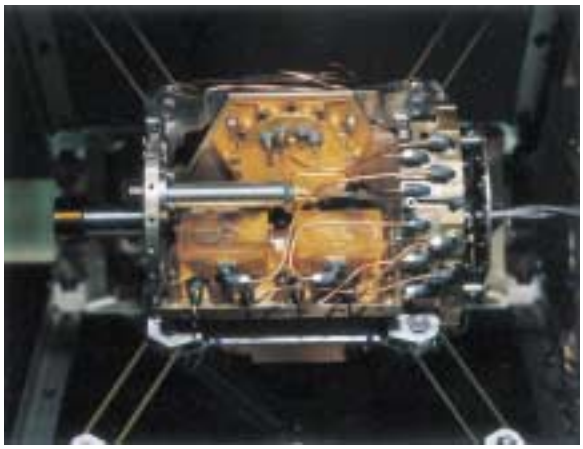
E.O. Hulburt Center for Space Research
Development and test facilities for spaceborne instruments to perform astrophysical, solar, high-atmospheric, and space-environment sensing
Clean-room facilities
Extensive computer-assisted data manipulation and interpretive capability for space-data imaging and modeling
Backgrounds Data Center (BDC) for analysis and archival storage of BMD-relevant natural backgrounds
Special Sensor Ultraviolet Limb Imager (SSULI) calibration facility
Ultraviolet remote sensing data center
Gamma Ray Observatory (OSSE) data analysis center
Solar instrument test facility
Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) operations and data analysis center
Large Angle White Light and Spectrometric Coronagraph (LASCO) operation and data analysis
Extreme-ultraviolet imaging telescope (EIT)
Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI) to measure OH and NO in middle atmosphere
Advanced Research and Global Observation Satellite (ARGOS) operations and data analysis
Ultraviolet and X-ray imaging of the upper atmosphere and astronomical objects



The temperature of the solar atmosphere rises from the photosphere out into the corona. Images taken in the light of emission lines arising from different stages of ionization and thus temperature probe different heights in the solar atmosphere. Here are shown images taken in the continuum, Ca II and Fe XV, which probes the photosphere, the (relatively) cool chromosphere, and the hot corona respectively.

Space Systems Development Department

Payload test facility and processor development laboratory
Spacecraft high-reliability electronic and electrical production facility
Spacecraft electronic systems integration and test facility
Spacecraft electrical power systems and battery laboratories
Tactical Technology Development Laboratory (TTDL)
Electromagnetic interference/electromagnetic compatibility (EMI/EMC) screen room test facility
Precision oscillator (clock) test facility
Radio frequency (RF) system development facility
RF microcircuit fabrication clean-room facility
Large tapered horn RF anechoic chamber facility
RF payload development laboratory with anechoic chamber
Precision high-frequency RF compact range anechoic chamber facility
Satellite telemetry, tracking, and control facilities
Pomonkey field site/large antenna, space communications, and research facility
Midway Research Center/space communications and research facility



High Temperature Superconductivity Space Experiment (HTSSE-II) space flight cryogenic structure showing some of the HTS microwave devices prior to installation of thermal blanketing. Northrop Grumman, ComDev, TRW, Conductus, Lincoln Laboratory, NASA, and NRL provided space qualified HTS components for the experiment, which was designed and built by NRL. HTSSE-II launched as the primary of nine payloads aboard ARGOS, an Air Force Space Test Program satellite, on 23 February 1999.

