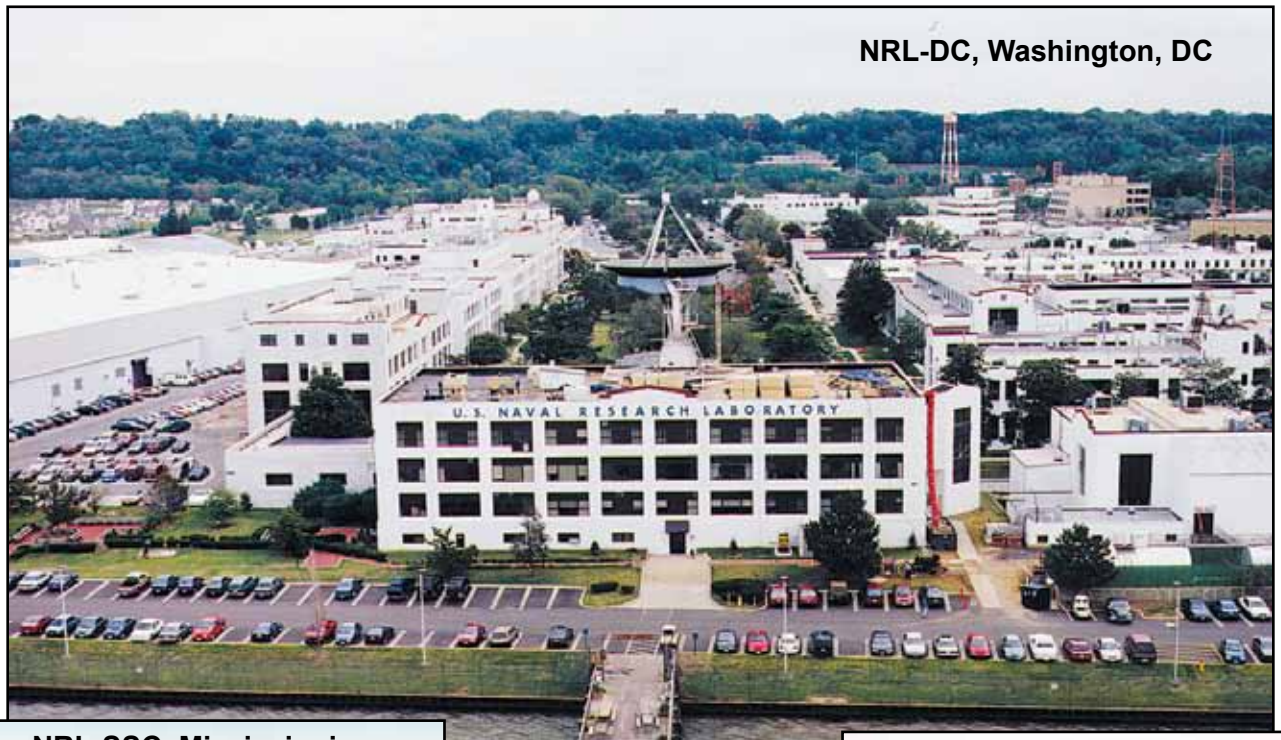
NAVAL RESEARCH LABORATORY'S

MAJOR FACILITIES 2013



NRL-DC, Washington, DC

NRL-SSC, Mississippi

CBD, Chesapeake Beach, MD

NRL-MRY, Monterey, CA

Ex-USS *Shadwell*, Mobile, AL

VXS-1
Patuxent River, MD

Further than you can imagine[SM]

EXECUTIVE DIRECTORATE

Code 1100 – Institute for Nanoscience
- Nanoscience Research Laboratory

Code 1600 – Scientific Development Squadron ONE (VXS-1)
Code 1700 – Laboratory for Autonomous Systems Research

BUSINESS OPERATIONS DIRECTORATE

Code 3500 – Research and Development Services Division
- Chesapeake Bay Detachment (CBD)

SYSTEMS DIRECTORATE

Code 5300 – Radar Division
- Advanced Multifunction Radio Frequency Concept (AMRFC) Testbed
- Radar Imaging Facility
- Radar Signature Calculation Facility
- Compact Range Facility
- Millimeter Wave Radar Facility
- Radar Test Facility
- Microwave Microscope

Code 5500 – Information Technology Division
- Freespace Communications Testbed
- Mobile Robot Laboratory
- Audio Laboratory
- Mobile Network Modeling Laboratory
- Integrated Communications Technology Test Laboratory
- General Electronics Environmental Test Facility
- Cognitive Radio Test Bed\
- Key Management Laboratory
- Cryptographic Technology Laboratory
- Navy Cyber Defense Research Laboratory
- Wireless Security Laboratory
- Navy Shipboard Communications Testbed
- Virtual Reality Laboratory
- Visual Analytics Laboratory
- Immersive Simulation Laboratory
- Warfighter Human-Systems Integration Laboratory
- Motion Imagery Laboratory
- Global Information Grid and Advanced Networking Facility
- Large Data Research Laboratory
- Affiliated Resource Center for High Performance Computing
- Ruth H. Hooker Research Laboratory

Code 5600 – Optical Sciences Division
- Nanochannel Glass Technology Facility
- Organic Opto-Electronics Fabrication and Characterization Facility

- Fiber Fabrication Facility for Non-Oxide and Specialty Glasses
- Laboratory for Research in Integrated and Advanced Thin Films
- Fiber-Optic Optical-Microwave Laboratory
- Ground Station Exploitation Laboratory
- IRCM Techniques Laboratory
- DIRCM Evaluation Facility
- Missile Warning System Facility
- Fiber-Optic Sensor Facility
- Oxide Optical Fiber Fabrication Facility

Code 5700 – Tactical Electronic Warfare Division

- Ultra-Near-Field Test Facility
- RF and Millimeter-Wave Laboratory
- Optics Laboratory
- Blackroom Laboratory
- Secure Computational Facility
- Human Perception Laboratory
- BSDF Measurement Facility
- Large-Scale Non-lithographic Processing (NLP) Facility
- Environmental Weathering Laboratory
- Vehicle Development Laboratory
- Offboard Test Platform
- Mobile Radio Frequency Measurements Laboratory
- Compact Antenna Range Facility
- MMW Antenna Range Facility
- RFCM Techniques Chamber Facility
- Low-Power Anechoic Chamber
- High-Power Microwave Explosive Laboratory
- High-Power Microwave Research Facility
- Electro-Optics Mobile Laboratory
- Infrared/Electro-Optical Calibration and Characterization Laboratory
- Infrared Missile Simulator and Development Laboratory
- Secure Supercomputing Facility
- CBD/Tilghman Island IR Field Evaluation Facility
- Ultra-Short-Pulse Laser Effects Research and Analysis Laboratory
- Central Target Simulator Facility
- Flying Electronic Warfare Laboratory
- Visualization Laboratory

MATERIALS SCIENCE AND COMPONENT TECHNOLOGY DIRECTORATE

Code 6040 – Laboratories for Computational Physics and Fluid Dynamics

- Parallel High Performance Computer Graphics Facility

Code 6100 – Chemistry Division

- Chemical Analysis Facility
- Mass Spectrometry Facility
- Magnetic Resonance Facility

- Corrosion Engineering and Coatings Characterization Facilities
- Ballast Water Treatment Test Facility
- Cathodic Protection Model Facility
- Sacrificial Anode Qualification Site
- Antifoulant Coatings Exposure Site
- Marine Coatings Facility
- Chemical Vapor and Plasma Deposition Facility
- Nanometer Characterization/Manipulation Facility
- Trace Explosives Testbed
- Complex Trace Vapor Generator Facility
- Chemical Dosimeter Exposure Testbed
- Navy Fuel Research Facility
- Fire Research Enclosure
- Large-Scale Damage Control Facility
- Ex-USS *Shadwell* Advanced Fire Research Ship
- Chesapeake Bay Detachment Fire Test Facility

Code 6300 – Materials Science and Technology Division

- Materials Processing Facility
- Micro/Nanostructure Characterization Facility
- Mechanical Characterization Facility
- Electrical, Magnetic, and Optical Measurement Facility
- Thin-Film Materials Synthesis and Processing Facility
- Magnetoelectronics Fabrication Facility
- Secondary Ion Mass Spectrometer/Single-Stage Accelerator Mass Spectrometer

Code 6700 – Plasma Physics Division

- Nike KrF Laser Facility
- Electra Repetitive Electron Beam Facility
- SWOrRD Laser Facility
- Railgun Materials Testing Facility
- Plasma Applications Laboratory
- Space Physics Simulation Chamber (SPSC)
- Gamble II Facility
- Hawk Facility
- Mercury Facility
- High-Frequency Microwave Processing of Materials Laboratory
- Laboratory for Microwave and Particle Beam Generation and Applications
- Intense Laser Interaction Physics Laboratory
- Directed Energy Laser Physics Laboratory

Code 6800 – Electronics Science and Technology Division

- Solar Cell Characterization Facility
- Optoelectronic Scanning Electron Characterization Facility
- Ultrafast Laser Facility (ULF)
- Infrared Sensor Characterization Laboratory
- Millimeter-Wave Vacuum Electronics Fabrication Facility (MMW-VEFF)

- Ultra-Violet Photolithography Laboratory for Submillimeter Devices (UV-PL)
- Compound Semiconductor Processing Facility
- Atomic Layer Deposition System
- Epicenter
- Power Electronics Characterization Facility
- Laboratory for Advanced Materials Synthesis
- Advanced Silicon Carbide Epitaxial Research Laboratory
- High Pressure Laboratory

Code 6900 – Center for Bio/Molecular Science and Engineering

- Micro Fabrication Facility for Microfluidics
- Quadruple Time-of-Flight Mass Spectrometer
- Advanced Microscopy Facility
- Automatic X-ray Diffractometers

OCEAN AND ATMOSPHERIC SCIENCE AND TECHNOLOGY DIRECTORATE

Code 7100 – Acoustics Division

- Shallow Water Acoustic Laboratory
- Laboratory for Structural Acoustics
- Structural Acoustics In-Air Facility
- Rail-based Broadband Synthetic Aperture Ocean Measurement System
- Geoacoustic Physical Model Fabrication Laboratory
- Acoustic Communications Measurement Systems (ACOMMS)
- High-Frequency Acoustic Flow Visualization Sonar Systems (HFAFV)
- Instrumentation Suite for Acoustic Propagation Measurements in Complex Shallow Water Environments
- Autonomous Acoustic Receiver System
- Salt Water Tank Facility
- Underwater Acoustic Time-Reversal Mirror
- 300 Hz and 500 Hz Autonomous Acoustic Sources
- Sediment Geo-Probe System
- Drifting Echo Repeater
- Shallow Water Ship Acoustic Signature System
- Sono-Magnetic Laboratory (SOMALab)
- Fabrication Workshop
- Low Frequency Sound Tube
- Measurement Laboratory
- Shallow-Water High-Frequency Measurement Systems

Code 7200 – Remote Sensing Division

- Naval Prototype Optical Interferometer (NPO)
- Optical Calibration Facility
- Free Surface Hydrodynamics Laboratory

Code 7300 – Oceanography Division

- Ocean Sciences and Remote Sensing Research Facility
- Environmental Microscopy Facility
- Ocean Dynamics and Prediction Network

- Ocean Color Facility
- Real-time Ocean Observations and Forecast Facility (ROOFF)
- Littoral Measurements Facility
- Salinity Temperature and Roughness Remote Scanner (STARRS)
- Field Staging Facility
- Ocean Optics Instrumentation Systems
- Autonomous Underwater Vehicle Laboratory

Code 7400 – Marine Geosciences Division

- Transmission Electron Microscopy Facility
- Sediment Physical and Geotechnical Properties Laboratory
- Marine Biogeochemistry Laboratory
- Computed Tomography Scanning Facility
- Digital X-Radiography Scanning Laboratory
- Sediment Core Laboratory
- Sediment Dynamics Laboratory
- Moving-Map Composer Facility
- Geospatial Services Laboratory

Code 7500 – Marine Meteorology Division

- Meteorological and Oceanographic (METOC) Research Library
- Satellite Data Ingest and Processing System
- Meteorological Archival Facility
- Environmental Prediction System Development Laboratory
- Mobile Atmospheric Aerosol and Radiation Characterization Observatory (MAARCO)

Code 7600 – Space Science Division

- Vacuum Ultraviolet Calibration/Testing Facility
- Fermi Gamma Ray Telescope
- Neutron Characterization Laboratory
- Semiautomatic Probe Station
- Gamma-Ray Imaging Laboratory
- Large Angle Spectrometric Coronagraph (LASCO)
- Helium Resonance Scattering in the Corona and Heliospere (HERSCHEL)
- Rocket Assembly and Checkout Facility
- Solar Coronagraph Optical Test Chamber (SCOTCH)
- Space Instrument Test Facility (SITF)
- Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI)

NAVAL CENTER FOR SPACE TECHNOLOGY

Code 8100 – Space Systems Development Department

- Precision Radio Frequency Anechoic Chamber Facility
- Satellite Mission Analysis Facility
- Maritime Navigation Radar Test Range
- Blossom Point Satellite Tracking and Command Station
- Midway Research Center Precision Spacecraft Calibration Facility
- Precision Clock Evaluation Facility

Code 8200 – Spacecraft Engineering Department

- Modal Survey Test Facility
- Static Loads Test Facility
- Payload Processing Facility
- Thermal Vacuum Test Facility
- Spacecraft Acoustic Reverberation Chamber Test Facility
- Spacecraft Spin Test Facility
- Spacecraft Vibration Test Facility
- Spacecraft Thermal Analysis, Fabrication, and Test Facility
- Proximity Operations Testbed
- Class 100 Clean Room Facility
- EMI Test Facility
- 125-ft Tapered RF Anechoic Chamber Facility
- 20-ft Rectrangular RF Anechoic Chamber Facility
- 3-ft x 3-ft mmWave Near-Field Scanner

GENERAL INFORMATION

- Naval Research Laboratory (Washington, DC)
- Location of Buildings at NRL Washington
- Location of Field Sites in the NRL Washington Area
- Chesapeake Bay Section (Chesapeake Beach, MD)
- Location of Buildings at the Chesapeake Bay Section
- John C. Stennis Space Center (Stennis Space Center, MS)
- Naval Research Laboratory Monterey (Monterey, CA)
- Key Personnel

Auditorium and Conference Support

Video Teleconferencing Facilities

NRL Auditoriums/Meeting Facilities

Video Teleconferencing Facilities

Auditorium Support – Code 1006.4
(202) 404-5843 or (202) 767-2756
NRL, Washington, DC

Function:

Video teleconferencing (VTC) facilities enable verbal and visual communication between NRL-DC staff and up to three other locations that use standards-based VTC systems. VTC allows you to disseminate information without spending time, money, and energy in getting from place to place.

Description:

NRL's three VTC facilities are equipped with the latest technologies.

The facility in Bldg. 226 accommodates 18 people and can communicate with up to three other sites. With a PC, users can display computer-generated graphics, hard copy, transparencies, and small 3D objects.

The VTC facility in Bldg. 43 accommodates 40 people and can communicate with up to three other sites. Users can display hard copy, transparencies, and small 3D objects.

The Video Teleconference Room in Building 222 is a multipurpose video/video conference/local presentation facility. This room accommodates 45 people (plus a kitchen and breakout rooms that accommodate 18 people each).

Equipment:

The NRL video conference infrastructure consists of two Tandberg 3000MXP systems located in Bldgs. 226 and 222. There is also a Tandberg 880 MXP located in Building 43. All of these systems are set up to communicate with any standards-based VTC system over ISDN or IP networks. Through its bridging capability, this new infrastructure allows for collaboration with up to three other sites simultaneously.

NRL Auditoriums/Meeting Facilities

Auditorium Support – Code 1006.4
(202) 404-5843 or (202) 767-2756
NRL, Washington, DC

Function:

Accommodates the symposia needs of the NRL research and support communities.

Description:

NRL's auditoriums are located in Bldgs. 28 (main auditorium and executive dining hall), 60, 222 (main auditorium, science lounge with kitchen, and exhibit room), 226 (main auditorium, VTC facility, three breakout rooms, kitchen, and a banquet room), and Quarters A (with kitchen). All are equipped with state-of-the-art projection systems that support PCs, Macs, and video. These systems can be used as workstations and all are networked to support electronic displays. All of the auditoriums have a pre-function area for badging and registration and for serving refreshments.

Equipment:

All meeting facilities are equipped with electronic display devices, dedicated Mac and PC, and document camera, and all have the capability of connecting external PC/Mac laptops.

Institute for Nanoscience

Nanoscience Research Laboratory

Nanoscience Research Laboratory

Code 1100
(202) 767-1803
NRL, Washington, DC

Function:

Conducts innovative, multidisciplinary research at the intersections of the fields of materials, electronics, and biology in the nanometer size domain. Serves as NRL's nucleus of collaborative activity in this rapidly evolving research area. The current research program emphasizes cross-division efforts in nanomaterials, nanoelectronics, and nanosensors/devices.

Description:

The Nanoscience Research Laboratory opened in 2003. The central core of this major facility is a 5,000 ft^2 Class 100 fabrication clean room outfitted with tools to permit lithographic fabrication, measurement, and testing of devices. The equipment includes deposition systems for metals and insulators, optical mask aligners, and etching systems. The lithography effort is supported by chemistry stations and fume hoods for spinning on photo resists, baking, and developing the patterns that ultimately result in small devices and circuits. The building also includes 5,000 ft^2 of controlled-environment laboratory space (12 laboratories) available to NRL researchers whose experiments are sufficiently demanding to require this space. These laboratories all provide shielding from electromagnetic interference and very low floor vibration and acoustic levels. In addition, eight laboratories control the temperature to within 0.5 °C and four to within 0.1 °C.

Equipment:

In the nanofabrication facility: atomic force microscope (AFM); benchtop transmission electron microscope (TEM); cascade probe station; critical point dryer; dual beam focused ion beam; e-beam writer system; e-beam evaporator; ellipsometer; inductively coupled plasma – reactive ion etching systems (Cl, F); ion beam assisted deposition system; ion mill; laser micromachining tool; laser pattern generator; low pressure chemical vapor deposition system optical mask aligners (0.2, 1.2 μm); optical and fluorescence microscopes; plasma cleaner/etcher/asher; plasma enhanced chemical vapor deposition system; scanning electron microscope; sputter deposition system; surface profilometer; thermal evaporator; wire bonder.

In the quiet and ultra-quiet measurement laboratories: AFM; laser vibrometer; low-temperature transport measurement systems; low-temperature magnetic measurement systems; scanning tunneling microscope; nanoindentation and nanomanipulation tools; nanomechanical resonators; nearfield optical microscope; physical vapor deposition system; scanning Auger microscope; surface analysis tools; and TEM.

Scientific Development Squadron ONE (VXS-1)

Scientific Development Squadron ONE (VXS-1)

Scientific Development Squadron ONE (VXS-1)

Code 1600
(301) 342-3751
Naval Air Station Patuxent River, MD

NP-3D aircraft

RC-12 aircraft

Function:

Provides airborne research platforms to conduct and support worldwide research projects. Operates and maintains a fleet of four uniquely configured, research-modified aircraft.

SCAN EAGLE Unmanned Aircraft System

MZ-3A airship

Description:

Scientific and Development Squadron ONE is the Navy's only squadron dedicated to science and technology (S&T) research. Located aboard Naval Air Station Patuxent River along the western Maryland shore of the Chesapeake Bay, the squadron operates three NP-3D Orion aircraft and one RC-12 King Air aircraft configured to conduct multidisciplinary programs of airborne scientific research and advanced technological development. The majority of VXS-1 S&T flights are conducted as single aircraft detachments supporting research efforts related to bathymetry, electronic countermeasures, geophysical mapping, and radar development/processing across a variety of domestic and overseas locations to include relevant Fleet operational environments. The squadron also functions as the Aircraft Reporting Custodian for the Navy's only manned airship – the MZ-3A – as well as nine SCAN EAGLE Unmanned Aircraft Systems operated by the Naval Surface Warfare Center in Dahlgren, Virginia. These platforms support a wide range of DoD efforts as well as efforts at the Naval Research Laboratory.

The squadron operates out of Hangar 109, which is comprised of 15,300 ft^2 administrative and maintenance workcenter spaces, access to a 40,240 ft^2 enclosed hangar bay as well as a 5,240 ft^2 storage facility. Additionally, the squadron maintains two research project buildings aboard NAS Patuxent River.

The NXS-1 Commanding Officer is responsible for setting policy, scheduling aircraft assets, managing the daily activities of the squadron, and ensuring the safe and successful execution of scientific research projects tasked by the Naval Research Laboratory.

Laboratory for Autonomous Systems Research

Laboratory for Autonomous Systems Research

Laboratory for Autonomous Systems Research

Code 1700
(202) 767-2684
NRL, Washington, DC

Function:

This laboratory will become a nerve center for autonomy research for the Navy and Marine Corps.

Description:

The one-of-a-kind laboratory provides specialized facilities to support highly innovative research in intelligent autonomy, sensor systems, power and energy systems, human–system interaction, networking and communications, and platforms. The LASR capitalizes on the broad multidisciplinary character of NRL, bringing together scientists and engineers from diverse backgrounds to tackle common challenges in autonomy research at the intersection of their respective fields.The objective of the LASR is to enable continued Navy and Department of Defense scientific leadership in autonomy and to identify opportunities for advances in future defense technology.

Facilities:

- The **Prototyping High Bay** can be used for small autonomous air vehicles, autonomous ground vehicles, and, of course, the people who interact with them. The most unique feature of this space is a motion capture system, which allows us to track up to 50 objects and gather high-accuracy ground truth data of all positions of these tracked objects at 120 Hz.
- The **Littoral High Bay** features a 45 ft by 25 ft by 5.5 ft deep pool. This pool has a 16-channel wave generator, allowing us to create directional waves. In addition, the far side of the pool contains a structure allowing us to put a slope on that end of the pool. We have materials such as sand, dirt, and gravel that can then be put into the pool, allowing us to create surf-like conditions.
- The **Desert High Bay** contains a 40 ft by 14 ft area of sand 2 ft deep, and contains 18 ft high rock walls that allow testing of robots and sensors in a desert-like environment. We can introduce blowing sand, and can control the lighting in that environment.
- The **Tropical High Bay** is a 60 ft by 40 ft greenhouse that contains a re-creation of a southeast Asian rain forest, with temperatures that average 80 degrees and 80 percent humidity year round. Rain events of up to 6 inches per hour can be generated, allowing us to test autonomous systems, sensors, and communications in these harsh environments.

We have specialized laboratories for human–systems interaction, sensors, and power and energy. The four human–systems interaction labs overlook the Prototyping High Bay and can be used, as described earlier, as control rooms for human-subject experiments, or for development of autonomy software. These labs contain eye trackers (useful for studying how people work with advanced interfaces for autonomous systems) and multiuser/multitouch displays. The sensor lab contains environmental chambers (including a smaller chamber where temperature, humidity, and barometric pressure can be controlled and a large walk-in chamber with control of temperature and humidity), an anechoic chamber, and an aerosol test facility.

Research and Development Services Division

Chesapeake Bay Detachment (CBD)

Chesapeake Bay Detachment (CBD)

Code 3522
(410) 257-4002
NRL, Chesapeake Beach, MD

Description:

The main site at Randle Cliff (Chesapeake Beach), Maryland, covers 157.6 acres contiguous to the Chesapeake Bay with a 0.75-mile waterfront. It is located in a relatively clear area away from congestion and industrial interference. The facility maintains towers for antenna support and a ship motion simulator. Off-site facilities include a 2.6-acre site with a 75-ft tower located 10 nmi east at Tilghman Island, Maryland, and small-craft berthing located in the town of Chesapeake Beach, 2 nmi north of the main site. A test control center for air and sea operations is available to researchers who use the NRL/CBD test range. The test range is a restricted zone directly east of the main site and extending across the bay.

Research watercraft include a 74-ft LCM 8 and a 22-ft Boston Whaler. These are used primarily in support of research projects and secondarily as transport to Tilghman Island.

Function:

Operates and maintains a unique land, sea, and air facility for NRL research in areas such as radar, electronic warfare, optical devices, materials, communications, and fire research. It has a variety of plant facilities and specialized equipment to support NRL and tenant research and development projects.

Equipment:

The principal investigator is responsible for all instrumentation and test equipment.

Radar Division

Advanced Multifunction Radio Frequency Concept (AMRFC) Testbed

Radar Imaging Facility

Radar Signature Calculation Facility

Compact Range Facility

Millimeter Wave Radar Facility

Radar Test Facility

Microwave Microscope

Advanced Multifunction Radio Frequency Concept (AMRFC) Testbed

Code 5303
(202) 404-1945
NRL, Washington, DC

Function:

The AMRFC testbed was developed as a proof-of-principle demonstration system that is capable of simultaneously transmitting and receiving multiple beams from common transmit and receive array antennas for radar, electronic warfare, and communications. These RF functions are controlled by common resource allocation manager (RAM) software over a real-time control network. New RF functionality may be readily added to the testbed as required for further demonstrations.

Description:

Testbed electronics are housed in seven converted 20-ft shipping containers, or trailers. The arrays are mounted on a 15-degree tiltback in the ends of two of the trailers overlooking the Chesapeake Bay, emulating a possible shipboard installation. Packaging the testbed electronics into trailers provides the ability to support laboratory equipment in a protected environment, and provides options to transport testbed assets to other test locations, such as aboard ship. One set of stacked trailers is allocated to the transmit array and associated signal generation electronics. A second stacked trailer pair is allocated to the receive array and associated digital receiver, digital beamforming, and electronic surveillance receive electronics. A fifth trailer houses the testbed communication electronics, and the remaining two trailers provide the central processing, displays, and operations electronics. Additionally, a portable power plant, dry air supply, and chiller unit provide the testbed power and array cooling.

Instrumentation:

The testbed consists of separate active transmit and receive arrays that operate over the 6 to18 GHz band (nominally). Current functionality includes a multi-mode navigation/surface surveillance Doppler radar, multiple communication links (line of sight and satellite), and passive and active electronic warfare capabilities. Additionally, several fixed dish antennas are located at the site for testing with equipment located at Tilghman Island. An over-the-air Ethernet link was also developed for remote control of Tilghman Island equipment.

Radar Imaging Facility

Code 5313
(202) 404-1979
NRL, Washington, DC

Description:

The general computing resources available include general purpose multi-core PCs running both Linux and Windows operating systems. Software is developed under Unix/X-Windows and Matlab environments. Software is available for real-time playback of ISAR data and offline processing of SAR data. Data storage is provided by RAID systems, with a current online capacity of 96 TB (and easy upgrade through expansion chassis). All systems are connected by a 1Gb network, which also provides connectivity to the other branch facilities.

Instrumentation:

The facility includes a modified AN/APS-137D(V)5 radar with digital In-Phase/Quadrature (I/Q) data recording capability. This system is currently installed on the roof of Bldg. 75 at NRL's Chesapeake Bay Detachment (CBD) facility. A trailer is also configured to host the APS-137 for operation at sites other than CBD. The facility also includes a receive only system, designed to work with the APS-137 radar, that can collect bi-static data. The receive only system is capable of operating on-land or hosted on ship and airborne platforms (including NRL's RC-12 aircraft).

Function:

Provides the capability to produce real-time and non-real-time synthetic aperture radar (SAR) and inverse synthetic aperture radar (ISAR) imagery. This facility contains the processing, data storage, and image display and recording resources to handle data from a number of platforms and also serves as an environment for the development of advanced imaging algorithms. Radar hardware and digital data recorders provide the capability to collect high resolution data to support the development and evaluation of radar imaging techniques.

Radar Signature Calculation Facility

Code 5314
(202) 404-8602
NRL, Washington, DC

Description:

The facility consists of several high performance computers for calculating the radar signatures of complex objects such as ships and phased array antennas. The radar signatures are calculated from computer aided design (CAD) models that describe the geometry and material properties of objects. The facility currently includes models of the FFG 7, DD 963, DDG 51, DDG-1000, CG 52, LPD 17, LHA-6, and CVN 68 class ships. A large collection of CAD models of individual ship components such as antennas, weapons systems, and deck equipment is also available. The radar signatures of large objects are calculated using the Radar Target Signature (RTS) model. The RTS model is based on high-frequency scattering techniques and was developed by the Radar Division specifically for calculating the radar signature of ships in a sea multipath environment. The radar signature of smaller objects such as phased array antennas can be accurately calculated using any of several low frequency computational electromagnetic software packages available within the facility.

Function:

The calculation, analysis, and visualization of the spatially extended radar signatures of complex objects such as ships in a sea multipath environment and phased array antennas. Radar signatures that are typically calculated include total radar cross section (RCS), high range resolution (HRR) profiles, and inverse synthetic aperture (ISAR) images. The facility has been used on numerous Navy programs including the design and live fire test and evaluation of the DDG 51 and LPD 71 class ships.

Instrumentation:

The facility currently consists of a LINUX Cluster of 75 Apple Mac pros with a total of 840 processors and 3.4 TB of physical memory, several smaller LINUX and Microsoft Windows workstations, and a General Dynamics TACLANE KG-175 for secure communications with a facility shared with TEWD containing additional computer resources.

Compact Range Facility

Code 5314
(202) 404-8602
NRL, Washington, DC

Function:

Measures electrical properties and characteristics of antenna systems and performs radar cross section (RCS) measurements of objects. These data are used to verify and optimize the designs of new or existing platforms.

Description:

The facility contains a Scientific Atlanta Model 5706M compact range reflector that produces simulated farfield conditions from 1 to 110 GHz with a quiet zone (maximum usable size) approximately 7 ft in diameter and 8 ft in length. The compact range reflector is housed in an environmentally and mechanically stable room that measures 20 x 20 x 40 ft. The chamber also includes a nearfield scanner capable of scanning a 12 x 18 ft region and can be configured for planar, cylindrical, or spherical nearfield testing. The system also incorporates a FARO Laser Tracker unit that optically tracks the test probe to within an angular resolution of 0.02 arcseconds. This enables the scanner to be operated at millimeter wavelengths without any performance degradation.

Instrumentation:

The facility contains an Agilient E8362A microwave receiver (with external mixers) capable of operating from 1 to 110 GHz, a five-axis positioner controller, a pulsed continuous-wave system used for RCS measurements, and a two-axis nearfield scanner positioner unit. The data collection system is controlled by the FR 959 antenna/RCS software package and uses several computer systems for data analysis and acquisition. The software also includes inverse synthetic aperture radar (ISAR) imaging capabilities.

Millimeter Wave Radar Facility

Code 5340.1
(202) 767-0253
NRL, Chesapeake Beach, MD

Function:

Experimental high-power 94 GHz tracking radar system (WARLOC) for use in research involving target cross-section measurement, propagation effects, radar imaging, cloud research, and other research that requires very high range and angular resolution.

Description:

The WARLOC radar is housed in a relocatable radar facility that consists of two equipment shelters, a chiller for cooling the transmitter, and a 175 kVA diesel generator for use at remote sites. A 40-ft-long shelter houses the transmitter power supply, modulator, and gyro-klystron and incorporates structures to provide a pedestal base for the roof-mounted tracking antenna. A second 20-ft shelter contains the receiver, exciter, signal processing, and recording equipment. Data recording at rates up to 80 MB/s and a capacity of more than 80 GB is available. The transmitter is capable of producing 10 kW of average power with a variety of waveforms suitable for precision tracking and imaging of targets at long range. Waveforms with a bandwidth of 600 MHz can be transmitted at full power. A 6-ft Cassegrain antenna is mounted on a precision pedestal and achieves 62 dB of gain.

Instrumentation:

Real-time radar control, signal processing, and image formation are accomplished with a VME-based system. An optical tracking system is mounted on the antenna to help in target acquisition at short range.

Radar Test Facility

Code 5340.1
(202) 767-2999
NRL, Chesapeake Beach, MD

Function:

Supports test and evaluation of radar concepts, techniques, and technologies in realistic over-water environments. Systems support the demonstration of improved detection, tracking, and electronic protection techniques.

Description:

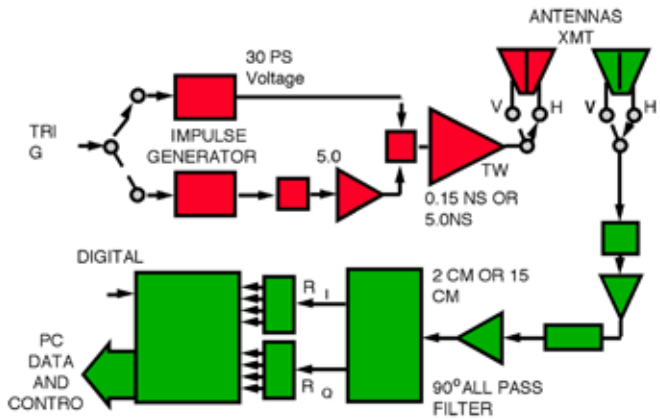
The Radar Test Facility is situated on top of a cliff overlooking the Chesapeake Bay, providing over water antenna heights comparable to many shipboard installations. Antennas for developmental and Navy product-line radar systems are located on the roof of a building or at ground level. Inside the building are the radar control rooms, transmitters, receivers, and data processing equipment.

Instrumentation:

Current instrumentation includes the AN/SPS-49 radar, the WARLOC radar, and an S-band system that is currently under development. When completed the S-band system will provide the ability to emulate the waveforms of a broad range of systems and support development of high performance detection, tracking, and electronic protection waveforms.

Microwave Microscope

Code 5348
(202) 404-1876
NRL, Washington, DC



Function:

Makes ultra-high-resolution field measurements. The Microwave Microscope (MWM) has been used in support of several NRL experimental programs involving sea scatter and mine detection.

Description:

The MWM, an ultra-wideband, ultra-high-resolution, dual-polarized measurement radar system, has been designed, implemented, and used in the field to measure ocean surface scattering at X-band frequencies. This experimental system uses a video-excited traveling wave tube (TWT) to produce 2-kW peak power transmit pulses as short as 150 ps in duration. Instantaneous receive bandwidths greater than 8 GHz are supported by a unique direct sampling detector that uses off-the-shelf digital sampling oscilloscope components. Data output consists of coherent I and Q measurements in a fixed number of range cells at resample periods as short as 25 μs. Final system range resolution is better than 2 cm. The system has been used at a field site at the Atlantic Undersea Test and Evaluation Center (AUTEC), in the Bahamas, to measure ocean surface scatter under high wind and rough sea conditions, and in laboratory buried-object (in sand) identification studies.

Instrumentation:

The MWM consists almost entirely of commercial off-the-shelf equipment. Antenna housings and polarization switching logic were designed and built at NRL.

Information Technology Division

Freespace Communications Testbed

Mobile Robot Laboratory

Audio Laboratory

Mobile Network Modeling Laboratory

Integrated Communications Technology Test Laboratory

General Electronics Environmental Test Facility

Cognitive Radio Test Bed

Key Management Laboratory

Cryptographic Technology Laboratory

Navy Cyber Defense Research Laboratory

Wireless Security Laboratory

Navy Shipboard Communications Testbed

Virtual Reality Laboratory

Visual Analytics Laboratory

Immersive Simulation Laboratory

Warfighter Human-Systems Integration Laboratory

Motion Imagery Laboratory

Global Information Grid and Advanced Networking Facility

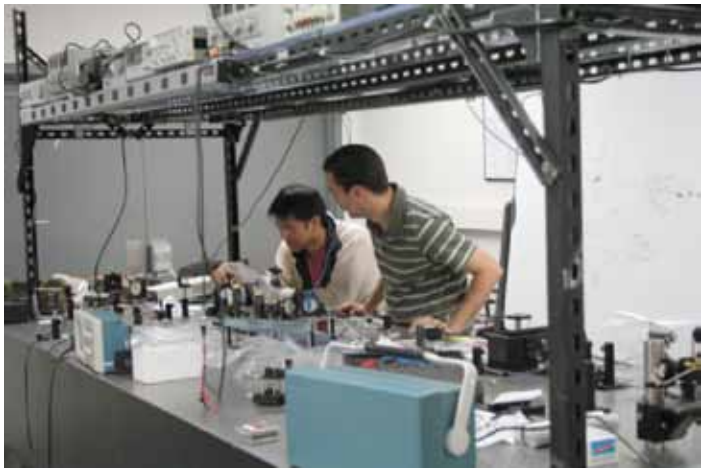
Large Data Research Laboratory

Affiliated Resource Center for High Performance Computing

Ruth H. Hooker Research Laboratory

Freespace Communications Testbed

Code 5505
(202) 767-0170
NRL, Washington, DC



Function:

Provides an environment to prototype and study devices and techniques to improve freespace optical and infrared communications. The laboratory is fully equipped with optics, electro-optics, lasers, electronics, and supporting instrumentation needed for automated data acquisition and control. Programs include applied research (6.2) initiatives supported by ONR, DARPA, OSD, and NRL base funds.

Description:

New concepts and approaches in freespace wireless infrared data links are explored in this lab. Projects include wireless router-based hybrid communications for “last mile” applications; combining adaptive optics with asymmetric retromodulator-based communications to extend range and data rate reliably; modulating retroreflector-based networking; atmospheric studies in a controlled, emulation environment; and analog modulation techniques for freespace optical communications. Subsystems and devices prototyped and tested at this lab are then brought to the NRL Laser Communications Testbed (LCTB) located at Chesapeake Bay Detachment for system tests in realistic marine environments.

Instrumentation:

The laboratory is equipped with analog and digital oscilloscopes, function and signal generators, components for adaptive optics and wavefront control, lasers, optics, photometers with heads calibrated at various wavelengths, holders, motorized positioners, and other components required to prototype new ideas.

Mobile Robot Laboratory

Code 5510
(202) 767-2684
NRL, Washington, DC

Function:

Provides an environment for developing and evaluating intelligent software for both actual and simulated autonomous vehicles, including machine learning, mapping, navigation, computer vision, cognitive modeling, and human-robot interaction. Several types of indoor and outdoor robot platforms serve as testbeds for robotics applications, whether individually, in homogeneous swarms, or in heterogeneous teams. The mobile robots are also available as test platforms for evaluating sensors, interfaces, and other technologies being developed by groups within NRL. Laboratory computers provide a simulation environment for offline learning and for air and undersea vehicles.

Description:

The robot laboratory is a 1338-ft^2 facility that allows space for indoor operation of mobile robots and can be configured with obstacles or furniture to simulate expected working environments. A large research support vehicle adds the ability to transport mobile robots to offsite or outdoor worksites, provides its own power, and supports computer workstations and local networking for work in the field. The facility maintains many mobile robots widely used in the robotics community, enabling the integration of outside research from other government, academic, and industry laboratories. Among these robots are models from Nomadic Technologies, iRobot, Sony, Segway, MobileRobots, and Xitome. The robots provide a range of functional capabilities, from autonomous navigation and sensing in indoor and outdoor environments, to complex human interaction with facial expressions and gestures.Proprioceptive sensors on the robots include odometry, joint positions, pitch/roll/yaw sensors, compass, GPS, inertial position trackers, and tactile bumpers. Additional sensors include sonar, active infrared, 2-D scanning laser LIDAR, 3-D structured light rangefinders, stereo vision cameras, omnidirectional cameras, and microphone arrays. The Xitome MDS robots have arms and hands that mimic human flexibility and scale as well as expressive, articulated faces. All of the robots carry onboard computers for local processing and decision making. The lab also employs Linux PCs, Windows PCs, and Macintosh computers for development and simulation.

Instrumentation:

In addition to the robots' autonomous capabilities, communication with stationary host computers is available via a wireless data network, permitting distributed computing and feedback to remote users. Sensor data and robot performance can be logged onboard or offboard, tailored to the project as arranged by the principal investigator.

Audio Laboratory

Code 5515
(202) 767-0491
NRL, Washington, DC

Function:

Provides an environment and facilities for auditory display research. A primary focus is the performance use of binaurally rendered 3D sound in conjunction with visual information tasks. Support for personal and free-field (multiperson) virtual sound environments is provided, enabling the simulation of real-world audio information settings, such as Navy combat information centers. Support is also provided for the conceptual design and evaluation of auditory information at various levels of processing.

Description:

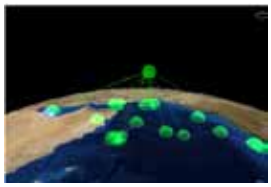
This 300 ft^2 laboratory space incorporates two controlled listening environments. A 121 ft^2 sealed booth allows auditory studies to be carried out in sonic isolation, and a 13 ft circular enclosure allows free-field, immersive aural environments to be rendered for one or more listeners. Audio sources for the circular enclosure can be either prerecorded or scripted. A number of software tools are available for sound editing and design, and binaural recordings can be made with an instrumented manikin. Software testbeds for listening studies involving human subjects are run on Windows and Macintosh workstations maintained in the lab; these platforms function as clients for the laboratory's 3D sound server. An updated prototype of the Navy's four-screen multimodal watchstation is also maintained for use in research involving combined audio and visual information displays. The laboratory is additionally equipped to measure and analyze audio stimuli and ambient sound pressure levels.

Instrumentation:

Sound design and real-time spatialization via head-related transfer functions and loudspeaker panning techniques are supported with a VRSonic SoundSim rack and studio-quality digital-to-analog signal processing. Sounds are rendered with headphones and a circular, 28-unit loud-speaker array in an echo-attenutating enclosure. Additional instrumentation includes an inertial head-tracker, a Brüel & Kjær head-and-torso and Pulse system, an Earscan audiometer, and a fully sound-attenuating booth.

Mobile Network Modeling Laboratory

Code 5522
(202) 767-2001
NRL, Washington, DC



Function:

Supports S&T development and evaluation of next-generation communication technologies for mobile and dynamic data networks. This includes wireless meshes, mobile systems, and other disruptive communication environments relevant to DoD operations. The Mobile Network Modeling (MNM) facility provides simulation, real-time network emulation, environment and scenario modeling, and specialized network measurement tools and methods. The facility supports a variety of sponsor organizations executing next generation networking S&T and there is significant external use and collaboration of related products across DoD.

Description:

The MNM Laboratory includes computing assets and software processes capable of conducting large-scale simulations of dynamic communication networks and protocols, with an experimental focus on wireless network scenarios typical of mobile tactical edge operations. The facility also has a set of high performance computer systems designed and dedicated to emulating dynamic, wireless networks systems in a scenario-driven manner that reflects more accurate expected operational environment performance. This includes more accurate network protocol, environment, mobility, and wireless system modeling components

Related laboratory emulation designs, such as the Extensible Mobile Ad hoc Network Emulator (EMANE), have been used to conduct testbed experiments of hundreds of mobile wireless nodes. This laboratory and experimental capability provides cost-savings, new technical insights, and accuracy to often overly abstracted S&T processes.

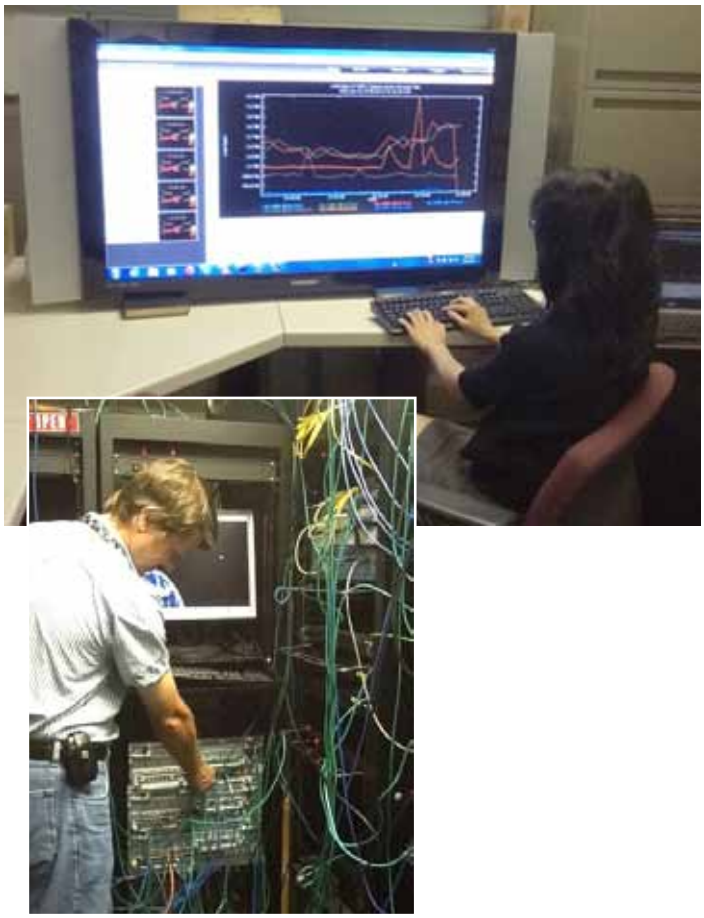
Instrumentation:

The laboratory maintains the ability to enable rapidly prototyping of candidate, advanced protocols and network communication applications. Laboratory prototypes are generally instrumented with sophisticated data collection and analysis capabilities as part of robust S&T efforts. Example implementations include protocols for reliable data transport, real-time communication (including voice, video, and other), collaborative computing, dynamic routing, and network self-configuration and organization.

The laboratory enables quantitative analysis and measurement of protocol and network operation. Software capabilities include: sophisticated scenario modeling and generation tools, dynamic traffic generators, and associated network data analysis tools to examine different system performance aspects. The laboratory employs a variety of data visualization capabilities for real-time and post-monitoring of complex, dynamic network operation.

Integrated Communications Technology Test Laboratory

Code 5523
(202) 404-2740
NRL, Washington, DC



Function:

Provides the capability to perform analysis, testing, and prototype development of high-speed wired and wireless networked data communication systems. It provides connectivity to both classified (SIPRNet) and unclassified (NIPRNet) networks through high-speed Ethernet and fiber optic interfaces with connections to the Defense Research and Engineering Network (DREN) to facilitate collaborative efforts with other DoD facilities.

Description:

The Integrated Communications Technology (ICT) Test Lab provides a rapidly reconfigurable means to perform testing and evaluation of advanced networking technologies. In the past, this has supported multiple DoD programs such as Fleet Battle Experiments, large-scale modeling and simulation exercises, Joint Experimentation, and several JTCDs. It currently provides research facilities for work done with OSD RDT&E, the Marines, and DREN. This facility provides the simulation and test environment required to support the research and development of advanced dynamic networking protocols, wireless communication, and network management for the Navy's future networking needs. This facility offers a unique capability to evaluate vendor capabilities that have potential benefits for Navy systems.

Instrumentation:

Test equipment such as network traffic generators and analyzers, signal generators, and spectrum analyzers allow real-time injection and monitoring of wired and wireless (e.g., WiMax, 802.11x) traffic flows from simulated and "real world" data sources. Routers, switches, and interface adapters provide reconfigurable connectivity throughout the facility. Test Lab computers running NRL-developed software test programs tailored to meet specific test requirements can assess the performance of military and commercial off-the-shelf (COTS) equipment such as network radios, routers, and communications security (COMSEC) devices. Network performance parameters such as throughput, latency, jitter, and packet error rates are easily measured and documented.

General Electronics Environmental Test Facility

Code 5524
(202) 767-0327
NRL, Washington, DC

Function:

Provides resources for testing the performance and functionality of electronic equipment under conditions that the equipment could experience during the deployment to and installation in a Naval ship or Marine Corps tactical environment. Enables evaluation of specified performance parameters in a benign environment and under environmental stresses.

Description:

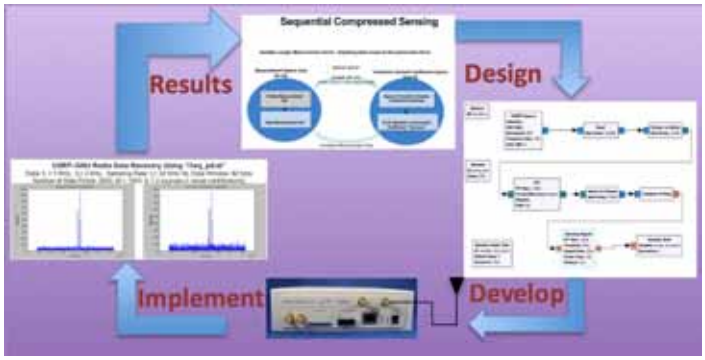
Several laboratories are available to test electronic equipment to validate performance under the conditions described in MIL-PRF-28800. Electronic equipment is first evaluated for performance in a benign laboratory environment. After successful completion of the baseline performance measurements, automated chamber facilities are employed to evaluate the performance during temperature test and over the course of a humidity cycle. Altitude testing is performed in a separate electronically controlled chamber. These represent a sampling of the test conditions defined in MIL-PRF-28800F that are designed to replicate the variety of environmental conditions that test equipment might experience when deployed to the Fleet. The complete set of tests employ other facilities available at NRL.

Instrumentation:

This laboratory includes an extensive array of automated electronic test equipment and instrumentation, including: a phase noise measurement system, a noise figure measurement system, precision spectrum analyzers, wideband signal generators, optical analyzers, optical sources, power meters for both RF and optical measurements, and precision voltage sources and meters for RF, AC, and DC measurements. The key environmental capabilities are a 40 ft^3 environmental chamber and an altitude test chamber. Additional stations are used for evaluating MIL-PRF-28800 handling and drop test performance requirements. The Laboratory contains a variety of additional test equipment, including: signal generators, signal analyzers, high speed digital oscilloscopes, real-time spectrum analyzers and assorted stimulation and response measurement equipment. A full assortment of ancillary cables, connectors, and accessories are available to be used in the performance validation of a wide variety of electronic equipment.

Cognitive Radio Test Bed

Code 5524
(202) 767-0327
NRL, Chesapeake Beach, MD



Function:

Provides facilities that employ Universal Serial Radio Peripheral (USRP) devices to develop a network of developmental cognitive radios (CR) where concepts can be explored. The evaluation environment complements the CR development by providing a virtual field test environment enabling an injection of spectral environments to evaluate CR behavior while quantitatively evaluating the RF and network performance.

Description:

The Cognitive Radio Test Bed provides an environment to develop a basic understanding of the tradeoffs inherent in CR algorithms. It provides a low-cost platform for exploring implementations of new technologies that may benefit cognitive radios. Implementation trials of new algorithms such as compressive sensing (shown in upper figure), feature detection, and other sensing augmentations can be evaluated under a common set of conditions. The development environment enables communications among network nodes to explore strategies advantageous to network communications. Successful strategies are then injected into the virtual field test environment where the strategies can be evaluated against a common set of representative spectral environments.