Tactical Electronic Warfare Division

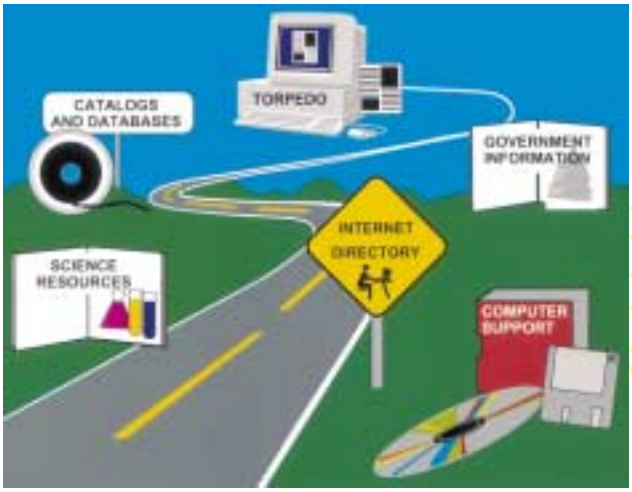
Mobile infrared signature measurement and simulation facility
Mobile ESM laboratory
Hybrid RF/IR missile-seeker simulation facility
Central target simulation facility for developing, testing, and evaluating EW systems and techniques, using real-time, hardware-in-the-loop models
RF simulation laboratory and signal simulators
Radar-cross-section measurement facility (at CBD)
Search radar ECM simulator
Advanced tactical EW environment simulator
Electronic warfare coordination test bed
Scale-model analysis facility
Wind tunnel for performance measurements of low-Reynold's number vehicles
Optical integration laboratory
Tempest signal-processing laboratory
Simulated ship-mast facility
Secure supercomputer facility
Vehicle development laboratory
Visualization laboratory

An ESM system, which features advanced signal processing technology to extract unique features from received radar signals to enable specific radar identification

Technical Information Division

History Office
Ruth H. Hooker Research and Technical Information Center:
- On-line catalog of unclassified publications
- LAN-based catalog of classified and unclassified publications
- Web access to journals, reports, press releases, NRL publications
- Digital library projects with association, commercial, and government publishers
- Consortial relationship with NIST, NASA, Goddard Space Flight Center, NSA

Writing, editing, and publication services
Graphic design and printing services
Imaging Center
NRL Exhibit Program: display, design, production
Multimedia design and production
Video editing suite
Scientific and technical photography
Auditorium services
Mail handling services
Correspondence review and archives services
Forms Supply Store
Electronic forms and forms design



Ruth H. Hooker Research and Technical Information Center web page

TRANSITIONING OF NRL TECHNOLOGY TO EXTERNAL ORGANIZATIONS

Office of Research and Technology Applications (ORTA) Program

Many of NRL's research efforts have applications well beyond their original defense-oriented objectives. Products, materials, and techniques developed by NRL research programs often have additional applications in the commercial or civilian sectors. NRL developments in areas such as radar, radio, satellite navigation, fire fighting, and a wide variety of materials and coatings have made significant contributions to the safety and welfare of the civilian sector. The ORTA Program ensures full use of the results of the nation's federal investment in research and development by transferring federally owned or originated technology to the private sector and to state and local governments.

NRL has a long history of working with industry and academia to assist in the transition of its products into non-military applications. This process was facilitated by the establishment of NRL's Technology Transfer Program. Through this program, technology developed at NRL for defense applications is made available to provide timely solutions to meet important civilian needs in such fields as safety, environmental protection/restoration, pollution control, transportation, telecommunications, health, and education. Mechanisms for technology transfer include Cooperative Research and Development Agreements (CRADAs), licensing of inventions, and work for outside parties.

Contact (202) 404-8411.
URL: http://techtransfer.nrl.navy.mil/index.html

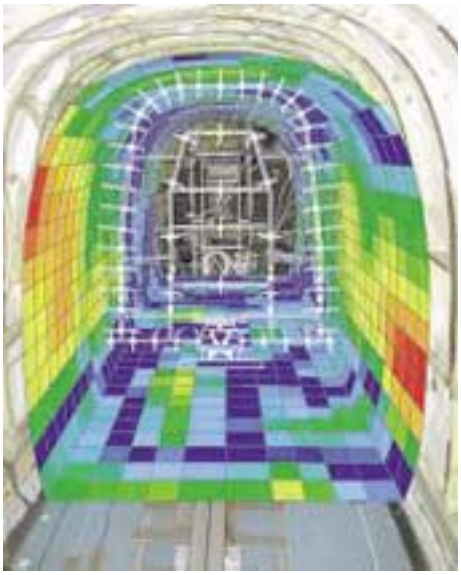
High-power erbium-doped fiber amplifier that is manufactured and sold worldwide by OptoCom Innovation under license from NRL