Instrumentation:

The Cognitive Radio Test Bed consists of a minimum of five radio nodes, each composed of a USRP and Linux computer using the GNU radio development software. Additional nodes can be introduced for special functions: interference signal source, out-of-band spectral sensing, and general spectral analysis. The development environment can be interfaced with the Virtual Field Test instrumentation. The virtual field test incorporates path loss controls, ports for other radios and signal sources, real-time spectral analysis for monitoring the spectral performance and timing, and the capability to inject broadband spectral environment profiles with automated and repeated playback capabilities.

Key Management Laboratory

Code 5541
(202) 404-4884
NRL, Washington, DC

Function:

Provides a secure environment to research and develop advanced electronic key management and networked key distribution technologies for the Navy and DoD. In conjunction with the Cryptographic Technology Laboratory, this lab also serves as a testbed for new key management components and key delivery protocols developed for the Electronic Key Management System (EKMS) and the emerging Key Management Infrastructure (KMI).

Description:

The Key Management Laboratory is used to develop networked key distribution architectures, secure key delivery techniques, and protocols for enhanced key delivery to the warfighter. This lab serves as the development site for the Net Key Management Segment (NKMS) key server suite, key distribution guarding techniques, single point keying, and secure wireless key-fill techniques. Powered by a high-performance network of workstations, servers, databases, network security components, and state-of-the-art development tools, the lab supports development of key management applications and a secure client-server framework for netted key distribution. A secure software development environment provides for J2EE programming, web and database applications, XML programming, key distribution guard development, and modeling of advanced protocols for key/data delivery over Ethernet and secure wireless networks. The lab is also equipped with EKMS components (current and prototype models), legacy and next-generation key-fill devices, and crypto key material to support interoperability testing and validation of new applications.

Cryptographic Technology Laboratory

Code 5541
(202) 404-4884
NRL, Washington, DC

Function:

Provides a secure environment to research and prototype programmable cryptographic technologies for Navy and DoD applications in support of the Communications Security (COMSEC) Modernization Program. The lab also allows for development of certifiable COMSEC/Information Assurance (IA) products including Type 1 programmable cryptographic devices, cryptographic applications, and high-assurance guards.

Description:

The Cryptographic Technology Laboratory is a secure environment where COMSEC/IA research, development, and testing are conducted. Powered by a classified high-performance network of workstations and state-of-the-art development tools, the lab supports development of software, firmware, and hardware. Software stations provide for embedded software development for real-time cryptographic/guarding technology applications via the use of computer-aided software engineering tools, embedded integrated development environments (IDE), compilers, real-time code debuggers, simulators, in-circuit emulators, and fabricated development boards. Firmware stations provide support for programmable logic design, VHDL coding and verification tools for field programmable gate arrays (FPGAs), and other programmable logic devices. Hardware development stations are powered with the Cadence suite of computer-aided engineering tools that support schematic capture, digital design and simulations, printed circuit board (PCB) layout, and testing. The lab is also equipped with a testbed consisting of various end cryptographic units (ECUs) and cryptographic modules used by Fleet systems, useful for interoperability testing.

Navy Cyber Defense Research Laboratory

Code 5544
(202) 767-9225
NRL, Washington, DC

Function:

Provides unique facilities for research into various aspects of Information Assurance (IA) and Computer Network Defense (CND). As the Navy's center of excellence for large-scale network security visualization, technological penetration testing, and reverse code engineering, the Navy Cyber Defense Research Laboratory (NCDRL) supports research that augments Navy and DoD network-centric warfare capabilities.

Description:

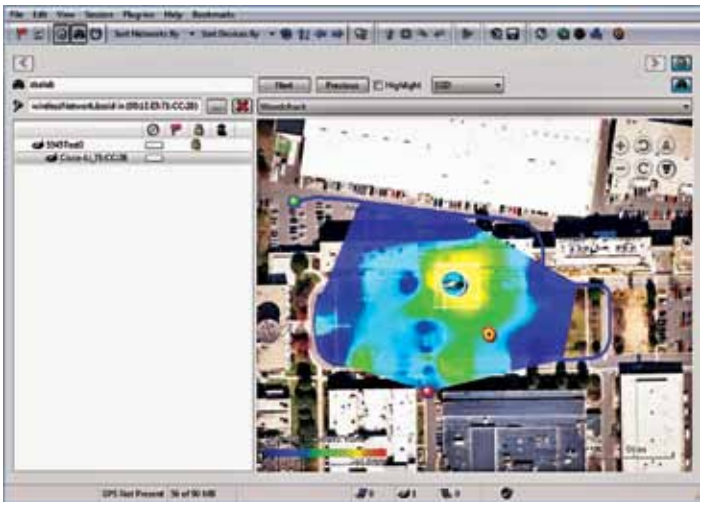
NCDRL aims to equip the cyber-warriors at the front lines of defending the network with the tools and capabilities needed to accomplish their mission. NCDRL aims to provide a centralized and unobstructed view of threats and mitigation strategies to the Navy networks by facilitating research and development into CND problems specific to enclaves and applicable to the Navy enterprise as a whole. Fleet and DoD-wide IA initiatives (commercial off-the-shelf and government off-the-shelf) are critically evaluated and assessed prior to production deployment. NCDRL also leads DoD-wide efforts in malicious code analysis and reverse code engineering.

Instrumentation:

NCDRL houses virtually every industry-standard security sensor and technology deployed in the Navy enterprise networks (which include ISNS, ONE-NET, and NMCI). The NCDRL research network supports a robust environment enabling the testing of a wide array of developmental security technologies. It can also be dynamically reconfigured to replicate Fleet Network Operations Center architectures.

Wireless Security Laboratory

Code 5545
(202) 404-3933
NRL, Washington, DC



Function:

Provides an environment to assess the security of various commercial wireless technologies, network devices and protocols, as well as to support the development of tools and applications that can be used to detect the presence of wireless network devices in support of the Navy's network security mission. This laboratory also provides an environment to design, develop, and test new radio waveforms in a secure environment.

Description:

The Wireless Security Laboratory's goal is to understand the security issues associated with using various wireless technologies on Navy networks, develop mitigating techniques and products when required, and spread awareness of such risks to the broader user community. The primary focus has been on the design and development of tools that can be used by the network defense community to detect the presence of network devices with wireless interfaces, such as IEEE 802.11, Bluetooth, WiMAX, CDMA2000 and LTE, to name a few. Laboratory personnel focus on researching the optimum detection techniques and implementing these techniques into products that can easily be used by network defenders to determine that state of the wireless environment at their command. The laboratory is also responsible for developing and supporting wireless discovery and mapping technologies for the entire DoD. Laboratory personnel collaborate closely with their counterparts in the other Services as well as the Intelligence Community.

Instrumentation:

The Wireless Security Laboratory has an extensive software development framework to support the rapid development of new wireless discovery capabilities. The laboratory also has an extensive array of radio frequency (RF) test equipment supporting protocols such as IEEE 802.11, Bluetooth, and IEEE 802.16 WiMAX. The laboratory contains an extensive software-defined radio capability to support new waveforms and RF detection technologies rapidly and efficiently. The laboratory also has a wide array of directional and omnidirectional antennas, as well as the ability to rapidly design and prototype antenna elements.

Navy Shipboard Communications Testbed

Code 5555
(202) 404-8842
NRL, Washington, DC

Function:

Provides resources for initial development and testing of new secure voice technologies for Navy shipboard applications.

Description:

This laboratory consists of a suite of rooms configured with Navy shipboard communications systems. By replicating the tactical communications installations aboard ships, this facility provides the means to perform interoperability testing of emerging communications technologies. It also contains workspaces for the development of both the electronic hardware and the various levels of software (embedded to application level) that typically comprise communications devices.

Instrumentation:

The core of the laboratory is the shipboard secure voice installation. This equipment consists of a single audio switch (SAS) 2112 Red Switch and the associated analog audio distribution system, which includes red-phone stations and several racks of tactical radios.

The laboratory also contains a Lucent Definity PBX and several stations of digital telephones. Both the red analog and the digital telephony systems are linked to other Navy installations to provide outside connectivity for more extensive testing.

Virtual Reality Laboratory

Code 5581
(202) 767-0380
NRL, Washington, DC

Function:

Performs basic and applied research in virtual environments (VE) and augmented reality (AR). Designs, implements, and evaluates user interfaces, applications, displays, and peripheral devices necessary for AR or VE systems. Provides system interfaces to connect with other simulation systems.

Description:

The VR Laboratory specializes in the combination of virtual imagery into one's view of the real environment, a technology known as augmented reality (AR), as well as traditional immersive virtual environments, better known as virtual reality. By using combinations of optical see-through displays and cameras with immersive displays, AR can present synthetic targets on a real training range, allow a trainee to fight with or against avatars, or provide real-time information for situation awareness (e.g., street names, routes, phase lines and locations of other users) or information inserted by other users (e.g., a selected target). A variation on the software embeds virtual forces controlled by a Semi-Automated Forces system. Rooftop-mounted cameras allow users to be forward observers. A 3D command center application and an indoor demonstration analog of the backpack system distribute real-time updates of information and mission-specific goals to mobile users.

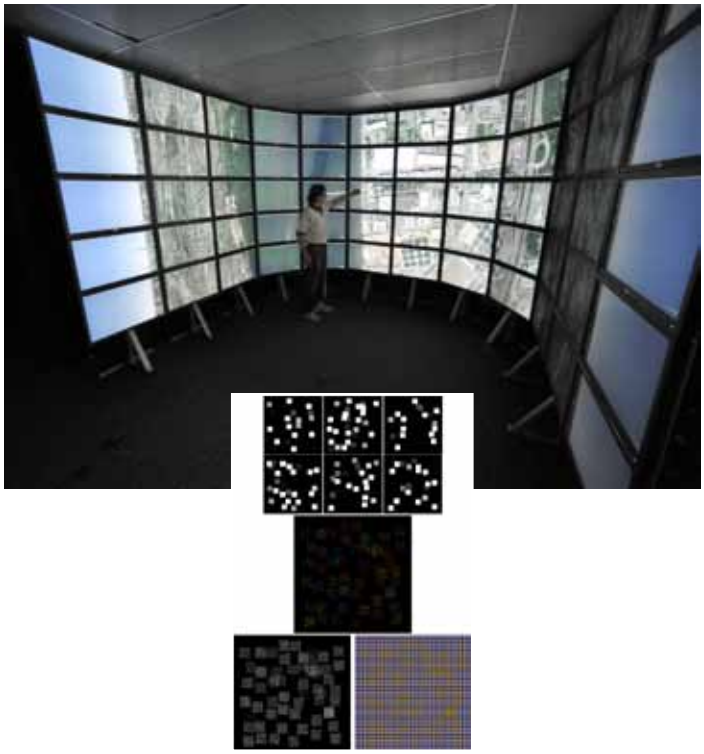
The VR laboratory at NRL has contributed numerous scientific articles on application design and human factors issues for AR systems. By selecting commercial components that have been reduced in size, weight, and power requirements, we can outfit a backpack for a dismounted warfighter or mount a system in a vehicle.

Instrumentation:

The VR Laboratory includes several head-worn display systems, using both optical combiners and video overlay technology, in addition to immersive displays in both head-worn and hand-held forms. These displays are driven by a variety of graphics workstations and clusters with programmable graphics processing units (GPUs). We also have capabilities to produce 3D audio and recognize voice and gestural commands. A variety of commercial sensors provide tracking of users both indoors (e.g., ultrasonic, optical, or inertial sensors) or outdoors (e.g., adding GPS).

Visual Analytics Laboratory

Code 5581
(202) 767-0380
NRL, Washington, DC



Function:

Performs basic and applied research in the science of analytical reasoning as facilitated by visual interfaces, known as visual analytics (VA). Designs, implements, and evaluates data representation paradigms, visual metaphors, visualization algorithms, and interactive data exploration techniques within the context of VA systems.

Description:

The VA Laboratory has focused on the increasingly important issue of operator overload in the context of “big data” problems with Naval and Marine applications. The recent increase in our ability to collect data has outpaced our capacity for analysis and understanding. By combining data analysis, visual presentation, and human-computer interface research, researchers and analysts can work together to understand the complex pieces hidden within the data puzzle.

Investigations into several major approaches to solving this type of challenge are underway. Coordinated multiple view systems enable the user to have several views of the data that are linked by common representational cues (such as color or shape) that highlight data relationships in traditional views such as scatterplots, principal components analyses, and maps, as well as in nontraditional data representations such as parallel coordinates, treemaps, and other sophisticated visualization techniques. Another major line of inquiry is into multivariate visualizations, which attempt to use subtle cues (color, shape, orientation, and juxtaposition) to separate and sample data fields into an integrated visualization with multiple data layers. Understanding the limits of these techniques to convey basic features of data is an open research question. We also take advantage of the relative ease of providing massive display systems; we have displays ranging from traditional desktops up to a wall-sized display. The VA laboratory at NRL has contributed numerous scientific articles on visualization systems and the human factors of multivariate visualizations.

Instrumentation:

The VA Laboratory employs a wide range of displays, ranging from mobile devices useful as control interfaces, through standard desktop displays and tiled workbenches, up to a display wall composed of 60 LCD tiles (240 megapixels), which together enable teams of analysts to explore massive, diverse streams of data. These displays are driven by a variety of graphics workstations and clusters with programmable graphics processing units (GPUs). We also have capabilities to produce 3D audio, recognize voice and gestural commands, and collect biometric feedback.

Immersive Simulation Laboratory

Code 5582
(202) 404-8847
NRL, Washington, DC

Description:

The facility supports the development of a range of user interfaces, from high-end body-driven interfaces that fully track the user and present the image through a head-mounted display to device-driven interfaces such as one that customizes the control mapping of a conventional dual joystick game pad to give the user the ability to independently specify direction of viewing and direction of movement. The Immersive Simulation Laboratory (ISL) maintains a distributed simulation system for use as a testbed. It is networked and allows multiple users to interact in the virtual world simultaneously. It was originally developed as part of ONR's VIRTE (Virtual Technologies and Environments) program and is modified in-house as new features are needed. The interface software component is developed in-house and includes a flexible interface that allows for the rapid prototyping of new interface designs.

Function:

Develops and tests novel user interfaces for 3D virtual simulators and first-person shooter games that make user interaction more like natural interaction in the real world. The goal is to design and implement interfaces that give users close to the same ability to move and coordinate actions as they have in the real world. The current emphasis is on developing interfaces to train Marines in tactics, techniques, and procedures for urban combat.

Instrumentation:

Components support the development of new user interfaces that meet the evolving needs of the Navy and Marine Corps. The lab has a variety of motion capture systems, including inertial, passive and active optical; head-mounted displays; large screen displays; input control devices such as game pads and joysticks; graphics and audio rendering computers; and simulation software. ISL also has customized equipment including instrumented Airsoft rifles that register trigger pulls and a custom-built mechanical centering harness that limits the drift of a standing user wearing a head-mounted display.

Warfighter Human-Systems Integration Laboratory

Code 5582
(202) 767-3960
NRL, Washington, DC

Function:

Develops and evaluates novel computer-based training platforms and approaches designed for the warfighter. The primary emphasis is on virtual environment training technologies and adaptive training techniques. Identification of individual and team performance measures is also a focus and may prove useful for enhancing the ability of autonomous systems to understand and interact with the warfighter in the field.

Description:

The Warfighter Human-Systems Integration Laboratory (WHSIL) consists of a suite of rooms, each containing a different virtual environment (VE) interface. These interfaces range from desktop PCs to high-end, 3D head-mounted displays with immersive body/head tracked technologies. These systems are all networked together, allowing teams of warfighters to interact with each other. NRL has designed software to enable physiological sensors to trigger events in the simulation software, e.g., making an environment more difficult when a participant appears to not be engaged in the training task.

Instrumentation:

The VEs are ONR-developed, government-owned, PC-based applications. The VEs include desktop PCs, an indoor simulated marksmanship trainer, and a 3D head-mounted display system with immersive body and head tracking. The lab can also utilize Virtual Battle Space 2, which is the commercially developed simulation engine presently used in the Marine Corps simulation centers. Additional technologies include physiological sensors, specifically a wireless EEG system and an off-the-head eye-tracking system.

Motion Imagery Laboratory

Code 5591
(202) 404-7344
NRL, Washington, DC

Function:

Supports research in leading-edge progressive-scan imaging, high-definition television (HDTV), technology needed to process very-high-resolution images, and the impact on human perception with various presentation and image capture techniques.

Description:

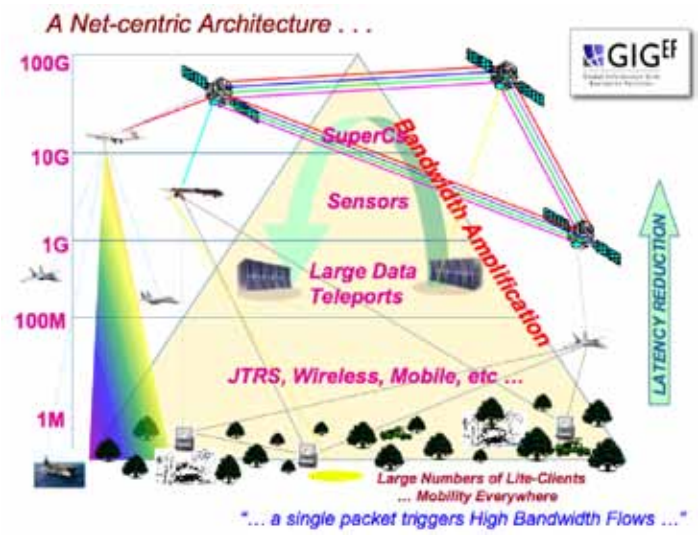
The Motion Imagery Laboratory (MIL) is a research environment that leverages high-end computational assets, networks, and applications to take advantage of leading-edge capabilities in state-of-the-art motion imagery with progressive-scan, large-format HDTV. The MIL is working with imagery requirements with minimum 1.5-Gbps data streams. Systems capable of transmitting, storing, processing, and rendering these multi-Gbps streams will require 100 Gbps capability and higher in the near future. The MIL is also used to assess innovative techniques in next-generation video teleconferencing. Research is conducted on the issue of large single streams on multi-gigabit networks over very long distances in near real time and faster than real time, and on the visual tools to support next-generation motion imagery capabilities. The MIL provides an environment to assess collaboration in intelligence, digital Earth models, test and evaluation, and other DoD needs where very-high-resolution imagery has an impact. The MIL supports work in compression technology, processing, transmission, and other technologies to allow access to high-resolution imagery by a full spectrum of users from average users at their desktops to those with the most demanding scientific and analytic needs.

Instrumentation:

The MIL includes projection facilities for very-high-definition immersion with surround screens, extremely high-resolution micromirror projection, progressive-scan studio cameras, recording/replay capabilities, and other tools for comprehensive work in this area.

Global Information Grid and Advanced Networking Facility

Code 5591
(202) 404-7344
NRL, Washington, DC



Description:

The GIG-NF is unique within DoD and the Federal government. No other test venue offers the ability to bring system and network designers, engineers, and end-users together on either formal evaluation and testing schedules or ad hoc experimentation schedules.

Instrumentation:

The GIG-NF supports a variety of systems and instrumentation that can be used to stress and measure net-centric performance. Devices range from actual production network devices (switches, routers, etc.) to computing blade servers on which to develop and test prototype network protocols, delay generators, satellite emulators, edge devices, and encryptors. GIG-NF provides the complete suite of software performance monitoring capabilities that enable IPv4/IPv6 packet capture and analysis from Kbps to 10–40 Gbps. The GIG-NF includes the all-optical research core that connects NRL to sites in-and-around the DC metro area over ATDnet; shared access to HPCMO DREN sites; and by arrangement, connection to DISA DISN CONUS/OCONUS services, National Lambda Rail, and Internet2.

Function:

Serves as a research and development testbed that provides a network infrastructure to demonstrate integration of leading-edge technology for the Navy/Marine/DoD warfighter and the intelligence community. The Advanced Technology Demonstration Network (ATDnet) portion of GIG-NF is a unique, all-optical (OOO) national asset connecting DoD, IC, and academia together to conduct advanced network research. The GIG-NF remains at the forefront of packet IPv6 technology and employs a “rapid prototype” process to deploy, stress, and quickly transition hardware and software communications developments to operations by testing in a real-world distributed system engineering testbed.

Large Data Research Laboratory

Code 5591
(202) 404-3132
NRL, Washington, DC

Function:

Addresses a critical need to rapidly prototype shared, unified access to large amounts of data across both the local and the wide area. LDR focuses on developing a global "large data" (LD) cloud along with communications pipes to rapidly access and produce knowledge from the best information available fused from federated, distributed, real-time sensors, and archived digital media assets. The LDR utilizes open source agent technology to ingest, store, access, process, fuse, display, and distribute traceback and reach-back information over unconstrained lightpaths in real time between producers and consumers without regard to location.

Description:

The LDR uses a proven "rapid prototype" process model to deploy, stress, debug, and quickly transition data-driven information technology to meet the global operational needs of DoD and the IC (Intelligence Community). In virtually every data processing domain today, the volumes of data being captured, manipulated, stored, transported, and displayed are increasing superlinearly. Global access to timely information is a key enabler. The LDR goal is to provide coherent virtualization of enterprise services over terabit flows by developing advanced applications and prototypes that cannot be sustained by traditional technology infrastructures. Warehouse-sized facilities and workloads are likely to be common for near-real-time access of operational data across the global AOR, necessitating InfiniBand enabled grids, clusters, farms, swarms, manycore processors, 100G networks, exabyte federated and distributed online data storage clouds, and object-based global file systems.

Instrumentation:

The LDR is equipped with leading-edge, high-performance, shared and distributed memory processing assets, application-specific servers, massive storage arrays, and seamlessly interconnected visualization systems. Multicore supercomputers and manycore FPGA-enhanced systems and software capture complete transactional or streamed performance and net-ops information, and monitor information assurance end-to-end on a per flow basis.

Affiliated Resource Center for High Performance Computing

Code 5594
(202) 767-3885
NRL, Washington, DC

Function:

NRL's Center for Computational Science is an Affiliated Resource Center (ARC) in the DoD High Performance Computing Modernization Program (HPCMP). It supports leading-edge introduction of high performance computing to DoD. The Center makes available a range of shared resources, including massively parallel computer systems and high performance networks, to NRL, Navy, and other DoD scientific users.

Description:

NRL's Affiliated Resource Center for High Performance Computing supports the introduction of a variety of leading-edge technologies in high performance computing (HPC). This includes the introduction or extension of new architectures, large globally addressable memory systems, and systems that use emerging capabilities such as field programmable gate arrays (FPGAs). The Center not only operates and maintains supercomputers from Silicon Graphics (SGI), Convey, and others, but also supports the scientific users in porting their code to and using these high-end assets. User support includes the computing assets at NRL and the HPCMP assets at 10 other locations across DoD. The Center also has more than 2 petabytes of online shared rotating disk as well as a robotic archival storage system that is scalable to over 16 petabytes. HPC research extends to the high-performance networks needed for true distributed computing using leading-edge techniques such as InfiniBand-across-the-WAN. Network research is conducted across the CONUS Defense Research and Engineering Network (DREN) and the Washington, DC Metro Area Advanced Technology Demonstration network (ATDnet). The networking efforts include high-speed I/O (100-GBps), security, dense wave division multiplexing (DWDM), and switching in optical networks.

Ruth H. Hooker Research Laboratory

Code 5596
(202) 767-2357
NRL, Washington, DC

Function:

Offers a full range of library services and resources to enhance and support the research program of the Naval Research Laboratory. Library services include a physical facility for study and research, staffed with subject specialists and information professionals to assist researchers in locating and retrieving published information. Extensive journal, technical report, and book collections have been created and maintained over the 80+-year history of the library. The NRL Library homepage (library.nrl.navy.mil) provides access to thousands of journals, books, and reference sources to desktops at NRL-DC, NRL-Stennis, NRL-Monterey, and the Office of Naval Research.

Description:

The Library collections focus on physics, chemistry, electronics, materials science, information technology, space sciences, and ocean and atmospheric sciences. They include 150,000 print books and journal volumes, 80,000 electronic books, 4,000 electronic journal titles, and more than 2 million technical reports in paper, microfiche, or electronic format. The collections are regularly analyzed, organized, and updated to provide quick and easy retrieval of the most appropriate items. Services include the following: research and reference assistance in using the collections and locating information from external sources; mediated literature searches of several hundred online databases, including classified databases, to produce on-demand subject bibliographies; circulation of materials from the collection including classified literature up to the SECRET level; interlibrary loan and document delivery to obtain needed items from other scientific and research libraries or from commercial document providers; procurement of journals for office retention; and user education and outreach to help researchers improve productivity through effective use of both the physical library and the digital library resources available via the Library's homepage and the TORPEDO digital repository. TORPEDO provides desktop access to more than 13 million full content articles, proceedings papers, industry standards, technical reports, and books. The Library's homepage is a portal to thousands of additional research journals; hundreds of technical databases; and reference tools including Web of Science, SCOPUS, and INSPEC that the Library licenses to support NRL research missions.

Equipment:

Public access computers, photocopiers, color printer, microform reader/printers, and self-service digital sender.

Optical Sciences Division

Nanochannel Glass Technology Facility

Organic Opto-Electronics Fabrication and Characterization Facility

Fiber Fabrication Facility for Non-Oxide and Specialty Glasses

Laboratory for Research in Integrated and Advanced Thin Films

Fiber-Optic Optical-Microwave Laboratory

Ground Station Exploitation Laboratory

IRCM Techniques Laboratory

DIRCM Evaluation Facility

Missile Warning System Facility

Fiber-Optic Sensor Facility

Oxide Optical Fiber Fabrication Facility

Nanochannel Glass Technology Facility

Code 5610
(202) 767-9468
NRL, Washington, DC

Function:

Provides for the fabrication of nanochannel glass, a specialized composite glass material that has regularly spaced features on a nanometer-size scale. Nanochannel glasses are used in the fabrication of nanocomposite and nanopatterned materials.

Description:

The Nanochannel Glass Technology Facility includes a state-of-the-art, fully automated, glass-fiber draw tower. This draw tower is specially equipped to permit the drawing of multielement fiber bundles. Nanochannel glasses are fabricated by first stacking thousands of composite glass fibers together in hexagonal-shaped bundles. These multielement bundles are drawn, using the draw tower, into boules that contain parallel arrays of fused nanometer-scale fibers or channels. The nanochannel glass boules are processed by slicing the boules into wafers that are subsequently etched, ground, polished, and characterized.

Instrumentation:

The Nanochannel Glass Technology Facility is fully equipped to address all aspects of fabrication, processing, and characterization of nanochannel glass. Specific instrumentation includes:

- An18-ft draw tower contained in a Class 100 clean room
- Computer control of downfeed, furnace temperature, and pinch wheels
- Optical microscopes
- Atomic force microscope
- Thermal analysis instrumentation: thermogravimetric analyzer (TGA), thermomechanical analyzer (TMA), and differential scanning calorimeter (DSC)
- Wafering, grinding, and polishing equipment.

Organic Opto-Electronics Fabrication and Characterization Facility

Code 5611
(202) 767-9470
NRL, Washington, DC

Function:

Prepares and spectroscopically characterizes electro- and photo-active organic thin films. Fabricates and evaluates the performance of organic electro-optic, opto-electronic, and electronic devices such as light-emitting diodes, solar cells, and field-effect transistors.

Description:

This state-of-the-art fabrication and characterization facility develops organic electro-optic, opto-electronic, and electronic prototype devices such as light-emitting diodes, solar cells, and field-effect transistors. Devices are prepared by sequential vacuum vapor deposition of organic and inorganic films on glass or flexible substrates. The deposition processes take place in separate adjacent chambers connected by gate valves. The samples are either rotated from one position to the next, or moved horizontally via magnetic arms. Spectroscopic characterization can take place in situ in vacuum and/or ex situ in a controlled-atmosphere chamber. The facility also provides capabilities for the growth and spectroscopic characterization of high quality electro- and photo-active organic thin films.

Instrumentation:

A versatile, high-vacuum, multi-surface film deposition apparatus is available for the preparation of organic films and devices. The chamber encloses a large, temperature-controlled (10–450 K) wheel that holds 14 substrates and four quartz crystal microbalances, and up to eight resistive heating furnaces for high-vacuum deposition. A Spex 270M monochromator outfitted with a liquid-nitrogen-cooled charge-coupled device (CCD) detector is used for spectroscopic characterization. A computerized, controlled-atmosphere experimental chamber equipped with a freezer and a microscope is available for handling sensitive chemicals, and for fabrication and characterization of prototype devices. The chamber houses several pieces of equipment such as an integrating sphere and a luminance meter for material and device characterization. A newly built ultra-high-vacuum (UHV) multichamber deposition apparatus interfaced to a controlled-atmosphere chamber is available for device fabrication (up to 5 in. diagonal) and sealing. This chamber will be soon moved and housed in a clean room at the Nanoscience Research Laboratory.

Fiber Fabrication Facility for Non-Oxide and Specialty Glasses

Code 5620
(202) 767-5836
NRL, Washington, DC

Function:

Unique facility for the research, development, and fabrication of non-oxide and specialty glasses and fibers in support of Navy/DoD programs.

Description:

Three Class 100 clean rooms, covering approximately 1500 ft^2, contain several fume hoods and inert gas dry-boxes for chemical handling. Resistance furnaces and RF induction furnaces are used for chemical purification and glass melting. Two state-of-the-art draw towers are used for fabricating fiber from specialty glasses under controlled atmospheres using two distinctly different techniques, the preform process and the double crucible process. The fibers fabricated at this facility possess low loss, high strength, and high threshold to laser damage. They are enabling many Navy/DoD applications.

Equipment:

Equipment is available for characterization of glass physical, thermal, and optical properties. Infrared (IR) lasers and spectrometers are routinely used for fiber characterization.

Laboratory for Research in Integrated and Advanced Thin Films

Code 5620
(202) 767-5836
NRL, Washington, DC

Function:

A variety of thin film optical devices may be fabricated by depositing a series of patterned layers of different materials under high vacuum. Each layer typically requires customized deposition techniques and conditions. This facility allows NRL scientists to deposit complex, multilayer structures such as thin film photovoltaics without exposing samples to air during processing.

Description:

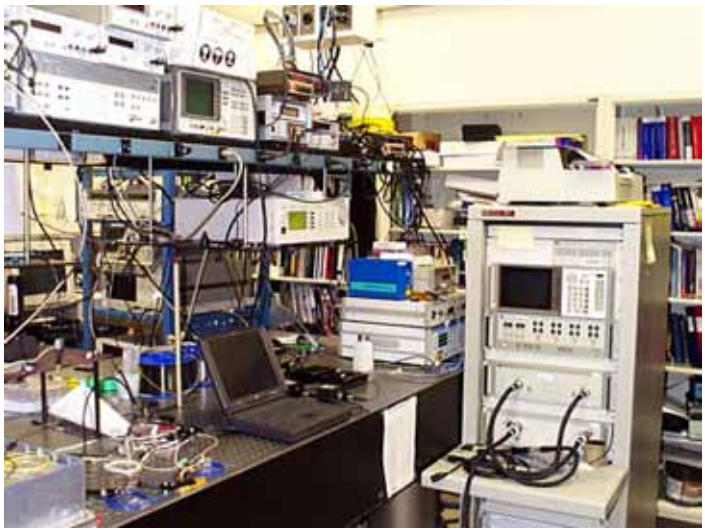
The Laboratory for Research in Integrated and Advanced Thin Films that was recently installed in the Optical Sciences Division is a state-of-the-art cluster system for vacuum deposition of thin films. The facility consists of a series of interconnected vacuum chambers, a glove box, and a sample distribution robot, allowing complex, multilayer films to be deposited without exposing the sample to air during processing. The system includes a sputterer for chalcogenide materials, a sputterer for oxides, an evaporator for metals, and an evaporator for dielectrics. A mask changing module holds deposition masks that can be applied to samples, permitting layers to be patterned in situ. This facility enables NRL scientists to fabricate novel, state-of-the-art thin film photovoltaic, plasmonic structures, and other devices while eliminating interfacial effects that result from exposure to air.

Equipment:

Sputtering chambers exist for both chalcogenide materials (sulfide- and selenide-based compounds) and oxide materials including transparent conductors. They contain multiple sputtering guns and thermal evaporation sources operable individually or in a co-sputtering configuration. Two electron beam evaporators with ion beam assists enable deposition of metal layers and dielectric materials. The deposition chambers and a nitrogen-purged glove box are served by a Genmark wafer-handling robot to permit sample manipulation and processing without atmospheric exposure.

Fiber-Optic Optical-Microwave Laboratory

Code 5650
(202) 767-9360
NRL, Washington, DC



Function:

Conducts programs of basic science and applied research in the development of laser sources, high-power fiber amplifiers, photonic control of phased arrays, antenna remoting, and microwave frequency conversion.

Description:

The laboratory is equipped with state-of-the-art microwave and millimeter-wave (MMW) components along with a wide variety of fiber-optics and free-space optics. Microwave photonics derives its strength from the merger of microwave and fiber-optic techniques for the development of systems with greater than 100 GHz of operational bandwidth. This merger has enabled the development of photonic links for low-loss antenna remoting, true-time delay for squint-free beam steering, microwave frequency conversion, low-noise optical transmitters, and highly efficient photodetectors. In addition, the optical and microwave components used in these systems are commercially available and are improving with advances in the telecommunications industry. Research equipment includes a wide variety of microwave and optical test instruments and components enabling the development of optical techniques valuable for future Navy capabilities.

Equipment:

The laboratory equipment includes an extensive array of microwave and optical test equipment. Optical and microwave components used in the lab are primarily commercially available and represent the state of the art in microwave photonics technology.

Ground Station Exploitation Laboratory

Code 5661
(202) 767-9576
NRL, Washington, DC

Function:

Operates a facility for research, development, integration, and operation of multiservice/agency exploitation and control station systems. Performs real-time screening, geo-registration, target detection, and data-basing of tactical intelligence, surveillance, and reconnaissance (ISR) data. Simulates real-time concept of operations (CONOPS) environments and networked input and output dissemination interfaces. Provides comparisons of custom and COTS/GOTS exploitation tools and target detection techniques.

Description:

Multiple databases consisting of deployed and emerging ISR sensor system data are stored for data-mining, target detection processing, and real-time screening/exploitation CONOPS development. Relevant mission data is obtained from national sources as well as from initiated airborne flight tests conducted to obtain specific target/background information. Example hosted exploitation systems include multiple Navy, USMC, Air Force, and other government agency systems.

Instrumentation:

Principal instrumentation consists of networked computer workstations capable of real-time receipt of legacy and emerging tactical airborne ISR data acquisition systems. Systems operate at various classification levels.

IRCM Techniques Laboratory

Code 5660.2
(202) 767-2115
NRL, Washington, DC

Function:

Assists the Navy and Marine Corps in the development of infrared countermeasure (IRCM) technologies and techniques for Fleet aircraft protection. Specifically, determines requirements for IRCM techniques to defeat infrared threats, imaging and reticle-based surface-to-air and air-to-air IR missiles, and forward-looking infrared (FLIR) devices. IRCM technologies and techniques include sensor damage, coherent and incoherent jamming, and expendable flares.

Description:

The IRCM Techniques Laboratory performs open-loop hardware testing of “real” missile/sensor threat seekers as well as all-digital missile modeling and simulation analysis to determine countermeasure requirements to defeat the IR threat. The laboratory provides a comprehensive testbed for all types of IR countermeasures against a variety of IR threats. The facility includes advanced countermeasure sources for testing directed IRCM/advanced threat IRCM (DIRCM/ATIRCM) systems and a two-color multiflare/expendable hardware simulator for testing advanced expendable techniques against multispectral threats. The laboratory also has an extensive modeling and simulation capability for testing IRCM against both reticle-based and IR focal plane array-based missile seekers.

Equipment:

- Two open-loop rate tables for IRCM testing of reticle and imaging IR seekers
- A 64-channel analog data acquisition system
- Three multiprocessor simulation workstations – SPARC, ALPHA, and MIPS machines
- One SGI 8-processor simulation supercomputer.

DIRCM Evaluation Facility

Code 5663
(202) 767-3084
NRL, Washington, DC

Function:

Evaluates smaller Directed Infrared Countermeasure (DIRCM) systems, measuring such performance parameters as response times, field of regard (FoR), tracking sensitivity, laser spatial profile, and various pointing-related accuracies as bias, jitter, handover error, installation repeatability, and farfield divergence, all of which together allow the determination of Energy on Dome (EoD), the prime measure of performance, over a variety of operational conditions.

Description:

This facility provides end-to-end testing of DIRCM systems, including both the missile warning subsystem and the active jammer. The calibrated virtual missile section mimics the signal presented to the system by an actual missile, thus providing an emulated threat to initiate tracking, declaration, and handover functions within the missile warning system, while allowing the stimuli to be tailored to facilitate measurements of particular characteristics. Resultant handovers to the jammer exercise its response, and allow similarly detailed measurements of its characteristics.

Equipment:

The facility is equipped to support all aspects of DIRCM system evaluation: a two-axis Aerotech motion stage serves as a platform surrogate, providing both platform motion for end-to-end studies, and raster-scanning capability for more specialized investigations. A virtual missile simulator, comprising a blackbody source, an off-axis paraboloidal mirror, and a 124 x 124 broadband pyroelectric array, project an apparent missile into the field of view of the system under test to probe the response of the system as a whole. Various other optics and additional instrumentation including high-speed detectors and power meters are also available.

Missile Warning System Facility

Code 5663
(202) 767-9530
NRL, Washington, DC

Function:

Operates a classified facility for research projects dedicated to the development of missile warning systems for the self-protection of Naval aircraft. Participates in exploitation measurements of missile signatures. Simulates the acquisition, guidance, and aerodynamic performance of threat missiles. Measures and models sensor responses to threat signatures as well as the performance of detection and declaration algorithms.

Description:

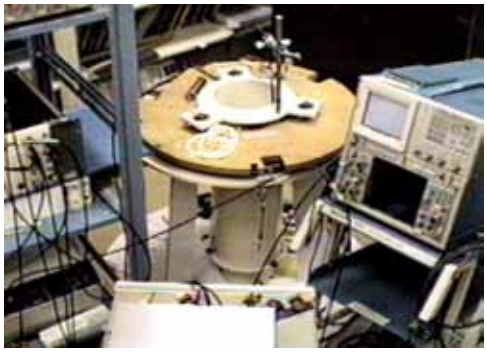
An extensive database of threat and background clutter signatures is maintained for developmental and fielded self-protection systems. Participation in field tests (missile live firings and overflights) ensures the data's relevance to the developmental effort. Simulations of threat missile engagements along with simulations of system hardware permit predictions of system performance. Recent activities include support for the AN/AAR-47 Missile Warning Set and the NRL Tactical Aircraft Directed Infrared Countermeasures (TADIRCM) System.

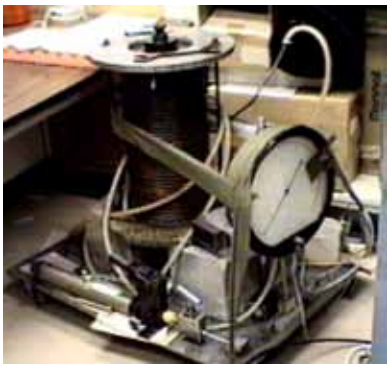
Instrumentation:

Principal instrumentation consists of a network of computer workstations capable of hosting system data and the required system software simulations.

Fiber-Optic Sensor Facility

Code 5674
(202) 767-1316
NRL, Washington, DC





Function:

Constructs and evaluates fiber-optic sensors for a variety of measurands. These measurands include acoustic, pressure, magnetic, and electric field as well as strain and rate of rotation.

Description:

The sensor construction facility includes two Accu-winder coil winding machines, seven optical fiber fusion splicers, annealing facilities for magnetic materials, and facilities for degassing adhesives for potting purposes. The evaluation facilities include two computer-controlled data reduction and analysis stations, one optimized for acoustic sensors and the other optimized for magnetic sensors. There are two environmental chambers that operate from –50° to 100 °C for life testing of prototype sensors. The acoustic sensor evaluation facility also includes a pressure chamber for determining dc acoustic sensitivity as well as crush performance of prototype fiber-optic hydrophone designs (bottom figure). Also available is a G-40 shipboard calibrator, which can operate over a 5 to 1000 Hz frequency range at ambient pressure and between 4° and 35 °C (top figure). The evaluation facility for rate of rotation sensors includes a Contraves rate table (1000 deg/s to Earth rate) and a suite of measurement equipment. The evaluation facility for magnetic sensors includes MuMetal magnetic shields for low-noise measurements and an automated system for dynamic magnetization and Barkhausen noise measurements. The facility has optical test equipment to evaluate optical sources as well as an optical time domain reflectometer (OTDR) and a Status Monitoring and Reliability Test System (SMARTS) to evaluate fiber-optic circuitry. A number of optical sources at 1.3 and 1.5 μm wavelengths (including a tunable source) are also available.

Equipment:

The facility uses seven Hewlett Packard 3562A and three Hewlett Packard 3582A dual-channel spectrum analyzers, one Hewlett Packard 3567 modular three-channel spectrum analyzer, three Tektronix single-channel spectrum analyzers, two HP 89410 network analyzers, three TEAC RD-200T 16-channel digital audiotape recorders, and one RX-800 32-channel DAT recorder. Other instruments include an Anritsu MS 9710B optical spectrum analyzer and an HP 8509B lightwave polarization analyzer.

Oxide Optical Fiber Fabrication Facility

Code 5675
(202) 767-2270
NRL, Washington, DC

Function:

Fabricates unique, state-of-the-art optical fibers based on pure or doped silica glass systems. It has the capability of fabricating both single-mode and multimode fibers doped with germanium, phosphorus, and fluorine and holey fibers containing photosensitive and/or laser-active elements. In addition, it can fabricate fibers with cores doped with high concentrations of laser-active ions such as erbium, ytterbium, and neodymium, together with aluminum. The facility supports Navy and DoD programs in fiber-optic sensing, nuclear radiation hardness, optical limiting, fiber-optic tethers, high-power fiber lasers, and small fibers with low visibility.

Description:

The facility consists of two parts: the Preform Fabrication Laboratory and the Fiber Draw Laboratory. In the Preform Fabrication Laboratory, optical fiber preforms are fabricated using the modified chemical vapor deposition process. The optical cladding and core are deposited layer by layer, and then the preform is collapsed into a solid rod whose refractive index profile and core/clad ratio are preserved in fiber drawing. In the Fiber Draw Laboratory, the preform is slowly lowered into a high-temperature furnace at the top of the 24-ft draw tower. The glass softens and the optical fiber is drawn out of the bottom of the furnace; the fiber diameter and draw tension are monitored using noncontact techniques. Fiber Bragg gratings may be written into the fiber with short pulses of UV light from an excimer laser. The fiber is coated with a polymer to protect its surface and preserve its intrinsic strength.

Instrumentation:

In the Preform Fabrication Laboratory, the reagent gases and rare earth chelate delivery systems are electronically metered. Deposition temperature and preform diameter are monitored, and a computer provides closed-loop control by varying torch temperature and exhaust back pressure. During drawing, the fiber diameter and coating concentricity are monitored with laser-based optical instruments. A noncontact instrument measures draw tension. In the grating writing process, the Bragg wavelength is computer controlled, and the computer also synchronizes the draw process with the firing of the pulsed UV laser to determine the spacing of the gratings along the fiber. The grating positions are marked with an inkjet bar code printer.

Ultra-Near-Field Test Facility

RF and Millimeter-Wave Laboratory

Optics Laboratory

Blackroom Laboratory

Secure Computational Facility

Human Perception Laboratory

BSDF Measurement Facility

Large-Scale Non-lithographic Processing (NLP) Facility

Environmental Weathering Laboratory

Vehicle Development Laboratory

Offboard Test Platform

Mobile Radio Frequency Measurements Laboratory

Compact Antenna Range Facility

MMW Antenna Range Facility

RFCM Techniques Chamber Facility

Low-Power Anechoic Chamber

High-Power Microwave Explosive Laboratory

High-Power Microwave Research Facility

Electro-Optics Mobile Laboratory

Infrared/Electro-Optical Calibration and Characterization Laboratory

Infrared Missile Simulator and Development Laboratory

Secure Supercomputing Facility

CBD/Tilghman Island IR Field Evaluation Facility

Ultra-Short-Pulse Laser Effects Research and Analysis Laboratory

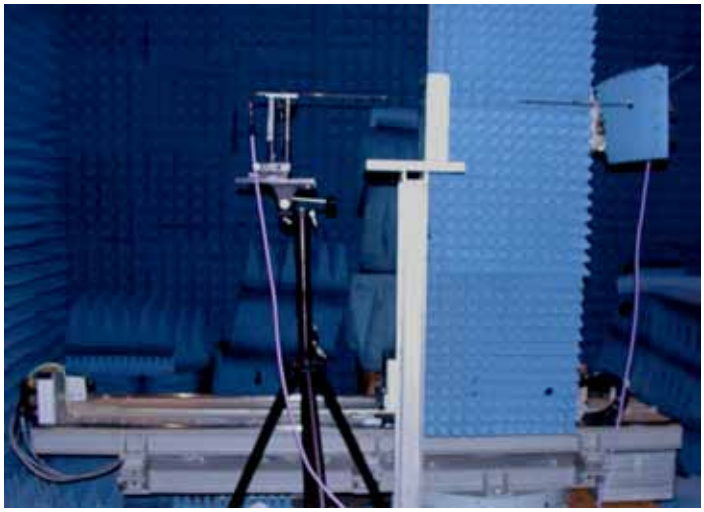
Central Target Simulator Facility

Flying Electronic Warfare Laboratory

Visualization Laboratory

Ultra-Near-Field Test Facility

Code 5708
(202) 279-5278
NRL, Washington, DC



Function:

Facilitates state-of-the-art research into the physics of scattering of microwaves from complex bodies in the ultra-near-field.

Description:

The Ultra-Near-Field Test Facility provides a unique capability to measure and investigate the physics of scattering from within a fraction of a wavelength from the body where evanescent fields enhance the complexity of issues involved. This lab explores rich phenomena associated with periodic structures and the development of new analytical tools for their study.

Instrumentation:

Agilent 8530C and 8510C vector network analyzers with measurement capability from 1 to 50 GHz combined with ORBIT/FR AL2000 positioner control provides a complete system for characterizing electromagnetic fields in planar and cylindrical geometries.

RF and Millimeter-Wave Laboratory

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Enables characterization of intrinsic properties of dielectric and magnetic materials, and the evaluation of specular and non-specular properties of absorbers at microwave and millimeter-wave frequencies.

Description:

The RF and Millimeter-Wave Laboratory is essential to NRL's efforts to develop new materials for microwave applications including signature control where complex designs are developed, tested, and evaluated.

Instrumentation:

Multiple vector network analyzers are employed including Agilent E8365B, 8510C, and 85106C models. Multiple waveguides spanning UHF to 100 GHz facilitate materials characterization over these bands. A state-of-the-art NRL Arch, fully computer controlled, enables full evaluation of specular absorbers over all angles from 2 to 50 GHz. Two additional arches are used for millimeter-wave bands up to 100 GHz. A focused lens system enables characterization of samples from 2 to 50 GHz. This system is also configurable as an Arch for specular and non-specular evaluation of absorbers.

Optics Laboratory

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Enables the optical characterization of materials in wavelength regions from the near ultraviolet to the longwave infrared.

Description:

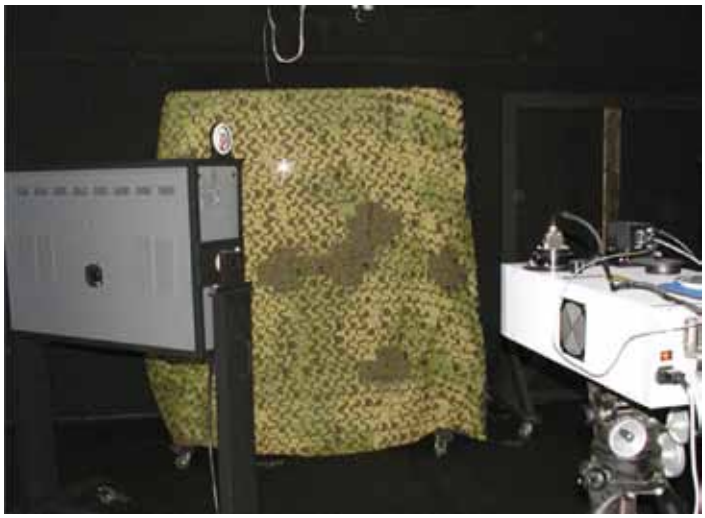
The Optics Laboratory enables rapid evaluation of the optical properties of materials. Optical characterization is routinely utilized in systematic studies of material treatments and paint pigment, for example. This lab has been essential for NRL's efforts, including in-house research and materials evaluation for signature control. A color shade evaluation room was added in 2012 and meets Defense Logistic Agency's (DLA) color shade room standards. All test methodologies implemented conform to ASTM or AATCC standards.

Instrumentation:

Perkin Elmer Lambda models 900 & 1050 UV/Visible/NIR/SWIR spectrophotometers, configurable with an integrating sphere or with a dual beam transmission system; Surface Optics Corp SOC-100 Hemispherical Directional Reflectometer (HDR) configurable for specular and/or reflection, and transmission measurements from 0.25μm to 25μm (MWIR/LWIR); Nicolet 760 Fourier transform infrared (FTIR) spectrometer; Gretag MacBeth ColorEye 7000A Spectrophotometer for color shade analysis of materials and color correction of paint formulations. Other instruments provide particle size analysis, differential scanning calorimetry, densitometry, and microscopy.

Blackroom Laboratory

Code 5708
(202) 279-5278
NRL, Washington, DC



Function:

Enables evaluation and characterization of large (>1 m^2) materials from the ultraviolet (UV) to the longwave infrared (LWIR) range.

Description:

The Blackroom Laboratory is used to conduct radiometry, thermography, and multispectral imaging (UV to LWIR) of materials. All surfaces of the lab (55 ft L x 55 ft W x 9 ft H) are coated with a highly emissive flat black treatment to minimize extraneous surface reflections. This facility meets the performance standard PRF-53134, established by the U.S. Army Night Vision and Electro-Optics Systems Directorate for the measurement of visual camouflage.

Instrumentation:

CI Systems SR-5000 Spectroradiometer; ASD Field Spec Pro Spectroradiometer; AN/PVS-7B and AN/PVS-15B night vision goggles; Toshiba IK-1000 ultra-lowlight color video camera; four Canon 60D digital SLR cameras equipped with Gen III image intensifier units; SOC-710C Handheld Visible/Near-Infrared Hyperspectral Camera; Merlin Indigo Midwave Infrared (MWIR) Camera; Telops HYPERCAM Longwave infrared (LWIR) Hyperspectral Camera; Goodrich Extended Near-Shortwave Infrared (NIR/SWIR) Camera; FLIR RECON III Dual Waveband (MWIR/LWIR) Tactical Binoculars; two Gretag-Macbeth Spectra-Light III sources; CI Systems SR-20 cavity blackbody; Santa Barbara Infrared dual 8-inch blackbodies; 1 m^2 Zenith Reflectance Target.