Cooperative Research and Development Agreements (CRADAs)

To promote the timely transfer of technology from government laboratories to the private sector and to improve the competitiveness of U.S. industry, Congress passed the Federal Technology Transfer Act (FTTA) of 1986. With this legislation, Congress authorized federal organizations to enter into CRADAs with non-federal parties. The objective of a Navy CRADA is cooperative research that will enhance the mission of the Navy and benefit the non-Navy party. The CRADA defines the individual responsibilities of the Navy and non-Navy parties toward achieving the objective, as well as rights to intellectual property developed under the CRADA. The Navy party in a CRADA may provide personnel, facilities, and equipment to perform the cooperative research. The non-Navy party may provide personnel, facilities, equipment, and funding. CRADAs can be established with industrial organizations, industrial development organizations, non-profit organizations, universities, state and local governments, licensees of inventions owned by federal agencies, and other federal agencies.

NRL signed the Navy's first CRADA in 1989. Since that time, the Laboratory has continued to pursue and promote this program actively. NRL has entered into CRADAs directed at the development of novel techniques for airport luggage screening, detectors for drugs of abuse, location and mapping devices for unexploded ordnance, fiberoptic dosimeters for radiation exposure, and other technological advances that have impacted the military and the civilian sectors.

Contact (202) 767-3083.
URL: http://techtransfer.nrl.navy.mil/index.html



Under a CRADA with Cessna Aircraft Company, nearfield acoustical holography has been combined with boundary element methods to model airplane fuselage vibration. In this reconstruction, highest vibration levels are observed on the wall in front of the propellers and on the floor in front of the wing support.

Under a CRADA, NRL and the University of Texas at Houston have developed a system for two-way communication of emergency medical information between an ambulance in the field and a hospital trauma center. A standard ambulance (left) has been retrofitted with the jointly developed hardware and software for use by emergency medical personnel (above).

Licensing of Navy Inventions

Because of the enactment of the FTTA, the effort to encourage the commercial use of government-funded technology has expanded in the federal laboratories. Title 35, Section 207, of the United States Code authorizes federal agencies to license their patents. The license authorizes the licensee to manufacture and market the product while allowing government inventors and the laboratories where they work to share the royalties generated by commercial licensing of their inventions.

NRL supports an active licensing program and has over 1,000 patents available for licensing in fields as diverse as advanced materials, chemistry, biotechnology, optics, ocean and atmospheric sciences, electronics, radar, and satellite technology. NRL has licenses with small and large U.S. businesses, foreign and multinational businesses, and non-profit organizations and universities. The majority of NRL's licensees are U.S. small businesses.

Contact (202) 404-8411.
URL: http://techtransfer.nrl.navy.mil/index.html

Under license from NRL, Lake Shore Cryotronics, Inc. markets this Hall Effect Measurement System for research and development applications where highly accurate materials characterization is required. NRL scientists have been working with Lake Shore to integrate improvements to the system under the scope of a Cooperative Research and Development Agreement (CRADA).

Work for Non-federal Parties

NRL has many unique capabilities that may enhance the R&D efforts of organizations external to NRL. When NRL's capabilities are unique and making them available to the public would not constitute undue competition with industry, NRL may sell testing, other services, and articles to non-federal parties. If it is in the interest of national defense, NRL may make the capabilities of its facility available for the testing of materials, equipment, models, computer software, and other items. NRL may sell articles, or services other than testing at NRL, if the sale requires no more than incidental subcontracting and the non-federal party agrees to hold harmless and indemnify the United States. The Navy requires advance payment, and incremental funding is often acceptable.