Secure Computational Facility

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Provides a secure computational modeling environment to support research into novel and better ways to control signatures across the electromagnetic spectrum.

Description:

The RF radar cross section (RCS) of 2D and 3D platforms with material treatments can be accurately predicted and modeled with a number of software tools, including CARLOS, MAXTDA, RTS, XATCH, HYPACED, CADDSCAT, and MOMD. Similarly, codes for signature prediction of treated platforms in the IR spectral region include IRIMAGE, SPIRITS, and SHIPIR/NTCS. A wide variety of material design codes are available to complement the signature codes. These include IRTNEW, OPTRAM, VBROB, and SCATCAD for RF and IR radar absorbing material designs. Performance of frequency selective surfaces and other metamaterials can be made with TENZ3D, MAXTDA, HFSS, and PMM.

Instrumentation:

The facility includes an SGI Origin 300 server with eight 600 MHz processors and 16 GB RAM, an SGI O2 workstation, and a Mac G4 with SIPPRNET access. Two other Mac G4s and two PCs running Windows XP provide added capability for computational modeling and data analysis.

Human Perception Laboratory

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Enables the study and analysis of human perception.

Description:

The Human Perception Laboratory facilitates the study of perception, particularly as it relates to visual tasks of a military nature. One of its primary assets is the NRL Eyetracker. The Eyetracker is used to monitor and analyze an observer's visual perception. It tracks the pupil of an observer. The pupil location determines eye movements that in turn indicate areas of attention and cognition. Eyetrackers are portable and do not restrict natural movements and behavior. Among its many applications, the Eyetracker can be used to evaluate search strategies, information display, and camouflage effectiveness.

Instrumentation:

Four NRL Eyetrackers; large-screen monitors; video processing and analysis stations.

BSDF (Bi-directional Scatter Distribution Function) Measurement Facility

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Measures the optical scatter (reflective or transmissive) from a surface in the plane of incidence at wavelengths of 633 nm, 1.06 µm, 3.39 µm, and 10.6 µm (visible, NIR, MWIR, LWIR).

Description:

Scatter is measured with a receiver mounted on a goniometer that transits ±90° from the specular in the plane of incidence. However, instrument occlusion and grazing angle effects limits the useful angular range to ± 75°. The incident beam is produced by lasers of 633 nm, 1.06 µm, 3.39 µm, and 10.6 µm (Visible, NIR, MWIR, LWIR) wavelengths. A raster scan of the surface scatter may also be measured by fixing the angle of the receiver and then moving the sample in a raster fashion.

Instrumentation:

Scatter measurements are made with a Schmitt Industries CASI (Complete Angle Scatter Instrument). The scatter data is presented as the scattered power density normalized by the incident power and plotted as a function of angle. For reflective measurements, this is the BRDF (Bi-directional Reflection Distribution Function). For transmissive measurements, this is the BTDF (Bi-directional Transmissive Distribution Function).

Large-Scale Non-Lithographic Processing (NLP) Facility

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Implements NLP and techniques to deposit functional and/or structural materials on virtually any substrate in digitally defined locations.

Description:

The development of printed electronics is significant and continues to grow. The NRL Large-scale NLP produces batch-specific, modifiable, and adaptable circuitry and electronics using techniques not common in traditional lithographic processes. These techniques produce rapid, low-cost/area solutions and heterogeneous integration for R&D applications. The impact of these technologies will be in the creation of unique hybrid materials/devices, nonplanar topologies, 2D and 3D architectures, and rapid prototyping of designs for implementing new families of R&D solutions.

Instrumentation:

Laser Direct Write System, a Class-1000 clean room, Glove box (36 ft^3), 200 mm Spin Coater, NanoScope Scanning Probe Microscope, Olympus Stereomicroscope, Cascade Microtech High Performance Probe System, and other instrumentation.

Environmental Weathering Laboratory

Code 5708
(202) 279-5278
NRL, Washington, DC

Function:

Provides controlled accelerated weathering testing of R&D materials.

Description:

This laboratory was designed and implemented in 2012 to test and evaluate various materials that are considered sight-sensitive for security purposes. These tests include, but are not limited to, environmental exposure (salt fog, humidity), durability testing (wash/dry cycling, freeze-thaw resistance), thermal insulation, accelerated weathering (UV radiation), stress/strain measurements, and heat signatures analysis. This RDT&E facility can achieve accurate, repeatable measurements and is one of the few facilities in the country that can conduct the required environmental, durability, and multispectral characterization of materials for the DoD in one self-contained and secure location.

Instrumentation:

Autotechnology Salt Fog Chamber (30 ft^3 capacity) with Jet Exhaust recirculation system; Blue M Steady State Stability Test Chamber (32 ft^3 capacity) with custom infrared-transmissive germanium windows; QLabs UV Weathering Station; Commercial washer/dryers; Sweating Guarded Hotplate; Sweating Thermal Manikin; Instron 5900 Mechanical Testing System; Industrial-sized Clicker Press.

Offboard Test Platform

Code 5712
(202) 767-4475
NRL, Washington, DC

Function:

Measures the aerodynamic forces and moments and studies the airflow characteristics over offboard countermeasures deployment vehicles. Supports the development and testing of propulsion systems for deployment vehicles. This facility is especially suited to the study of subsonic low Reynolds number aerodynamics because of its low turbulence intensity.

Description:

The Offboard Test Platform (OBTP) is particularly focused on the development of air vehicles designed to operate at low speed, low altitude, and low Reynolds number. The wind tunnel is a continuous flow design that operates over a range of 20 to 200 kts and has two interchangeable test sections. The aerodynamic test section has a 4 ft × 4 ft cross section and a full 3-axis, 6-component strain gauge balance. Models are attached to the balance “sting,” which can be manually or automatically controlled to sweep through ranges of angle of attack and sideslip, while force and moment data are collected. The propulsion test section is used to develop electric, internal combustion, and miniature turbojet engines. It features an open-jet test section and provides a simulation of in-flight airflow conditions.

Instrumentation:

The aerodynamic test section has a full 3-axis, 6-component strain gauge balance; a 48-port scanivalve pressure measurement system; and an automated data collection system.

Vehicle Development Laboratory

Code 5715
(202) 767-4475
NRL, Washington, DC

Function:

Supports the development of prototype deployment platform vehicles for offboard countermeasure systems.

Description:

The Vehicle Development Laboratory is involved in technology development related to offboard countermeasure deployment platforms. This includes research in new airframe materials and fabrication techniques, low-cost flight control sensors and controllers, and low Reynolds number airfoil design. Full-scale and subscale remote control and autonomous prototype vehicles are fabricated and flight tested. Also, avionics subsystems, precision guidance, navigation, control, and deployment mechanisms are refined through flight testing aboard various remotely piloted test aircraft operated by the laboratory.
The Vehicle Development Laboratory has a substantial capability to fabricate airframe and mechanism test articles, light metalwork, and composite structures.

Instrumentation:

The Vehicle Development Laboratory has supporting equipment and instrumentation associated with prototype flight testing such as radio control systems, miniature autopilots, video cameras, data collection systems for both onboard and RF telemetry, and a variety of sensors such as accelerometers, gyros, airspeed sensors, and altitude transducers.

Mobile Radio Frequency Measurements Laboratory

Code 5715
(202) 767-0313
NRL, Washington, DC

Function:

Provides a mobile facility to characterize and quantify the radar cross section (RCS) signature of ships and electronic warfare (EW) passive and active systems over 8 to 18 GHz band and within Ka band. Additionally, the system can measure the effective radiated power (ERP), sensitivity and other target signature characteristics of ships. Active or passive EW systems over the same frequency range can also be characterized.

Description:

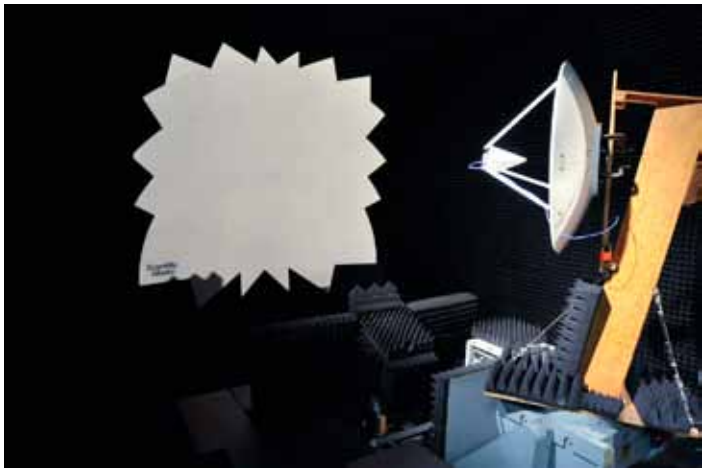
The Mobile Radio Frequency Measurement Laboratory (MRML) consists of an I-band tracking radar, an optical designator to aid in target acquisition, a dual 1-kW broadband traveling wave tube based radar for ERP, RCS, sensitivity and other target characteristic measurements. Similar measurements can be made with its Ka band radar. Radar parameters such as pulse repetition frequency, pulse width, frequency, transmit polarization and receive polarization are programmable. Measurements can be made with selectable transmit polarization and received with pulse-by-pulse switched received polarization or dual received polarizations if required. The complete self-contained system is controlled from up to three operator workstations in an 8 × 24-ft instrumentation hut with all required antennas, cooling and generator power mounted on a 45-ft trailer that can be moved to any test range where measurements are to be made.

Instrumentation:

The instrumentation radar digitizes and stores on a pulse-by-pulse basis coherent data for a target of interest for post-test data processing. ERP, RCS data, sensitivity and other target characteristics are collected using fast analog-to-digital converters (ADCs), data collection, and storage systems. Data processing is very flexible; the data can be supplied in predetermined processing and display formats or the processed data can be tailored to user requirements. The instrumented data radar is calibrated using a combination of automated internal and external procedures.

Compact Antenna Range Facility

Code 5731
(202) 404-3014
NRL, Washington, DC



Function:

Supports the measurement of phase and amplitude pattern characteristics of devices under test (DUT) over a frequency range of 2.0 to 50.0 GHz in a controlled environment. The facility also provides the capability for radar cross section (RCS) measurements over the same frequency range.

Description:

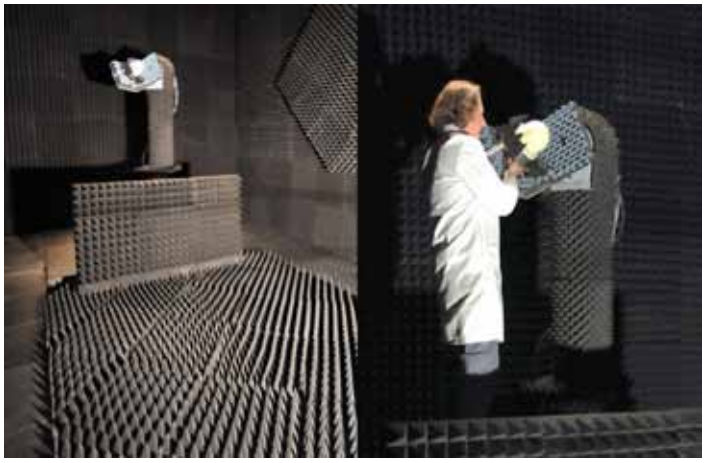
The facility is an anechoic chamber that is designed to operate in conjunction with a Scientific Atlanta Compact Range Model 5751 with millimeter-wave (MMW) reflector. The Compact Antenna Range Facility consists of a shielded anechoic chamber (18 ft high × 22 ft wide × 40 ft long) and a geometry that enables farfield radiation patterns to be taken in a small space. Illumination of the MMW reflector at one end of the chamber provides a cylindrical quiet zone (4 ft diameter × 6 ft long) in which all the radiation patterns are measured. The quiet zone is specified to provide at least 45 dB of background noise isolation from 2.0 to 8.0 GHz and at least 50 dB from 8.0 to 94.0 GHz. The amplitude taper is specified to be no more than 0.5 dB over the quiet zone, with a corresponding specification of no more than 10° phase taper. Test antennas or subsystems are positioned by attaching them to an azimuth-over-elevation mount. Further degrees of freedom (DOF) are allowed with the mounting point being on a roll axis and the entire positioner on a slide axis. A second roll axis is provided for source illumination and enables the source polarization to be quickly rotated.

Instrumentation:

The Compact Antenna Range Facility uses a complete complement of microwave laboratory instrumentation, including network analyzers, microwave receivers, spectrum analyzers, frequency counters, power meters, function generators, and microwave synthesizers. Antenna and RCS measurements are made using an Agilent E8364C Precision Network Analyzer coupled with Orbit/Flam & Russell 959 antenna and RCS measurement software. Four simultaneous channel measurements can be made to characterize an antenna or the RCS of a target from 2.0 to 50 GHz. Broadband, dual-polarized source antennas are available from 2.0 to 26.0 GHz. A high-speed source switch, coupled with a 16-channel switch matrix, supports 32-channel dual-polarized measurements from 2.0 to 26.0 GHz or 16-channel single-polarized measurements from 2.0 to 50.0 GHz.

Millimeter-Wave Antenna Range Facility

Code 5731
(202) 404-3014
NRL, Washington, DC



Function:

Supports the measurement of phase and amplitude pattern characteristics of devices under test (DUT) over a frequency range of 18.0 to 50.0 GHz and 75.0 to 110.0 GHz in a controlled environment.

Description:

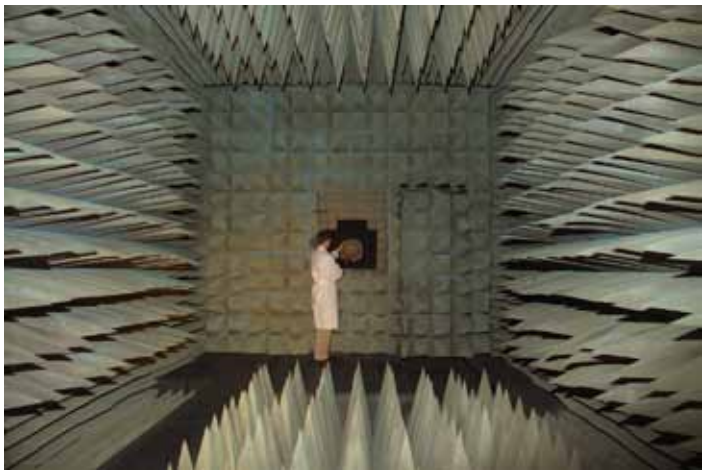
The facility is a shielded anechoic chamber that is 29 ft long x 16.5 ft wide x 16 ft high. This chamber is configured for direct illumination of a device under test (DUT) that is mounted on a pedestal whose center of motion is coincident with the center of the quiet zone of the chamber. The quiet zone is a 3-ft diameter sphere centered at one end of the chamber. The quiet zone is illuminated from a transmit tower located 20 ft away. Test antennas or subsystems are positioned by attaching them to an azimuth-over-elevation mount. Further degrees of freedom (DOF) are allowed with the mounting point being on a roll axis. A second roll axis is provided for source illumination and enables the source polarization to be quickly rotated.

Instrumentation:

The Millimeter-Wave (MMW) Antenna Range Facility uses a complete complement of microwave laboratory instrumentation, including network analyzers, microwave receivers, spectrum analyzers, frequency counters, power meters, function generators, and microwave synthesizers. Antenna measurements are made using an Agilent E8364B Precision Network Analyzer (PNA) coupled with Orbit/Flam & Russell 959 Antenna Measurement software. The PNA supports measurements from 2 to 50 GHz and 75 to 110 GHz. Two simultaneous channel measurements can be made to characterize an antenna from 75 to 110 GHz. The absorber design for the anechoic chamber is what drives the 18 GHz low frequency specification.

RFCM Techniques Chamber Facility

Code 5731
(202) 404-3014
NRL, Washington, DC



Function:

Provides the capability to develop radio-frequency countermeasure (RFCM) techniques in a controlled environment from 2.0 to 40.0 GHz. The configuration of the chamber allows for direct illumination of a target system from an electronic countermeasure (ECM) system.

Description:

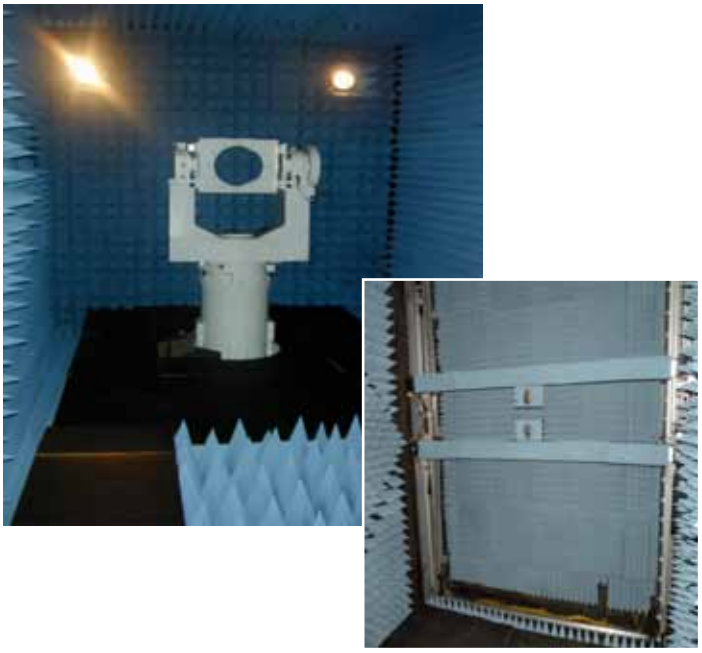
The facility is a shielded anechoic chamber that is 39 ft 3-1/2 in. long x 17 ft 1 in. wide x 16 ft 1-3/8 in. high. This chamber is equipped with a moveable end wall at the east end of the chamber and a single quiet zone located adjacent to the fixed end wall at the west end of the chamber. The quiet zone is 4 ft long x 4 ft wide x 4 ft high. The center of the quiet zone is located on the chamber boresight axis and 2 ft from the absorber tips on the fixed end wall. Target systems are positioned by attaching them to an azimuth-over-elevation mount located in the main control room of the chamber. The system antennas extend through an opening in the wall centered in the quiet zone of the chamber. For servicing, the mount is located on a track that allows it to be rolled back into the control room. The ECM systems are located on the other end of the chamber behind a moveable absorber wall. The ECM antennas are mounted to or placed in front of the opposite wall.

Instrumentation:

This facility has no dedicated instrumentation; users supply both the target and ECM systems.

Low-Power Anechoic Chamber

Code 5743
(202) 404-3733
NRL, Washington, DC



Function:

Develops electronic attack (EA) techniques against antishipping missiles and evaluates the effectiveness of the techniques. All countermeasures programmed in the active AN/SLQ-32(V) area threat libraries are developed, tested, and evaluated in this facility. New EA techniques against modern antishipping missiles using an advanced EA techniques generator are investigated for implementation on future EW systems.

Description:

The Low Power Anechoic Chamber is instrumented to develop techniques against antishipping missiles operating in the X, Ku and Ka bands of the frequency spectrum. It comprises a two-axis pedestal to mount the threat radar seeker, a dual-horn antenna positioner system to simulate RF signals radiated towards the radar seeker, RF generation equipment, and an EA techniques generator. One of the horn antennas is used to radiate the ship return and the EA technique waveform along the missile-ship line-of-sight. The other horn antenna is used to radiate EA signals representing passive or active decoys. In closed-loop simulations, the missile orientation is incorporated in the pedestal geometry utilizing synthetic line-of-sight. The dynamic RF environment of a missile–ship EA engagement is modeled through the angular motion of the radar on the pedestal and the motion of the decoy horn antenna. Realism of ship return pulses is achieved by including in the generation of the ship return RF structural features of the ship, radar cross-section (RCS), range attenuation of power, and scintillation and environmental effects. EA technique waveforms are radiated to include the effects of seeker antenna pattern, range attenuation, and realistic jamming-to-signal ratios. The missile autopilot and aerodynamics simulations are run in real time using an Applied Dynamics Real-Time System (ADRTS) workstation.

Instrumentation:

EA equipment includes operational Fleet technique generators, advanced EA technique waveform generators, motorized cross-pole jamming horn antennas, and digital RF memory units (DRFMs) to replicate target return signals. The facility instrumentation assets include electronic strip-chart recorders, RF spectrum analyzers, oscilloscopes, RF power meters, RF synthesizers and amplifiers in microwave and millimeter bands.

High-Power Microwave Explosive Laboratory

Code 5745
(202) 404-2466
NRL, Washington, DC

Function:

Develops and evaluates the effectiveness of waveforms for the disruption of various systems of interest. Included in the facility are an anechoic chamber, RF transparent blast chamber, nearfield focusing dish antenna, and associated sources and instruments. High-power RF frequencies between 0.6 and 40 GHz may be used inside the anechoic chamber as well as lasers and high-voltage discharge systems. Interactions with explosives can be explored using the blast chamber inside the anechoic facility.

Description:

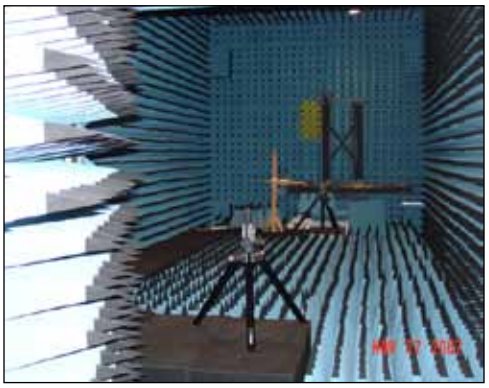
The facility is used to explore explosively generated RF systems as well as the interactions of RF on explosive materials. A storage locker in the facility is cleared to store explosives in small amounts and the blast chamber is rated for up to 0.01 lb of explosive (the equivalent of three standard blasting caps). Explosives may be characterized using various instruments before and after testing. The nearfield focusing antenna allows for high intensity RF fields directed into a spot. This allows component-specific exposure to RF of complex systems. Additionally, the facility is capable of handling laser system-based experiments, the testing of interactions between RF and lasers, and high-voltage discharge experimentation. The anechoic chamber is 24 ft wide x 30 ft long x 50 ft high.

Instrumentation:

The facility contains sources, measurement equipment, and data acquisition instrumentation for a wide range of RF and DC characterization. Available sources include high-power traveling wave tubes (TWTs), solid-state devices and magnetrons to provide both continuous and short-pulse high-power RF. DC sources include Marx bank generators, Tesla coils, and regulated DC power supplies for a variety of high-voltage requirements. Antennas covering multiple frequency ranges are also available. Survey meters are available for measuring RF inside and outside the chamber along with a variety of power meters and associated probes. High-speed scopes and spectrum analyzers are also available for the measurement and analysis of waveforms. A network analyzer may also be used to carry out circuit measurements. A pulley sytem has been integrated into the chamber roof for handling of lightweight items (such as radar targets) at the large distances.

High-Power Microwave Research Facility

Code 5745
(202) 767-5746
NRL, Washington, DC



Function:

Develops and evaluates the effectiveness of high-power microwave waveforms for the disruption of electronic systems. Included in the facility are an anechoic chamber, gigahertz transverse electromagentic (GTEM) cell, associated RF sources and instruments, and various computer processing systems. High-power RF frequencies between 0.6 and 100 GHz may be used inside the anechoic chamber, while frequencies between 0.6 and 20 GHz may be used inside the GTEM cell. Computer simulation and analysis of RF environments may be carried out.

Description:

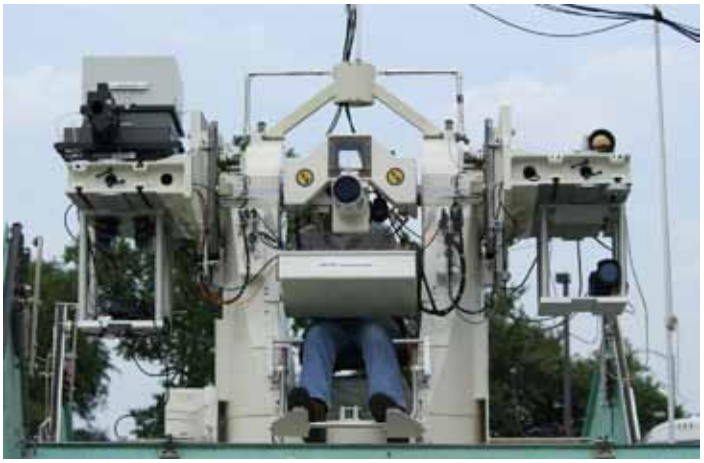
The facility is used to test the response of electronic systems to high-power RF waveforms. Primary interest is in the disruption of the function of a system using out-of-band waveforms, i.e., waveforms with frequencies that are not the normal operating frequencies of the device. One of the objectives is to find waveforms that may disrupt a large number of systems with power levels that are as low as possible. Positioners are available to displace device(s) under test or the radiating antenna to obtain angular information. The performance of the system is monitored to determine the portion of the system that was affected by the RF waveform. More invasive instrumentation may also be used to determine point of entry. The facility is also used to develop techniques that will harden systems to RF attack. Once RF susceptibilities and RF entry points are determined, hardening techniques may be evaluated to determine the level of protection provided.