Contact the Office of Counsel at (202) 767-2244

An example of one of NRL's unique facitilities is the Epicenter for Advanced Materials Growth and Characterization shown above. The facility includes six multiple, interconnected ultrahigh vacuum systems for molecular beam epitaxial film growth, etching, and film analysis. Film analysis is accomplished with an angle-resolved electron spectrometer and a scanning tunneling microscope.

Letters of Intent

With increasing frequency, funding agencies are granting R&D programs to consortia consisting of industry, national laboratory, and/or university members. NRL participates actively in research consortia on programs funded by ONR, DARPA, and other public and private funding agencies. At the proposal phase of such programs, NRL may submit a letter of intent describing the work NRL will perform on a best efforts basis, if the proposal is funded. The funded programs may result in a CRADA between NRL and one or more of the other consortium members or, in those cases where NRL's contributions are unique, may be structured as a work for non-federal parties agreement whereby a government contractor subcontracts work to NRL from its prime contract. Whenever possible, NRL arranges for direct funding of its efforts by a U.S. Government agency via the Economy Act.

Contact the Office of Counsel at (202) 767-2244

Memoranda of Understanding

NRL scientists participate actively with scientists from other federal laboratories and organizations on projects of national interest. Such collaborations among federal organizations may be formalized with a Memorandum of Understanding or a Memorandum of Agreement that defines the scope of the work and the responsibilities of each federal party toward achieving the objectives. NRL has entered into Memoranda of Understanding or Agreement with the Army, Navy, Air Force, Marine Corps, Department of Energy, and other U.S. Government activities.

Contact the Office of Counsel at (202) 767-2244

Funding External Activities

In addition to actively performing research, NRL supports various R&D projects that directly relate to its ongoing work. This support is provided through contracts and grants with industrial firms, colleges and universities, and non-profit organizations.

NRL outsources an average of $370 million per year for contracts and grants and about $50 million per year for small purchases. Performers are competitively selected after review of proposals submitted in response to Broad Agency Announcements (BAAs) or Requests for Proposals (RFPs).

NRL encourages industry, educational institutions, small businesses, small/disadvantaged business concerns, historically black colleges and universities, and minority institutions to submit proposals in response to BAAs.

Broad Agency Announcements

BAAs are issued under the provisions of paragraphs 35.016 and 6.102(d)(2) of the Federal Acquisition Regulation, which provides for the competitive selection of research proposals for scientific study or experimentation directed toward advancing the state of the art or increasing knowledge or understanding. Proposals submitted in response to a BAA that are selected for award are considered to be the result of full and open competition and are in full compliance with the provisions of Public Law 98-369, "The Competition in Contracting Act of 1984." The typical range of funding for contracts under NRL BAAs is $100,000 to $5 million. In FY 2000, NRL awarded $60 million under BAA procedures.

To be eligible for a contract award, prospective offerors (with the exception of other federal government activities) must meet certain minimum standards pertaining to financial resources, adequacy of accounting systems, ability to comply with performance schedules, record of prior performance, integrity, organizational structure, experience, operational controls, technical skills, facilities, and equipment.

Current BAA information, including award considerations and instructions for submitting proposals, is available on the Internet at the following address:

http://heron.nrl.navy.mil/contracts/baa.htm

For additional information contact (202) 767-6263.

Commercial Contracts/ Procurements

Information for small businesses may be obtained by contacting Mrs. Michelle Nicholl on (202) 767-6263, FAX (202) 767-0494, or e-mail nicholl@contracts.nrl.navy.mil.

NRL also contracts with commercial firms, non-profit organizations, and academic institutions to obtain specific products and services. These contracts and purchases are for equipment (either complete systems or components), professional and technical services supporting the Laboratory's ongoing R&D programs, and special projects. NRL contract opportunities are announced as Request for Proposals (RFPs) and are advertised in the *Commerce Business Daily*.