Instrumentation:

The facility contains sources, RF measurement equipment, and data acquisition instrumentation. Available RF sources include high-power traveling wave tubes (TWTs), solid-state devices, and magnetrons to provide both continuous and short-pulse high power RF. Horn antennas covering multiple frequency ranges of interest are also available. Survey meters are available for measuring RF inside and outside the chamber along with a variety of power meters and associated probes. High-speed scopes and spectrum analyzers are also available for the measurement and analysis of waveforms. A network analyzer may also be used to carry out circuit measurements.

Electro-Optics Mobile Laboratory

Code 5750
(202) 767-3337
NRL, Washington, DC



Function:

Provides quantifiable IR spatial and spectral radiometric measurements of various types of targets. Typical targets include ships, aircraft, and IR decoys.

Description:

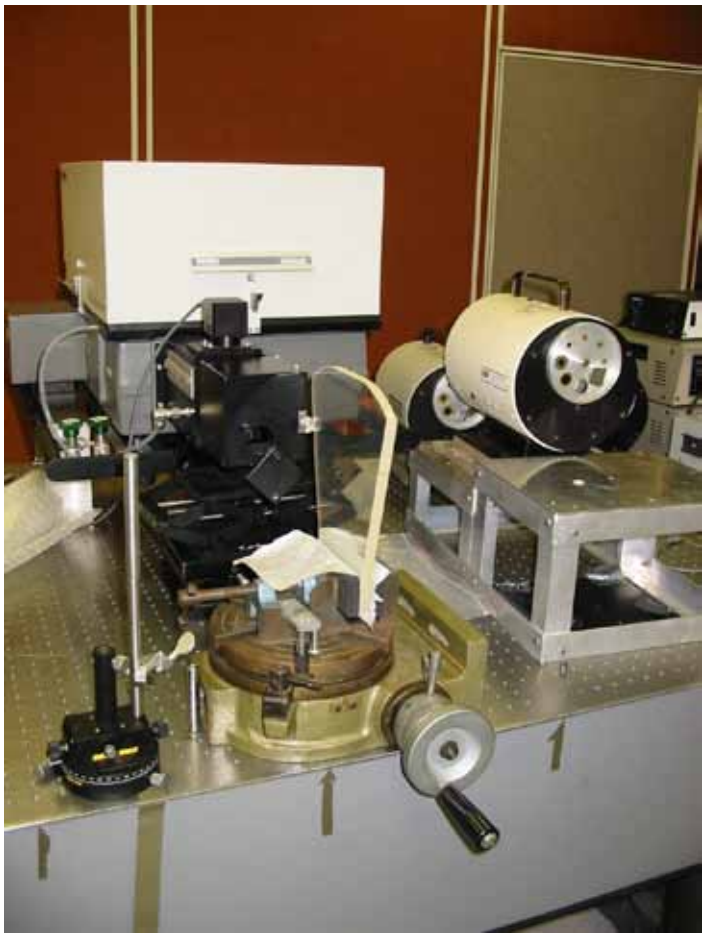
The Electro-Optics (E/O) Mobile Laboratory is a specially modified, fully instrumented vehicle and a trailer-configured precision tracking mount. This facility provides the work space, storage, and power for instrumentation racks and their operators. Front-end optics and electronics are bore sighted on a Kineto tracking mount to provide a stable platform. The mount provides motions of 640° azimuth and 90° elevation at up to 60°/s. Full velocity can be reached within 1 s from a standing position with a full load of 300 lb on each arm along with the operator. This mobile laboratory is outfitted for visual and IR imagery, which can be used for tracking or spatial measurements. High-precision IR radiometers and interferometers provide calibrated measurements in the 3 to 5 μm and 8 to 12 μm bands. A full data acquisition system permits archiving and prompt data reduction.

Equipment:

E/O Mobile Laboratory test equipment includes weather, ranging, video, and electro-optical instruments. Radiometric and imaging instruments are calibrated and characterized before each test. Equipment currently in use includes a Bomem MR304 high-speed Fourier transform infrared (FTIR) interferometer spectrometer (1.5 to 14 μm), Indigo Phoenix MW (3 to 5 μm) and LW (8 to 9 μm) imagers, and FLIR Systems MW (3 to 5 μm) and LW (8 to 9.4 μm) imagers. Calibrations are verified in the field with IR blackbody sources to assure accuracy and consistency.

Infrared/Electro-Optical Calibration and Characterization Laboratory

Code 5750
(202) 767-3337
NRL, Washington, DC



Function:

Enables the optical characterization of IR materials and precise calibration of IR radiometric and spectroscopic instrumentation.

Equipment:

Included are state-of-the-art instruments and devices. Calibration is carried out with precision IR calibration sources and a 24-in.-diameter, 200-in. focal length off-axis collimator. Equipment currently in use includes two circular variable filter (CVF) wheels spanning several IR bands for use in characterizing instrument spectral response, several high-temperature blackbodies and large-area differential blackbodies, and a visual monochromator (350 to 1050 nm). Calibrations and characterization measurements can be carried out at different temperatures using a Tenny environmentally controlled chamber.

Description:

The Infrared/Electro-Optical Calibration and Characterization Laboratory is an essential element of NRL's IR signature measurement and signature control programs. Naval Sea Systems Command-supported ship signature measurement and ship decoy development programs rely on this laboratory for accurate calibration of instruments such as interferometer spectrometers, circular variable filter radiometers, and IR imaging radiometers. This facility also provides the capability for characterizing and calibrating visual cameras and spectrometers.

Infrared Missile Simulator and Development Laboratory

Code 5750
(202) 767-3337
NRL, Washington, DC

Function:

Determines the effectiveness of ship-based IR decoys and IR laser countermeasure (CM) systems against IR-guided antiship missiles (ASM). Develops performance bounds of IR ASMs to detect and engage both conventional and signature-reduced U.S. surface platforms. Evaluates the performance of various infrared countermeasure (IRCM) techniques.

Description:

The IR Missile Simulator and Development Laboratory includes IR seeker simulators and a fully equipped laboratory for sensor evaluation, processor design and development, flight hardware assembly, algorithm design, and data analysis. The captive aircraft-mounted systems use fiber-optic communications between the wing pod and the instrumentation/display consoles inside the aircraft, which provides low noise on all data. The towed aircraft-mounted systems use wireless telemetry to communicate between the pod and console inside the aircraft. The simulator systems contain an integrated data system for analysis of extensive field trials and allow ready visualization. One simulator is a reprogrammable system permitting evaluation of multiple threats. Detector configurations and algorithms are changed to properly represent the threats. The large system gimbal accommodates newly developed imaging IR cameras. By using flexible distributed software architecture, a complete missile seeker system with exceptional ability to incorporate new algorithms and infrared counter-countermeasure (IRCCM) approaches is obtained. Digital data collection allows post-test analysis, system development, and simulation.

Equipment:

An extensive array of optical and electronic analysis equipment supports the development, test, and operation of the electro-optical (EO)/IR simulators. Test and analysis of much of the electronics is accomplished through standard and custom interfaces coupled to portable computer-based data acquisition subsystems. Software development facilities employ both high and low-level, distributed, and parallelized code for real-time operations and to maximize resource utilization.

Secure Supercomputing Facility

Code 5750
(202) 767-3337
NRL, Washington, DC

Function:

Provides NRL, the Navy, and DoD with a high-speed, large-memory computation facility for classified projects. Cluster-based computers provide a very high throughput with large on-line memory for analysis of complex electronic warfare scenarios. Large storage is provided for analysis results and archival purposes.

Description:

The Secure Supercomputing Facility applies several modern high performance Linux clusters to complex, computation-intensive, classified Navy modeling and simulation studies. A premier cluster is a Dell PowerEdge Blade Cluster consisting of 32 Quad-core blades with 48 GB of RAM for a total of 256 processors and a peak processing capability of over 750 GigaFLOPS and 1.5 terabytes of RAM. Local shared disk storage is provided by a high performance Linux NFS file server with 96 terabytes of storage. The facility's computational capacity is supplemented by two additional 20-blade clusters, providing a peak processing capability of 240 GigaFLOPS and 160 GB of RAM. An additional 16-blade cluster provides a peak processing capability of over 380 GigaFLOPS and over 750 GB of RAM.

Equipment:

Secure Supercomputing Facility operators interface to the high performance clusters through Windows workstations via X/Windows displays and protocols. A range of color laser printers and large format printer-plotters are available in the installation. A rich set of productivity and development tools is applied, including OpenMotif and other graphical user interfaces, Matlab, Linux tools and debuggers, Intel C/C++ and FORTRAN compilers and debuggers, high performance Math libraries, and parallel and distributed programming tools, data visualization, and multimedia tools.

CBD/Tilghman Island IR Field Evaluation Facility

Code 5750
(202) 767-3337
NRL, Washington, DC

Function:

Research and development facility for electro-optical/infrared (EO/IR) threat simulators including antiship-capable missile seekers. The facility also enables field evaluations of EO/IR countermeasures (decoys and active jamming) in an over-water environment with a focus on the protection of Navy ships.

Description:

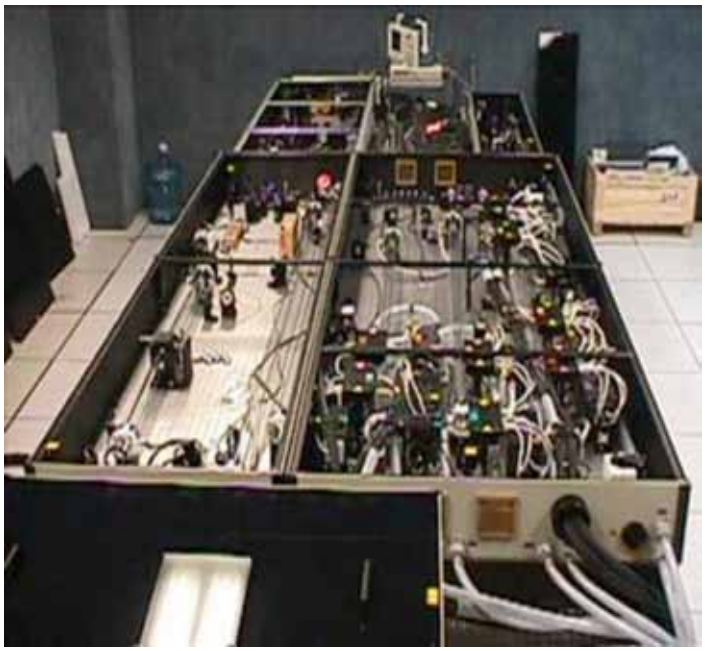
The facility has two components, one at the Chesapeake Bay Detachment (CBD) and one at Tilghman Island. Located at CBD on the western side of the Chesapeake Bay is the CBD Building 5, which houses EO/IR sensors, sources, and measurement instrumentation. This building is set on a 32-m high cliff overlooking the bay. Sixteen kilometers across the bay is the Tilghman Island facility, with a 22-m high tower that contains instrumentation and threat simulators. These facilities enable the research that leads to the development of techniques and systems to defeat antiship-capable missile threats. The reference instrumentation quantifies the countermeasure performance and records the environmental conditions. Countermeasures may be deployed from either shore-based location or from one of the support vessels attached to the facility.

Equipment:

The CBD site overlooks the bay and includes instrumentation power and environmental controls in a large space for multiple antiship-capable seeker simulators and reference instrumentation. This site has an environmentally controlled space with optical bench. The Tilghman Island site on the eastern side of the bay features a 22-m tower, affording a 16-km over-water path to the CBD site. The tower includes instrumentation power and environmental controls for the seeker simulators. Support vessels are available as reference targets and to deploy decoys.

Ultra-Short-Pulse Laser Effects Research and Analysis Laboratory

Code 5750
(202) 767-3337
NRL, Washington, DC



Function:

Enables advanced scientific research into laser-material interactions and their potential utility for Navy applications.

Description:

This laser facility has a capability to produce extremely high peak-power levels of 28 TW (~1 J/pulse at 35 fs). Such high peak-power laser pulses provide the capability to study laser-material interactions with ultra-high electric fields which is unattainable with conventional laser systems.

Instrumentation:

The key component in the facility is an ultra-short pulse laser (USPL) with very high peak power. The operating environment has a tightly controlled temperature and low-humidity system. A foundation separate from the rest of the building isolates the laser from the normal building vibrations. This facility has an electrically-isolated target area to study interactions with materials, test assets, and laser-induced discharges with diagnostics to measure optical spectra, pulse characteristics, plasma densities, and electronic properties of the interaction.

Central Target Simulator Facility

Code 5760
(202) 767-2208
NRL, Washington, DC

Description:

The Central Target Simulator (CTS) Facility is built around a 114 ft × 127 ft × 38 ft high shielded anechoic chamber. A spherical array of 225 dual-polarized antennas operates in I/J band and is used to simulate the RF environment that a missile encounters in an engagement. Two feed networks distribute time and space coincident signals. A smaller array driven by a single feed network operates at K band. The RF generation subsystem is synchronized to the missile radar in time, frequency, and phase. State-of-the-art modulation equipment replicates the characteristics of ship and decoy echoes, correctly triggering target discriminates. External inputs allow jamming signals and waveforms to be included in the simulation. Missile hardware is mounted 75 ft from the array on a three-axis flight motion simulator. The loop between the missile and the facility is closed through a six-degrees-of-freedom (6-DOF) threat simulation that interacts with the guidance hardware in response to the RF stimuli. Simulations execute in real-time at update rates of up to 1000 Hz. A battery of open-loop characterization tests is used to evaluate the performance of the missile radar subsystems, identifying design features, vulnerabilities or limitations for potential exploitation by EW tactics and techniques.

Function:

A high-performance, hardware-in-the-loop missile engagement simulation facility for real-time closed-loop testing and evaluation of electronic warfare (EW) systems and techniques to counter threats to the U.S. Navy in the 8.0 to 40.0 GHz frequency range. The facility uses actual missile guidance hardware. It operates in open and closed-loop configurations. Closed-loop tests feature actual missile closure rates; results are reported in multiple formats, including hit/miss distances. Open-loop characterization tests evaluate the capabilities of threat systems and contribute data to the simulator validation process. Radar transmitters are activated for the measurement and collection of observable parameters.

Equipment:

The facility uses general-purpose and custom laboratory instrumentation and recording equipment to capture information pertinent to the tests being conducted. The simulation computer stores the complete engagement scenario, along with 64 analog signals and 24 digital bits captured from the missile hardware. SIMDIS provides real-time and post-test visualization and analysis tools. A video distribution system allows test equipment/computer displays to be viewed in the control room and throughout the facility; recording is performed via multiple digital video recorders. Communication is provided by a dedicated intercom system.

Flying Electronic Warfare Laboratory

Code 5760
(202) 404-3819
Naval Air Warfare Center, Patuxent River, MD

Function:

Provides aircraft host platforms for Effectiveness of Navy Electronic Warfare Systems (ENEWS) Program antiship missile (ASM) seeker simulators used for electronic warfare (EW) effectiveness assessment in an at-sea environment. This capability provides the Navy's research, development, test, and evaluation (RDT&E) and operational communities with unique assets and realistic methods for evaluating surface Navy EW systems.

Description:

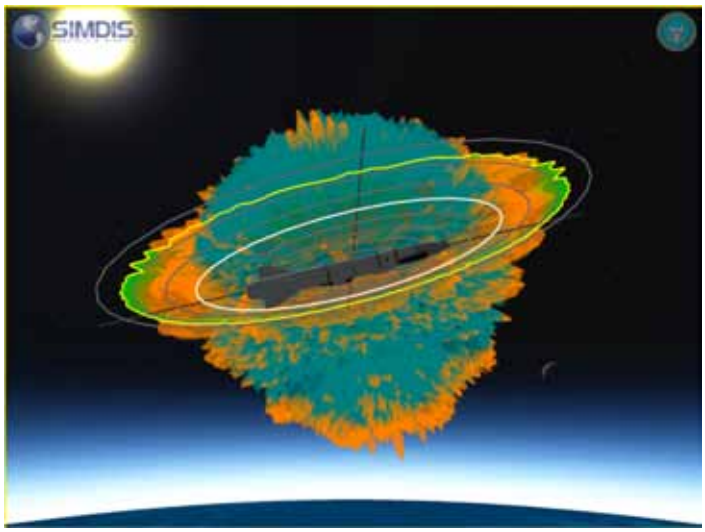
The Flying Electronic Warfare Laboratory provides ASM threat representation through the adaptation of a host of missile seeker simulators. These simulators use a combination of hardware and software to model the external parameters and internal functions of various threat systems. Operational testing against ships' EW assets is enhanced through the unique ability to provide real-time feedback of the effectiveness of electronic attack (EA) responses to the threat seeker's stimuli. Ten different simulators representing various ASM threat types are available as part of the ENEWS Program. Several simulators can be operated simultaneously to exercise the onboard/offboard EW assets being tested. Internally mounted equipment racks contain seeker control panels, data displays, data acquisition systems, and communications systems that are organic to each simulator. Special features include the ability to monitor and record simulator status, receiver/processor functions and select decision logic. The laboratory supports RDT&E and operational activities on a worldwide basis, providing EW testing support to U.S. and NATO programs, and those of individual countries.

Instrumentation:

Two Lear 36 aircraft are configured to carry two simulators in pods under the wing. If more than two simulators are required for a test, the NRL NP-3D can be utilized to carry up to eight simulators for simultaneous operation. These simulators represent a large cross-section of the threat missile systems available worldwide and are derived from other programs or are hardware systems modified to represent various threat seekers. All of the simulators are one-of-a-kind systems, with the associated instrumentation tailored to the individual simulator. GPS and data link systems allow the collection of aircraft and ship's position information for ground truth determination.

Visualization Laboratory

Code 5770
(202) 767-6813
NRL, Washington, DC



Function:

Evaluates and improves the operational effectiveness of existing and emerging electronic warfare systems. Analyzes and visualizes simulation results and test data in order to address the requirements in system design, tactics, and training.

Description:

The Visualization Laboratory visualizes and analyzes scenarios to evaluate electronic warfare systems. It uses three-dimensional computer graphics to display parameters in an intuitive manner, providing depth, volume, and spatial information. Several analysis routines exist to review the static and dynamic components of the simulation. Static analysis tools convey attributes such as number of platforms, missiles, and emitters used with the scenario, the location of emitters on various platforms, and their characteristics. Dynamic analysis tools convey information about time-variant components, the number of detectable emitters, their bearing, and operation mode. High-resolution imagery overlaid on digital elevation data is used to provide an accurate representation of the geographical areas. Live data sources and multimedia interfaces to naval databases and Geospatial Information System (GIS) databases also exist.

Equipment:

The Visualization Laboratory is equipped with advanced computer graphics workstations, software tools, a high-fidelity sound system, acoustic wall panels, and a large video wall consisting of three Clarity Lion UXGA (1600 ×1200) display systems. The facility is supported by workstations running both Windows and Linux operating systems.

Laboratories for Computational Physics and Fluid Dynamics

Parallel High Performance Computer Graphics Facility

Parallel High Performance Computer Graphics Facility

Code 6040
(202) 404-1063
NRL, Washington, DC

Function:

The Laboratory for Computational Physics and Fluid Dynamics (LCP&FD) is in round-the-clock production for computational studies in the fields of compressible and incompressible fluid dynamics, reactive flows, fluid-structure interaction (including submarine, ship, and aerospace applications), plasma physics, atmospheric and solar magnetoplasma dynamics, application of parallel processing to large-scale problems such as unstructured grid generation for complex flows, and other disciplines of continuum and quantum computational physics.

Description:

The facility is used to develop and maintain state-of-the-art analytical and computational capabilities in fluid dynamics and related fields of physics, to establish in-house expertise in parallel processing and online graphical rendering for large-scale scientific computing, to perform analyses and computational experiments on specific relevant problems, and to transfer this technology to new and ongoing projects through cooperative programs.

Instrumentation:

- 1120-core x86 cluster
- Two 64-core SGI Altix systems
- 184-core x86 cluster
- 256-core SGI ICE cluster
- 256-core Opteron cluster
- More than 60 SGI, Apple, and Intel workstations

Each system has on the order of 14 terabytes of disk for storage during a simulation. All computers and workstations have network connections to NICENET and ATDnet, allowing access to the NRL Center for Computational Science facilities (including the DoD HPC resources) and many other computer resources, both internal and external to NRL.

Chemistry Division

Chemical Analysis Facility

Mass Spectrometry Facility

Magnetic Resonance Facility

Corrosion Engineering and Coatings Characterization Facilities

Ballast Water Treatment Test Facility

Cathodic Protection Model Facility

Sacrificial Anode Qualification Site

Antifoulant Coatings Exposure Site

Marine Coatings Facility

Chemical Vapor and Plasma Deposition Facility

Nanometer Characterization/Manipulation Facility

Trace Explosives Testbed

Complex Trace Vapor Generator Facility

Chemical Dosimeter Exposure Testbed

Navy Fuel Research Facility

Fire Research Enclosure

Large-Scale Damage Control Facility

Ex-USS *Shadwell* Advanced Fire Research Ship

Chesapeake Bay Detachment Fire Test Facility

Chemical Analysis Facility

Code 6110
(202) 404-6392/(202) 767-3138
NRL, Washington, DC

Function:

Uses state-of-the-art instrumentation for qualitative and quantitative analysis of organic and inorganic compounds, and biomolecules from gas, liquid, and solid samples. Principal functions of the facility include analyzing samples of environmental importance, ranging from the atmospheres of submarines to polycyclic aromatic hydrocarbons in harbor sediments, and characterizing synthetic products and materials (such as polymers).

Description:

The facility includes instrumentation for characterizing many types of environmental and synthetic samples using a variety of analytical techniques. Environmental samples (air, water, and sediment) are prepared by techniques such as solid-phase extraction, liquid extraction, and thermal desorption. Quantitative and qualitative analytical information is provided by gas chromatography (GC), GC/mass spectrometry (MS), liquid chromatography (LC), LC/MS, inductively coupled plasma MS, capillary electrophoresis, excitation/emission fluorimetry, infrared spectroscopy, and UV-visible spectroscopy. Additional detailed information about molecular structures is obtained by nuclear magnetic resonance (NMR) spectrometry, isotope ratio MS, and matrix-assisted laser desorption MS.

Instrumentation:

The facility contains gas chromatographs with flame ionization, thermal conductivity, nitrogen-phosphorous, and mass spectrometer detectors; liquid chromatographs with UV-visible, fluorescence, and mass spectrometer detectors; capillary electrophoresis instruments with UV-visible and conductivity detectors; a thermal desorption–gas chromatograph with tandem infrared and mass spectrometer detectors; an inductively coupled plasma mass spectrometer; a matrix-assisted laser desorption time-of-flight mass spectrometer; Raman, near, and mid-infrared spectrophotometers; UV-visible spectrophotometers; fluorimeters; and NMR spectrometers.

Mass Spectrometry Facility

Code 6115
(202) 767-0719
NRL, Washington, DC

Function:

Mass spectrometers throughout Code 6100 provide detailed chemical analysis capabilities.

Description:

The Chemistry Division at NRL maintains several mass spectrometers, providing analytical support of basic and applied research underway at the laboratory, as well as addressing analytical challenges posed by sponsor agencies.

Several instruments are mass spectrometric detectors for chromatographic instrumentation, including multiple gas chromatographs with mass spectrometer (GC-MS) detection and one liquid-chromatograph mass spectrometer (LC-MS). Agilent GC-MS instruments provide electron impact and chemical ionization with quadrupole-based mass-selective detection. These instruments provide unit mass resolution and analysis of a wide range of liquid and vapor samples through the use of thermal desorption units, cryo-cooled inlets and liquid autosamplers. Two LECO Pegasus GC-MS instruments utilize time-of-flight (TOF) mass analyzers and electron-impact ionization. One of these instruments is configured to perform two-dimensional gas chromatography (GCxGC) for rapid analysis of complex mixtures. Two JEOL AccuTOF GCv GC-MS instruments provide electron-impact ionization followed by TOF mass spectrometry with mass resolution of approximately 6000. Both of these instruments are equipped with Gerstel CIS-G online gas sampling inlets for analysis of trace organic vapor streams, in addition to standard split/splitless GC inlets. Finally, a Varian 500-MS LC-MS instrument with an ion-trap mass spectrometer and electrospray ionization (ESI) and matrix assisted laser desorption ionization (MALDI) capabilities provides protein and polymer analysis for proteomic or metabolite identification. This instrument includes a MASCOT enabled interface for protein identification and multistage fragmentation (MS^n) capabilities.

A Thermo Finnegan Element 2 inductively-coupled-plasma mass spectrometer (ICP-MS) based on a double focusing magnetic sector mass analyzer allows elemental analysis of liquid samples covering nine orders of dynamic range (ultra-trace to matrix level) and almost all of the periodic table.

A Thermo Scientific LTQ Orbitrap XL instrument provides high-resolution (≥100,000) mass spectra of vapor, liquid, and solid samples with atmospheric pressure chemical ionization (APCI), ESI, and flowing atmosphere-pressure afterglow (FAPA) ionization sources. This instrument is capable of a variety of MS^n experiments for molecular structure elucidation utilizing a linear triple quadrupole (LTQ) mass filter followed by an orbitrap mass analyzer.

Instrumentation:

One Varian 500-MS LC-MS with ion trap mass spectrometer and ESI and MALDI ionization capabilities, five Agilent GC-MS instruments with quadrupole mass-selective detectors and electron impact ionization, two JEOL AccuTOF GCv GC-TOF-MS instruments equipped with gas-sampling cryo-cooled GC inlets, one LECO Pegasus HT GC-TOF-MS equipped with a Gerstel TDS-G thermal desorption inlet, one LECO Pegasus 4D GCxGC-TOF-MS capable of two-dimensional gas chromatographic separations, one Thermo Finnegan Element 2 ICP-MS, and one high-resolution LTQ Orbitrap XL instrument from Thermo Scientific with ESI, APCI, and FAPA ionization sources.

Magnetic Resonance Facility

Code 6122
(202) 767-2337
NRL, Washington, DC

Function:

Addresses basic and applied research problems in materials chemistry. Critical Navy problems in materials performance and reliability are stressed, utilizing innovative techniques and approaches, principally in magnetic resonance.

Description:

Advanced high-resolution solid-state nuclear magnetic resonance (NMR) spectroscopy techniques can be used to observe nuclei across much of the periodic table and provide detailed structural and dynamical information.

Instrumentation:

The facility operates advanced Agilent and Bruker Fourier transform NMR spectrometers at 11.7 and 7.0 Tesla for solids and liquids, with provisions for variable-temperature multinuclear studies between 148 K and 523 K, magic-angle spinning to 60 kHz, double and triple resonance, high-power decoupling, and gradient-enhanced spectroscopy. Specialized spectrometers for NMR of solid samples at fields from 2.35 to 7.05 T and pressures to 1 GPa, or temperatures to 4.2 K with the option for optical irradiation, and for nuclear quadrupole resonance are also available.

Corrosion Engineering and Coatings Characterization Facilities

Code 6130
(202) 767-0833
NRL, Washington, DC

Function:

Performs basic and applied materials development, corrosion engineering, corrosion control, cathodic protection design, marine coatings formulation/characterization, electrochemical systems, seawater sensor systems, and materials failure analysis related to marine environments. Additionally, laboratories support efforts at the NRL Center for Corrosion Science and Engineering in Key West, Florida.

Description:

Specialized analytical laboratories determine the mechanisms of materials degradation and develop coatings technology for Naval systems. Seawater effects on materials are studied to understand fundamental physical properties of the electrochemical reactions, mechanisms of materials degradations, and the methodology for materials preservation and protection. The facilities and capabilities include basic electrochemical test laboratories, surface chemical analysis, organic coatings properties measurement, mechanical failure analysis, stress corrosion cracking/hydrogen effects instrumentation, and corrosion properties measurement. Marine coatings laboratories enable the analysis of barrier coating properties, surface preparation scenarios, application, and performance testing. Electrochemical facilities enable the theoretical understanding of interfacial processes and surface chemistry and use the information gained to guide materials development, improve material performance, and reduce maintenance costs.

Instrumentation:

Electrochemical testing equipment for ac and dc measurements; Kelvin probe; low-temperature carburization furnace; coatings formulation lab; Fourier transform infrared spectroscopy; gas chromatography/mass spectroscopy; Zeta potential measurement system; Participating Research Team (PRT) member on beamline X11 at the National Synchrotron Light Source (NSLS); fuel cell test station; X-ray photoelectron spectroscopy; and X-ray fluorescence.

Ballast Water Treatment Test Facility

Code 6130
(202) 767-0833
NRL, Washington, DC

Function:

Provides functionality for the full-scale testing and controlled simulation of ship ballasting operations for assessment of aquatic nuisance species (ANS) treatment in accordance with U.S. and international protocols. The facility conducts research concerning full-scale treatment, organism viability, and biological efficacy. System fully documents process requirements or treatment scenarios and facilitates developing U.S. requirements for Environmental Technology Verification (ETV).

Description:

The Ballast Water Treatment Test Facility (BWTTF) includes land-based ballast tanks (150 to 300 m^3), test organism injection systems, pumping capacity >300 m^3/h, and in-line pipe sampling. The BWTTF is integrated using an industrial plant SCADA system which provides control and feedback of >100 valves, 10 pumps, biological subsystems, physiochemical sensors, and test technologies. The BWTTF is sufficiently flexible to allow for the testing of most ballast water treatment systems and also includes a collection tank and wastewater treatment capability for management of prepared test waters and treated discharges. Finally, the BWTTF incorporates a fully instrumented microbiology laboratory.

Instrumentation:

Three 150 to 300 m^3 test tanks, >300 m^3/h seawater pumping capacity, advanced sampling/measurement capability, spectrophotometers, flow cytometry, fluorometer, epifluorescent microscopes, and Honeywell process control.

Cathodic Protection Model Facility

Code 6130
(202) 404-2123
NRL, Washington, DC

Function:

Performs Navy design and engineering of ship and submarine impressed current cathodic protection (ICCP) systems for underwater hull corrosion control and evaluation/analysis of electric field (EF) and corrosion-related magnetic (CRM) signature.

Description:

Located at the Naval Air Station, Key West, FL, the facility consists of 30-ft-diameter modeling tanks with state-of-the-art multichannel electrochemical controller, sensors, and datalogging capability. The physical models, which range from 1/2 to 1/96th scale, represent exact geometry and provide data for ICCP system design and for computational science and technology. Capabilities include the ability to control electrolyte conductivity, lifecycle/failure mode analysis, dynamic flow situations, equipment design, and EF signature analysis.

Instrumentation:

50,000-gal and 100,000-gal modeling tanks, 30-zone analog and 60-zone digital controller capability, AISHE Controller (SSN 774), static/dynamic flow simulation, seawater simulation and stabilization, advanced scanning underwater EF/magnetic sensors, scale class models for CG, DDG, LHD, LHA, LCS, LPD, CVN, AOE, MCM, FFG, SSN (688, 21, and 774), and experimental hulls.

Sacrificial Anode Qualification Site

Code 6136
(305) 293-4214
NRL, Key West, FL

Function:

Meets testing requirements for qualification of anodes under MIL-A-24779 (aluminum) and MIL-A-18000H (zinc). The site provides natural seawater exposure and represents a large steel cathode specifically instrumented for both S&T and qualification Navy efforts.

Description:

Located on Pier D-3 at the Naval Trumbo Point Annex in Key West, Florida, the site consists of an 800 ft steel seawall with 60 anode stations and an average seawater depth of 30 feet. Sacrificial anodes can be evaluated for performance, efficiency, passivation potential, and qualification properties. The “real-world” steel bulkhead offers a unique, large, unpolarized cathode surface exposed with flowing natural seawater that is not polarized by the addition of anode test specimens.

Instrumentation:

60 anode stations with enclosed datalogger and control circuitry.

Antifoulant Coatings Exposure Site

Code 6138
(202) 404-4132
U.S. Coast Guard Station, Miami, FL

Function:

Provides “real-world” natural seawater exposure capability in support of Navy S&T efforts to develop and evaluate underwater hull antifoulant systems.

Description:

This tropical exposure site, located on the U.S. Coast Guard station along the intercoastal waterway in Miami, Florida, facilitates long-term specimen exposure with excellent biofouling capability and supports a key part of the qualification process for new technology assessment. The raft holds in excess of 200 6-in. x 24-in. exposure panels and supports natural growth of both micro- and macrofouling organisms within the Biscayne Bay ecosystem.

Instrumentation:

Seawater exposure raft, sample exposure system, and seawater physical chemistry monitoring.

Marine Coatings Facility

Code 6138
(305) 293-4214/(202) 404-4132
Naval Air Station, Key West, FL

Function:

Conducts research, development, test and evaluation (RDT&E) in direct support of 21st-Century Fleet requirements concerning seawater materials performance, corrosion behavior, and marine coatings technology.

Description:

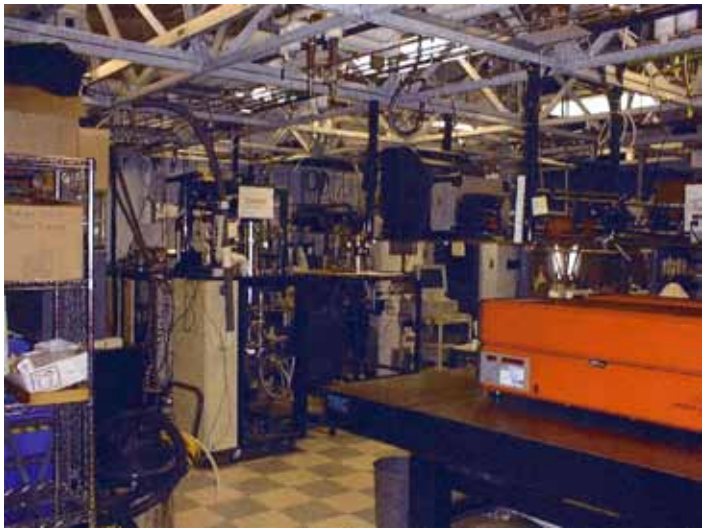
The Marine Coatings Facility is located at Naval Air Station Key West, Trumbo Point Annex, Florida. The laboratory has an unparalleled database for natural seawater exposure testing and marine-related materials evaluation. It receives a plentiful, unpolluted supply of Gulf of Mexico seawater throughout the year. The tropical climate is ideally suited for marine exposure testing. There is minimal climatic variation and a stable biomass throughout the year. The laboratory has more than 1000 ft of waterfront access, natural “blue” ocean-quality seawater access, a 2500 ft^2 atmospheric test site, and more than 14,000 ft^2 of laboratory facilities.

Instrumentation:

Complete state-of-the-art coatings evaluation facilities with 32°–125 °C environmental coatings application chamber, atmospheric exposure site (southernmost site in continental U.S.), complete powder coatings facility, plural component spray capability, natural seawater exposure (open ocean environment), physical analytical properties laboratory, material preparation and application, Fourier transform infrared spectroscopy, seawater flow channel, and Navy antifoulant test site in Miami.

Chemical Vapor and Plasma Deposition Facility

Code 6178
(202) 767-3579
NRL, Washington, DC



Function:

Facility to study and fabricate materials such as diamond by chemical vapor deposition and plasma processing, using in situ diagnostics (laser, Fourier transform infrared, optical emission, and mass spectroscopies), laser machining, and plasma deposition reactors.

Description:

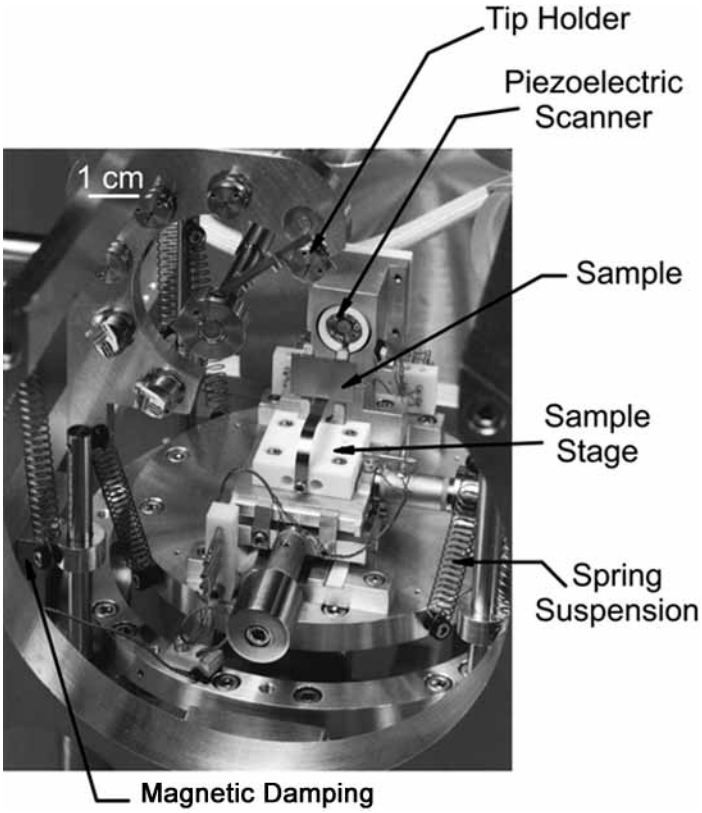
Fundamental and applied research is conducted in a dedicated laboratory space with single-pass air flow, toxic gas alarm system, and gas scrubbers on exhaust air. The research is directed toward the growth and surface chemistry of advanced materials, the spectroscopy of species at or near interfaces, and the molecular/structural characterization and modification of surfaces and solid-gas interfaces. To this end, techniques involving chemical vapor deposition (CVD), high-temperature environments, photon-assisted processes, and plasma processing and plasma deposition/etching are applied. Such modified surfaces/interfaces impact a broad array of DoD-related problems including plasma modification, electronic device processing, protective coatings, corrosion, and synthetic metastable materials.

Instrumentation:

The laboratory features four microwave plasma enhanced deposition facilities (ASTeX HPMM and electron cyclotron resonance plasma deposition chambers); novel inductively coupled plasma research tools; FTIR spectrometers; a triple monochromator, microscope, and optical multichannel channel analyzer for Raman/emission spectroscopy of surface species; a Lambda Physik 2101 excimer laser, a Quantel Nd/YAG laser, a Lambda Physik LPD 3002E dye laser, and an auto-tracking frequency doubling system; quadrupole mass spectrometer in situ sampling system (Hiden) with automated data acquisition; a CW q-switched YAG laser machining facility for cutting diamond films; and a novel RF inductively coupled pulsed plasma source for CVD, etching, and material modification.

Nanometer Characterization/Manipulation Facility

Code 6177
(202) 767-2519
NRL, Washington, DC



Function:

Characterizes the nanometer scale of biological, chemical, physical, electronic, and mechanical properties of surfaces and thin films using scanning probe microscopies/spectroscopies, and a variety of complementary surface analysis techniques. The limits of materials miniaturization are explored by using the new microscopes to fabricate and manipulate surface structures of nanometer size. This technology is used to investigate new chemical, biological, and magnetic sensors, electronic devices, and nanoscale materials.

Description:

Scanning tunneling microscopy/spectroscopy enables observation of the surface topography, chemical reactivity, and electronic structure of conductive substrates with atomic-scale resolution. The atomic force microscope (AFM) provides nanometer-scale resolution of surface topography, mechanical properties, and tip-surface interaction forces on both conductive and insulating substrates. The tip-surface interaction forces, including frictional forces, can be measured with nanonewton (single chemical bond) precision. An ultra-high-vacuum (UHV) system for nanomanipulation and nanoprobe characterization is also available in the Nanoscience Research Laboratory.

Instrumentation:

NRL-built UHV scanning tunneling microscope/spectroscope (STM/S) with facilities for low-energy electron diffraction (LEED) and Auger electron spectroscopy (AES); Omicron UHV variable temperature STM/AFM integrated with a second UHV system housing a multitip STM with a scanning electron microscope (5 nm resolution) and scanning Auger microprobe; Park Scientific Instruments AutoProbe UHV STM/AFM integrated with the NRL Molecular Beam Epitaxy (MBE) Epicenter for characterizing semiconductor surfaces following MBE, including cross-sectional STM; Nanoscope IIIa multimode AFM (lateral force, magnetic force, and tapping modes) equipped with breakout box and force-volume mapping system; TM Microscopes Autoprobe CP AFM used for dip pen nanolithography; Digital Instruments Bioscope AFM integrated with a Zeiss Axiovert 100 inverted optical microscope with fluorescence, micromanipulation, and microinjection capabilities; and Nanoscope IIIa and Multimode AFM, NRL-built lateral-force microscope, and Hysitron scanning-nanoindenters (Triboscope and Bioindenter) with commercial and custom software to measure surface mechanical properties.

Trace Explosives Testbed

Code 6180
(202) 767-3138
NRL, Washington, DC

Function:

Provides uniform, reliable methods for evaluating new explosives detection systems and sensors under development for personnel and platforms protection.

Description:

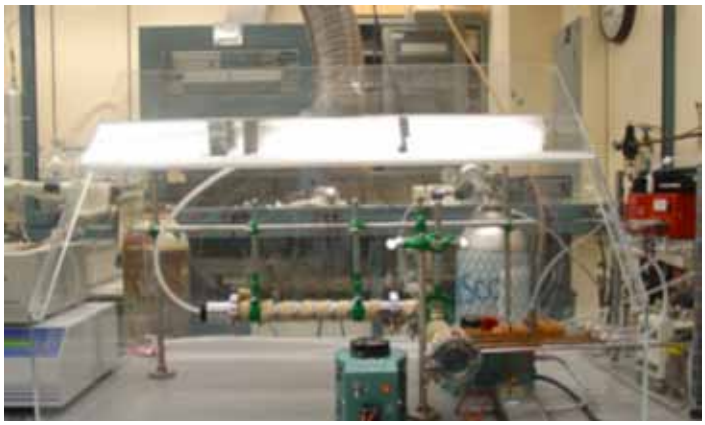
The trace explosives detection testbed employs a zero-grade air source with temperature and humidity control, and vapor generation systems for comprehensive testing of trace levels of explosives and potential interferents. The testbed is a fully automated system using NRL-developed custom software controlled by a custom GUI touch screen interface. Six sample ports are available for single or multiple simultaneous tests of novel sensors and materials for trace explosives detection. The testbed consists of SilcoNert treated stainless steel gas lines, a custom mixer, and a dual-distribution manifold enclosed in a custom oven that can operate at temperatures up to 150°C. The dual manifold was designed to permit rapid switching between clean air and the analyte sources via computer-controlled actuators that drive custom feed-throughs to open and close all valves. All oven-enclosed components are bakeout compatible, but the manifold may be easily exchanged with a duplicate to prevent any possibility of cross-contamination between different explosive analytes. The testbed was analytically characterized using both TNT and RDX for concentrations from parts per trillion (ppt) to parts per billion (ppb). Consistent results were observed at all six sample ports for humidities from 20% to 85% RH. An online verification system that uses a Thermal Desorption/Gas Chromatography/Mass Spectrometry/Electron Capture Detector (TD-GC-MS-ECD) has also been incorporated into the testbed. In another facility (not shown), large domes are also available to provide uniform vapors over a large area for the evaluation of entire instruments or arrays of sensors.

Instrumentation:

Environics Zero Air Generators, Miller-Nelson Test Atmosphere Generators, Kin-Tek FlexStream Automated Permeation Tube System, custom vapor generators: Liquid Injection Vapor Generator (LIVG) and Nebulizer/ pneumatically modulated liquid delivery system (PMLDS), Thermal Desorption, Gas-Chromatography-Electron Capture Detection (TD-CG-ECD), and online verification system.

Complex Trace Vapor Generator Facility

Code 6181
(202) 767-3845
NRL, Washington, DC



Function:

Enables the generation and validation of a wide range of complex test mixtures of gases necessary for research into novel chemical sampling and sensing technologies.

Description:

The trace vapor generation facility is capable of delivering accurate and stable flows of complex mixtures composed of trace chemical vapors at concentrations from parts per million (ppm) to parts per trillion (ppt) in purified air. This facility enables critical research for a variety of applications, such as high-throughput characterization of novel sorbent materials for atmospheric sampling and evaluation of chemical sensing technologies with complex test mixtures.

Vapor mixtures are generated by means of a dilution approach in which purified diluent air is supplied to the manifold at controlled temperature and humidity levels at a calibrated flow rate from 5 to 50 liters per minute. Sample mixtures are generated by introducing chemical vapors into a chemically passivated and heated mixing manifold via one or more of three different inlet methods: calibrated flow from gas cylinders, calibrated low-flow injection and vaporization of liquid mixtures, and a bank of three Kin-Tek Flexstream® gel-permeation tube ovens. Chemical sources can be configured and implemented in a modular fashion, allowing for generation of the widest possible range of chemical mixtures. A distribution manifold provides standard one-quarter inch Swagelok® fittings for dispensing gas mixtures. All manifold parts are modular so that they can easily be disassembled for cleaning, constructed from stainless steel passivated with Siltek Sulfinert® coating to allow heating and to minimize sample adsorption. Validation of vapor mixtures is accomplished by direct, online sampling of the vapor stream by one of two JEOL AccuTOF GC-TOFMS analytical systems. Each instrument is equipped with a Gerstel online cooled inlet gas sampling system, in addition to standard split/splitless inlets, which are used to analyze liquid calibration standards.

Instrumentation:

One custom-built gas mixing manifold, a Miller-Nelson air flow, temperature, and humidity controller, three Kin-Tek Flexstream® gel-permeation tube ovens, one Mitos pressure pump coupled to a nebulizer for nL/min liquid mixture injection and vaporization, and multiple mass flow controllers for injection of gas standards. Two JEOL AccuTOF GC-TOFMS instruments equipped with automated liquid samplers, Gerstel CIS-4 cryo-cooled inlets and Gerstel CIS-G gas sampling inlets provide online analysis of the generated vapor streams.

Chemical Dosimeter Badge Test Facility

Code 6181
(202) 767-3845
NRL, Washington, DC

Function:

Provides a unique capability to reliably and robustly characterize the performance of chemical dosimeter badges and chemical sensors under long-term, low-concentration exposure to trace organic vapors.

Description:

The chemical dosimeter badge validation testbed enables rigorous characterization and evaluation of the performance of chemical dosimeter badges and chemical sensors under chronic, low-concentration exposures to chemical vapors. This mimics conditions typically observed in normal chemical monitoring scenarios and was motivated by the Navy's need to validate commercially available chemical dosimeter badges originally developed for eight-hour shift workplace monitoring for 24-hour, long-term use onboard Navy submarines.

In the current configuration, up to four independent vapor streams can be tested, exposing up to six badges simultaneously per vapor stream. An additional exposure chamber provides "control" exposures to purified air only, and is never subjected to chemical vapors. The system is capable of performing multiday exposure experiments with minimal user supervision. Chemical vapors are generated via a bank of four Kin-Tek Flexstream® gel-permeation tube ovens, the output of which is diluted with purified air to provide target concentrations in the parts-per-billion (ppb) range. Trace chemical vapor streams from each permeation tube unit are directed into a dedicated badge exposure manifold constructed from stainless steel and passivated with SilTek Sulfinert® coating technology. The geometry of the exposure chamber is designed to provide laminar flow of trace vapor across each of six radially mounted dosimeter badges or sensors. The badge mounting plates are removable and thus configurable for a limitless array of different badge/sensor geometries. Ports for active sampling of the vapor stream are included on mounting plates so that an appropriate active-sampling based reference method analysis can be performed in parallel to long-term badge exposure experiments.

Instrumentation:

One Agilent 7890/5975 GC-MS instrument for reference sample analysis, four Kin-Tek Flexstream® gel-permeation tube trace vapor generators, a multibed diluent air purification and humidification system, and five custom-built stainless steel dosimeter badge exposure chambers, each passivated with SilcoTek Sulfinert® surface coating. Badge exposure chambers have modular mounting plates that can be adapted to different badge or sensor geometries and sampling ports for vapor stream validation. Sierra mass flow controllers and a central volume displacement pillar provide control of badge exposure face velocity.

Navy Fuel Research Facility

Code 6181
(202) 404-3138
NRL, Washington, DC

Function:

Performs basic and applied research to understand the underlying chemistry that impacts the use, handling, and storage of current and future Navy mobility fuels.

Description:

The analytical capabilities of the Fuel Research Facility are utilized to correlate the chemical composition of both traditional petroleum-derived and non-petroleum-derived fuels to the critical properties that define their fit for purpose in Navy propulsion systems. Fundamental research is conducted to define the key chemical processes that determine stability and oxidation behavior, rheological properties, and the flammability and ignition hazards of all Navy fuels. Additives used to mitigate undesirable fuel properties are examined for effectiveness and for mechanism of activity. Basic research to develop technologies for strategic synthesis of Navy fuels is also being conducted. The fuel modeling group in the Fuel Research Facility employs state-of-the-art chemometric modeling to extract the critical chemical information from complex analytical data that define fuel structure-performance relationships, and is employed to develop sensor-based instrumentation for rapid shipboard fuel quality surveillance.

Instrumentation:

Jet fuel thermal oxidation hot zone reactor with gas chromatography (GC)-helium ionization detection for liquid phase oxidation kinetics; high performance liquid chromatography (HPLC) with electrochemical, fluorescence, ultraviolet, and refractive index detectors (preparative through analytical scale); capillary GC-mass spectrometry; Fourier transform infrared spectroscopy (FTIR) (transmission and attenuated total reflectance [ATR]); near-infrared (NIR), UV-visible, and FT-Raman spectroscopy; a fuel reference library consisting of over 1000 characterized worldwide fuels for chemometric calibration.

Fire Research Enclosure

Code 6185
(202) 404-8101
NRL, Chesapeake Beach, MD

Function:

Simulates submarine fires, enclosed aircraft fires, and fires in enclosures at shore facilities.

Description:

FIRE I is a pressurizable, 324 m^3 (11,400 ft^3) fire test facility that simulates a one-quarter scale submarine compartment capable of pressurization to more than six atmospheres. This facility is used to study large-scale confined fires under controlled conditions and to test prototype equipment and firefighting agents. Two fixed fire-suppression systems for enclosures—nitrogen pressurization and preliminary water mist—have been tested.

Instrumentation:

The facility has over 200 sensors measuring pressure, temperature, radiation, total heat flux, and fire byproducts. The data are collected, analyzed, and displayed in real time. Nitrogen suppression pipes are embedded along the chamber walls. Thermocouples in the skin of the chamber record the effect of heat transfer to the chamber wall. The size and complexity of FIRE I require intricate safety considerations with built-in interlock systems. There are several television cameras to visually record the test fires.