For contracts, contact the Contracting Division at (202) 767-5227. For simplified acquisitions, contact the Supply Division at (202) 767-2374.

Grants

A grant is another mechanism used by NRL to fund outside activities. Grants are made primarily to educational and non-profit organizations for proposals submitted under BAAs. NRL occasionally enters into cooperative agreements for research traineeships or fellowships (see *Visiting Scientist and Engineer Programs*, p. 26) and awards small grants for S&T conferences and symposia. NRL awards from 25 to 50 grants per year. In FY 2000, the Laboratory awarded $10 million through grants and cooperative agreements.

For grants, contact the Contracting Division at (202) 767-5227.

Visiting Scientist and Engineer Programs

These programs enhance the quality of the Laboratory's research programs through interchanges with highly capable scientists and engineers and by providing opportunities for outside scientists and engineers to work in a Navy laboratory and related environments. Along with enhancing NRL research, these programs also acquaint participants with the Navy's capabilities and concerns.

• **The National Research Council Cooperative Research Associateship Program** selects physical scientists to conduct research at NRL in their chosen fields in collaboration with the Laboratory's scientists and engineers. The tenure period is two years, after which some associates may be offered a post-tenure research grant at an academic institution.

• **The American Society for Engineering Education (ASEE) Fellowship Program** is aimed at identifying graduate engineers for limited-tenure appointments at NRL. Appointments are for one year (renewable for a second and sometimes a third year). These competitive appointments are made by the ASEE.

• **The Consortium for Oceanographic Research Education Postdoctoral Fellowship Program** is administered in much the same manner as are the above two programs. However, this program is focused on selecting associates with advanced degrees in the oceanic and atmospheric environmental sciences. The purpose of this program is to recruit scientists and engineers in these specialized areas.

An NRC-NRL Postdoctoral Associate in the Surface Chemistry Branch

• **The Navy Summer Faculty Research Program** is also administered by the ASEE. This program is for university faculty members who work for 10 weeks with professional peers in participating Navy laboratories on research projects of mutual interest.

• **The United States Naval Academy (USNA) Cooperative Program for Scientific Interchange** allows faculty members of the USNA to participate in NRL research. This collaboration benefits the Academy by providing the opportunity for USNA faculty members to work on research of a more practical or applied nature. In turn, NRL's research program is strengthened by the available scientific and engineering expertise of the USNA faculty.

• **The National Defense Science and Engineering Graduate Fellowship Program** helps U.S. citizens obtain advanced training in scientific and engineering disciplines critical to the Navy. The three-year program awards fellowships to recent outstanding graduates to support their study and research. This research must lead to doctoral degrees in specified disciplines, such as electrical engineering, computer sciences, material sciences, applied physics, and ocean engineering. Award recipients are encouraged to continue their study and research in a Navy laboratory during the summer.

For information on the above programs, contact (202) 404-7450.

Dr. Timothy Coffey, Director of Research (front row, third from left) and the NRL 2000 Summer Faculty

Annual NRL Intellectual Output

The Navy continues to pioneer in the initiation of new developments and in applying these advancements to military requirements. The primary ways to inform the scientific and engineering communities of the advances made at NRL are through the Laboratory's technical output—reports, articles published in scientific journals, contributions to books, papers presented to scientific societies and topical conferences, patents, and inventions.

The figures listed below represent the 1999 output of NRL's facilities in Washington, DC; Stennis Space Center, Mississippi; and Monterey, California. In addition to the output listed, NRL scientists made more than 1,822 oral presentations in 1999.

NRL Contributions in 1999	Total
Articles in periodicals, chapters in books, and papers in published proceedings	1,117
NRL Formal Reports	30
NRL Memorandum Reports	97
Patents granted	88
Statutory Invention Registrations (SIRs)	4

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February 2001

Dr. Timothy Coffey
Director of Research

URL:http://www.nrl.navy.mil/