Large-Scale Damage Control Facility

Code 6185
(202) 767-2357
NRL, Washington, DC

Function:

Performs large-scale fire protection experiments that simulate actual Navy platform conditions. Remote control firefighting systems are also tested.

Description:

The facility consists of five buildings and three testbeds. Two of the buildings are for enclosed fire experiments, qualification of firefighting agents, efficacy of dispensing these agents, and control and visibility through smoke. A third building is a staging area and a fourth is for storage. The fifth building contains a hydraulics laboratory and is equipped with a full-scale shipboard balanced pressure proportioner for aqueous film-forming foam (AFFF). A testbed simulates the lower section of a submarine for studying bilge fires and their extinguishment. A simulated 930 m^2 (10,000 ft^2) flight testbed is used to develop fire scenarios and suppression technologies. The third testbed has two test compartments, with internal volumes of 28 m^3 and 300 m^3 (1,000 ft^3 and 10,500 ft^3), that are used for fire suppression experiments.

Instrumentation:

Specific instruments for these testbeds are incorporated as a function of the particular experiment, but include sensors, gas sampling, control equipment, mixing vessels, calibrated fuel and aqueous flow metering, and video recording. The fire test building (15 m x 15 m; 50 ft x 50 ft) has a large cone calorimeter for full-scale fire tests of materials and furnishings.

Ex-USS *Shadwell* Advanced Fire Research Ship

Code 6186
(202) 404-8459
NRL, Mobile, AL

Function:

Conducts full-scale fire/damage control experiments in a shipboard environment. This test platform can provide an integrated picture of the interactions of man, equipment, materials, tactics, doctrine, and systems in the development of fire protection/damage control concepts and technology.

Description:

Ex–USS *Shadwell* (LSD 15) has an overall length of 457 ft, beam of 72 ft, and full load displacement of 9000 tons. As a testbed, the ship contains one pressure zone to study smoke management, including a collective protection system (CPS) that has been created on all levels forward of frame 35. Selected ship systems that are important to fire protection and damage control, such as ventilation, electrical power, fluid distribution, fire mains, fire pumps, aqueous film-forming foam (AFFF) proportioning system, and internal communication are available for use. Other specialized systems and test site include a machinery space test area fitted with water mist protection; a large volume test area emulating a hangar bay, well deck and vehicle storage spaces, aircraft carrier hangar bay; the forward section of an SNN 688 submarine; a flight deck; and a Peripheral Vertical Launch System (PVLS) cell.

Instrumentation:

The facility has extensive sensor and analytical sampling and analysis capabilities for measuring temperature, pressure, smoke obscuration, fluid flow, radiation flux, and total heat flux. There are video recorders for documentation of the fire tests and significant computing facilities for data collection, manipulation, and presentation. There is a 1-gigabit blown fiber network, which is tied into the data system, with 12-node rooms for input, output, and control of ship sensors and functions. This provides video coverage throughout the ship.

Chesapeake Bay Detachment Fire Test Facility

Code 6186
(202) 404-8459
NRL, Chesapeake Beach, MD

Function:

Performs large-scale fire protection experiments that simulate actual Navy platform conditions.

Description:

The CBD fire test facility is primarily dedicated to conducting experimental studies related to all aspects of shipboard safety, particularly related to flight decks, submarines, interior ship fire mishaps, and firefighting agent development. The facility has a number of specialized testbeds that include two fully instrumented fire research chambers for testing small (28 m^3) and large (300 m^3) surrogate shipboard compartments for testing small volume machinery spaces, a gas turbine enclosure and flammable liquid storeroom fire suppression systems; three pressurizable (0.3, 5, and 324 m^3) test chambers for conducting experiments up to 6 atmospheres of pressure; a 50-ft x 50-ft fire test chamber fitted with a large-scale calorimeter hood rated at 4 MW; a 10,000 ft^2 mini-deck that affords capabilities for studying characteristics and suppression of flight deck fires and suppression techniques; two mobile instrument vans for remote field testing support; and an LCAC gas turbine engine enclosure.

Instrumentation:

Specific instruments for these testbeds are incorporated as a function of the particular experiment, but include sensors, gas sampling, control equipment, mixing vessels, calibrated fuel and aqueous flow metering, and video recording. The fire test building (15 m x 15 m; 50 ft x 50 ft) has a large cone calorimeter for full-scale fire tests of materials and furnishings.

Materials Science and Technology Division

Materials Processing Facility

Micro/Nanostructure Characterization Facility

Mechanical Characterization Facility

Electrical, Magnetic, and Optical Measurement Facility

Thin-Film Materials Synthesis and Processing Facility

Magnetoelectronics Fabrication Facility

Secondary Ion Mass Spectrometer/Single-Stage Accelerator Mass Spectrometer

Materials Processing Facility

Code 6350
(202) 404-8324
NRL, Washington, DC

Function:

Provides a full-spectrum capability to synthesize and process materials, from small to large sizes, by a variety of methods and under varying thermal, mechanical, pressure, and rate-sensitive processes.

Description:

Alloy fabrication facilities include arc melting for synthesis, melt spinning and splat quenching for rapid solidification, induction melting for bulk samples, and a single crystal growth furnace. The isothermal heat treatment facility and quenching/deformation dilatometer permit accurate determinations of the phase transformations for both isothermal and continuous cooling conditions. Processing facilities also include a variety of rolling mills and swagers. Facilities to process powder into bulk specimens by hot and cold isostatic pressing permit a variety of consolidation possibilities. Thin films are produced in a variety of computer-controlled, physical vapor deposition systems for coating surfaces. Polymer matrix composite materials are processed in an autoclave. Ceramics processing facilities include a wide variety of furnaces (conventional, vacuum, and controlled atmospheric), presses (cold, hot, cold isostatic and hot isostatic), mills (ball, attrition, and SPEX), sol-gel and organometallic coating, tape-casting, freeze casting/drying, glass melting/pouring, and have particle characterization capabilities such as size determination, shape, density, and surface area.

Instrumentation:

Many of the facilities are modified versions of commercially purchased apparatus that have been adapted to the special needs of our research.

Micro/Nanostructure Characterization Facility

Code 6360 – (202) 404-4143
Code 6350 – (202) 767-2622
NRL, Washington, DC

Function:

Characterizes the internal micro/nanostructures of metallic, magnetic, electronic, and other multi-functional and structural materials using a variety of electron microscopy techniques.

Description:

(1) In Code 6360: JEOL 2200FS transmission electron microscope(TEM): A 200KeV field emission TEM for sub-nanometer-scale analysis of structure and composition. Capabilities include: atomic resolution TEM (AR-TEM), electron energy loss spectroscopy (EELS), energy dispersive spectroscopy (EDS), and scanning transmission electron microscopy (STEM) with atomic resolution Z-contrast imaging, energy filtered imaging, electron holography, and spectrum imaging. Specialized holders for cold-stage, in situ electrical biasing, tomography, wet cell, and and electrochemical cell measurements are also available.

(2) In Code 6350: FEI Tecnai G2 30 S-Twin TEM: A 300 KeV operating voltage analytical TEM with a wide range of applications including characterization and analysis of advanced naval steels. This TEM performs conventional bright field, dark field, and weak beam imaging through a wide tilt range, scanning transmission electron microscopy, various electron diffraction techniques, compositional analysis through energy dispersive spectrometry, HAADF imaging, and electron tomography.

JEOL JSM-7001F Scanning Electron Microscope (SEM) with a field emission gun (FEG) source and variable pressure capabilities (up to 50 Pa). Capabilities include high-resolution SEM, EDS, and EBSD (TSL/Ametek Hikari Camera) with automated orientation mapping and quantification.

Instrumentation:

A fully automated, robotic, serial sectioning system (RS3) for acquisition of 3D microstructures. This system consists of a UES Robomet 3D automated grinding/polishing/etching system for removing specified thicknesses of material, a Tescan Mira SEM with high-speed Bruker EBSD system, Bruker EDS system, and forescatter detectors that can be scripted for automated operation including sample exchange and EBSD imaging, and a 6-axis, high-resolution robot arm to transfer samples between them with a high spatial accuracy.

LECO AMH43 automated microhardness tester: A completely automated microhardness tester that can measure microhardness variations from thousands of locations across a sample surface.

Complete TEM specimen preparation facilities including Streuers Tenupol and Fischione electropolishers, Gatan and Fischione ion mills, tripod polishers, and plasma cleaners.

Mechanical Characterization Facility

Code 6350
(202) 404-8324
NRL, Washington, DC

Function:

Characterizes the mechanical behavior of metal, polymer, ceramic, and composite materials under a variety of loading and environmental conditions using servo-hydraulic, electromechanical, and creep-load frames for use in advanced material modeling and material response testing under simulated service conditions.

Description:

The facility consists of various testing systems, many with automated computer control and data acquisition, for determining the mechanical response of materials under controlled loading-deformation and environmental conditions. Basic capabilities include quasistatic tensile and fracture testing; dynamic storage and loss moduli as a function of frequency and temperature; cyclic fatigue crack growth and corrosion fatigue testing; and stress corrosion cracking testing. Fatigue crack growth rates can be determined under constant ΔP, ΔK, or K_{max} conditions.

Instrumentation:

Various MTS/Instron servohydraulic load frames (5 to 550 kN) including multiple horizontal 5-kip servo-hydraulic load frames for corrosion fatigue and stress corrosion cracking experimentation in liquid environments; MTS Insight 100 (100/10/1/0.2 kN screw-drive; variety of load fixtures and strain-displacement instrumentation); Instron Electropuls 3000 (3000/200 N electromechanical drive; loading to 200 Hz; Bluehill and WaveMatrix software; environment chamber); Instron 1332 (250 kN servo-hydraulic; 8800 digital controller); ATS 2330 (60 kN screw-drive); Instron 4201 (5 kN, screw-drive); Instron Dynatup 9210 Drop-Tower (5/10 kN tups, 4.6 to 300 J impact energy, to 5.0 m/s drop speed, various fixtures); ATS 3200 furnace (1000 °C); Instron 3119 Environment Chamber (–70° to 250 °C); Fracture Technology Associates (FTA) Crack Growth software.

Electrical, Magnetic, and Optical Measurement Facility

Code 6360
(202) 767-4694
NRL, Washington, DC

Function:

Provides tools necessary for electrical, magnetic, and optical characterization of bulk and thin-film materials. This includes the ability to determine the resistivity as a function of temperature and magnetic field and the magnetization as a function of temperature using superconducting quantum interference device (SQUID) magnetometry and vibrating sample magnetometry (VSM). Electroluminescence facilities are also available for determining the magneto-optic properties of light-emitting diode structures.

Description:

This facility comprises several complementary instruments that allow for the magnetic, electrical, optical, and heat capacity characterization of materials and devices. SQUID and vibrating sample magnetometry are used to determine important properties of superconducting, para- and diamagnetic, and ferromagnetic materials. The transport properties of materials, namely the temperature and magnetic field-dependent resistivity combined with heat capacity measurements, allow for a fundamental physical understanding of electronic properties. VSM extends the experimental temperature range of magnetic properties characterization to 1000 K. Measurement of luminescence properties of light-emitting devices under varying temperature and magnetic field is also possible in this facility.

Instrumentation:

Quantum Design Physical Properties Measurement System (PPMS): Temperature and magnetic field-dependent measurements of transport, AC magnetic susceptibility, and heat capacity; temperature range 200 mK to 350 K; magnetic field range ±8 T. Quantum Design Magnetic Properties Measurement System (MPMS): Characterization of magnetic properties of materials by SQUID magnetometry; optical-fiber access for magneto-optic characterization; temperature range 1.7 K to 400 K; magnetic field range ±5 T; sensitivity less than 5×10^{-7} emu. Digital Measurement Systems VSM: Magnetic materials characterization for magnetic fields up to ±2 T; temperature range 110 K to 1000 K. Optical access flow cryostat/electromagnet system for magneto-electroluminescence measurements.

Thin-Film Materials Synthesis and Processing Facility

Code 6360
(202) 767-4694/(202) 767-5653
NRL, Washington, DC

Function:

Provides a wide capability for deposition and processing of thin films, including sputter and ion-beam deposition, thermal evaporation, electro-deposition, pulsed laser deposition (PLD), chemical vapor transport, and laser direct-write fabrication. These tools allow for thin-film growth of metals, dielectrics, oxides, and solid electrolyte materials, and for laser patterning of thin-film structures.

Description:

This facility provides users a wide array of techniques for growth and processing of thin films (thickness 1 μm or less). Sputter deposition offers a versatile method of depositing metallic and dielectric films and is a primary tool of this facility. Thermal evaporation of metals is implemented in both high-vacuum and ultrahigh-vacuum systems. PLD with variable stage temperature and controlled atmosphere allows growth of oxides. Electrolytic deposition offers efficient growth of gold and silver films. Laser direct-write ablation and deposition provide unique methods for imposing computer-aided design (CAD)-defined features via ablation of a substrate film and ablative mass transfer to a substrate.

Instrumentation:

Dual-gun sputter system for RF and DC magnetron deposition of metals and dielectrics. Kyocera high-temperature oxide sputtering system. Physical Electronics molecular beam epitaxy system with 8 Knudsen cell sources, quadrupole mass analyzer (QMA) rate-monitor for sub-monolayer control of thickness, and in situ reflection high-energy electron diffraction (RHEED) and Auger analysis. Multitarget PLD system using a 248 nm excimer laser excitation with high-temperature stage and variable chamber atmosphere. Chemical vapor deposition furnace for growth of transition-metal oxides. Laser direct-write system for transfer of CAD-generated features to a wide variety of substrates and printed circuit boards.

Magnetoelectronics Fabrication Facility

Code 6360
(202) 767-4694
NRL, Washington, DC

Function:

Provides a wide range of lithography tools for construction of micrometer- and nanometer-size devices of interest in the study of magnetoelectronics.

Description:

The Magnetoelectronics Fabrication Facility is a Class 1000 clean room facility equipped with tools for lithographic construction of magnetoelectronic and spintronic devices. The facility provides pattern definition, metallization, dielectric layer deposition, and reactive and Ar+ ion etching of wafers and small pieces.

Instrumentation:

Karl Suss MJB3 mask aligner/contact printer with mid-ultraviolet (UV) optics capable of optical lithography to 500 nm resolution. Spin/bake/develop equipment for processing of photoresists and e-beam resists. Four-source thermal evaporation system; RF/DC magnetron sputter deposition system; ultra-high-vacuum (UHV) dual ion beam deposition system. CF4/O2 reactive ion etching; Ar+ ion mill system; wet etch process station. Olympus BX5O optical microscope with differential interference contrast imaging and camera; KLA-Tencor Alpha-step surface profilometer; Cascade Microtech REL-3200 manual probe station and electronic instrumentation rack; Kulicke and Soffa ultrasonic wire bonder. FEI Inc. FIB-200 focused ion beam system equipped with enhanced etch, Pt-metal deposition, and dielectric layer deposition.

Secondary Ion Mass Spectrometer/Single-Stage Accelerator Mass Spectrometer

Code 6360
(202) 767-5738
NRL, Washington, DC

Function:

Performs spatially resolved composition analysis using secondary ion mass spectrometer (SIMS) to sputter atoms, and single stage accelerator mass spectrometer (SSAMS) to reduce background interferences from commonly present molecular ions. Provides high-sensitivity and high-precision measurements.

Description:

Samples of interest are inserted into Cameca IMS 4f secondary ion mass spectrometer (SIMS) for analysis. Either O or Cs primary ions sputter atoms from the sample, generating positive or negative secondary ions for analysis. The operator chooses whichever one provides greater utility. These ions are transmitted into a single stage accelerator mass spectrometer (SSAMS), where the ions are accelerated to a higher energy, transit a gas cell to both destroy molecular species and convert the ions into a +1 charge state, and are then mass analyzed with magnetic and electrostatic sector elements. Spatial distributions (few micrometer resolution) and depth profiles (few nm resolution) of sample composition can be measured down to part per billion levels.

Instrumentation:

A commercial Cameca IMS 4f SIMS instrument is employed to generate the secondary ions for analysis. This instrument can operate in either the microscope mode with stigmatic focusing, or in the microprobe mode with raster of a focused spot beam. In either case, lateral spatial composition can be determined with the mass spectrometer capabilities of the SIMS instrument. Depth profiles are measured from erosion occurring during the sputtering process. The 4f SIMS has been modified by replacing its normally used electron multiplier with the SSAMS instrument as a secondary ion detector. The two instruments are coupled using beam steering and focusing elements. Ions selected by the SIMS are injected into the SSAMS through a 90° bend injector magnet (2.6 MeV·u), accelerated by up to 300 kV of potential, transit a gas cell that is differentially pumped and whose pressure can be precisely controlled, are momentum analyzed by 90° sector magnet (up to 75 MeV·u), energy analyzed by a 90° spherical electrostatic analyzer (ESA), and finally measured by one of two electrostatically selected detectors. Ions up to a mass of 250 u can be measured. The ions transmitted through the SSAMS can be rapidly switched by “bouncing” the ion energy, so that the magnetic fields in the SSAMS need not be switched. Deviations of 5% of the ion energy are attainable. This enables isotopic distributions to be conveniently measured. In addition, offset Faraday cups are provided at the outputs of both the injector and the momentum analysis magnets so that more intense matrix related beams can be measured with ease. Crater depths are measured with a confocal microscope to convert sputter times into physical depths for depth profile measurements.

Plasma Physics Division

Nike KrF Laser Facility

Electra Repetitive Electron Beam Facility

SWOrRD Laser Facility

Railgun Materials Testing Facility

Plasma Applications Laboratory

Space Physics Simulation Chamber (SPSC)

Gamble II Facility

Hawk Facility

Mercury Facility

High-Frequency Microwave Processing of Materials Laboratory

Laboratory for Microwave and Particle Beam Generation and Applications

Intense Laser Interaction Physics Laboratory

Directed Energy Laser Physics Laboratory

Nike KrF Laser Facility

Code 6730
(202) 767-0689
NRL, Washington, DC

Function:

Studies the physics and technology issues of direct-drive laser fusion. Primary areas of research include studies of means to reduce hydrodynamic instability in laser-accelerated targets, studies of the response of materials to extreme pressures, and generation of X rays from laser-heated targets. This work supports the Department of Energy's program for science-based stockpile stewardship.

Description:

The Nike laser is a 56-beam krypton fluoride (KrF) system that provides 2 to 3 kJ of laser energy on targets. The laser uses controlled spatial incoherence to achieve highly uniform focal distributions in each of these beams. Nike has the deepest UV of all high energy lasers and that property substantially improves its capability to drive targets to the very high velocities. Nike has driven plastic targets to velocities above 1000 km/s (>2 million miles per hour). Nike utilizes 44 of the beams overlapped onto targets at peak intensities near 10^{14} W/cm^2 for target acceleration experiments and above 10^{15} W/cm^2 for laser-plasma-interaction experiments. Nike's overlapped beams produce extremely uniform illumination of the targets. The combination of uniform illumination and deep UV light allows Nike to conduct precise studies of targets laser-accelerated to extreme velocities and multi-megabar pressure physics without interference from laser plasma instability. Nike has an additional 12 laser beams that are used to generate diagnostic X rays that radiograph the primary laser-illuminated targets. The improved laser-target interaction physics with KrF laser light makes it a promising technology for achieving the performance needed for laser fusion energy.

Instrumentation:

A computer-controlled data acquisition system, high-speed X-ray and optical cameras, high-resolution X-ray imaging systems, X-ray and visible spectrometers, high-speed digital oscilloscopes, and cryogenic target capability.

Electra Repetitive Electron Beam Facility

Code 6730
(202) 767-2705
NRL, Washington, DC

Description:

The Electra facility has two 500 KeV, 100 kA, 140 ns long electron beams that are injected through thin (0.002-in-thick) metal foils into a cell containing gas at 1 to 2 atmospheres. A recirculator cools the gas and foil between pulses to achieve long runs. Electra can run for 10 hours continuously at 2.5 Hz (90,000 pulses), and can deposit more than 8,000 Joules into the gas (40 kW at 5 Hz). When configured as a KrF laser, Electra produces from 300 to 700 Joules of 248 nm (UV wavelength) light. The typical electron beams are 30 cm x 100 cm, but they can be made smaller if higher current density is required. For some applications (surface treatments), only one electron beam is used. As an adjunct to this facility, a small scale all-solid-state pulsed power system has been built that can produce GW power 250 kV pulses. It has operated for 11,000,000 shots continuously at 10 Hz (319 hours).

Function:

Develops the science and applications for repetitively pulsed, high energy electron beams. The main applications for this technology currently being investigated are surface modifications of materials (for both enhanced corrosion and wear resistance), reformation of fuels (gas to liquid conversion), electron beam conversion of biomass to fuels, flue gas remediation (NO_x removal, CO_2 remediation), and reliable, efficient, high-energy, repetitively pulsed gas lasers for both fusion energy (krypton fluoride (KrF) laser) and defense applications.

Instrumentation:

Electra is operated through a computerized system that continually monitors and controls all system parameters, including the input, interstage, and output voltages, magnet current, trigger laser operation, and gas, electrolyte, and coolant temperature and flow. A totally separate system is used to acquire data from the experiment, including electron beam voltage and current, gas parameters (temperature and pressure), gas constituents, and when configured, laser parameters.

SWOrRD Laser Facility

Code 6730.2
(202) 767-9117
NRL, Washington, DC

Description:

SWOrRD, the Swept-Wavelength Optical resonance-Raman Detector sequentially illuminates a sample with a laser that is tunable from 210 to 2100 nm in increments of up to 0.1 nm and measures the spectrum of the scattered light with a two-stage tunable spectrometer. All components of the SWOrRD system are synchronized to the laser wavelength and operate automatically. SWOrRD can switch from one wavelength to another in less than one second. SWOrRD's laser has a bandwidth of 15 cm^{-1}, average power from 10 to 400 mW, and runs at 1 KHz, resulting in low peak power. All these characteristics make it especially suitable for substance identification. After acquisition, the raw spectra are processed with a semi-automated toolbox that corrects for system-response characteristics, smoothens noise, subtracts backgrounds, and performs the housekeeping tasks needed to produce device-independent spectral signatures. The individual resonance-Raman spectra acquired at each illumination wavelength are then assembled to form a single 2D signature, where the two independent dimensions represent laser-illumination wavelength and scattered-wave number. Various algorithms are applied that assume that the 2D spectrum of a mixture is a linear superposition of the 2D spectra of the mixture's components, and so use the signatures to identify the presence and amount of the substance or substances being sought. The signatures are also stored in a database where they are available to researchers.

Function:

Measures optical signatures of substances in the 210 nm to 2000 nm wavelength range. This device is capable of characterizing both chemical and biological substances and thus is useful for a wide variety of chemical and biological applications, including scenarios related to health and national security. In most practical situations, the substance of interest is not alone, but rather is part of a mixture containing other substances that are present in the background. SWOrRD's multiwavelength capability enhances the ability to identify constituents of a mixture without prior purification.

Instrumentation:

A laser that is tunable from 210 to 2100 nm in increments of up to 0.1 nm, a two-stage tunable spectrometer, and associated optics as well as computer and control equipment. SWOrRD is housed in a dry and wet laboratory certified for work with chemicals, small amounts of explosive materials, radiological materials, and biological materials up to biological safety level 2 (BSL2).

Railgun Materials Testing Facility

Code 6750
(202) 767-0332
NRL, Washington, DC

Function:

Contributes to the Navy program to develop a high-performance electromagnetic launcher for a future electric warship. This laboratory, together with NRL materials analysis laboratories, focuses on materials aspects of high-power railgun operation. This includes developing high-performance rails, insulators, and armatures that can withstand the megampere currents and thousands of atmospheres of pressure needed to launch projectiles at high velocities. The facility houses a medium-sized railgun, a capacitor bank driver, and multiple diagnostics to measure barrel performance.

Description:

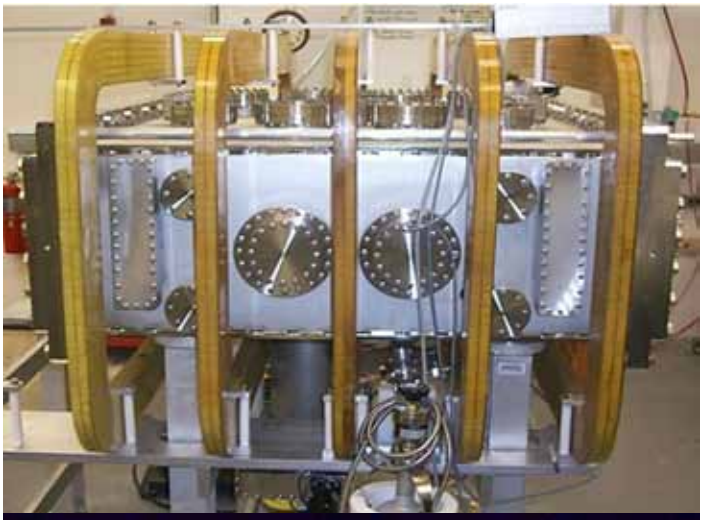
The high bay laboratory contains a 6-m-long railgun firing into an evacuated transport tube and target chamber. The rails and insulators of the gun are located within a stainless steel containment capable of withstanding the extreme pressures generated during launch. A target chamber is contained within a concrete block house with 18-inch thick walls on all sides. The gun is powered by 24 half-megajoule capacitor banks, each of which is discharged using high-current solid-state switches. The banks can drive peak currents of up to 1.8 megampere for the 5 millisecond launch time. Current, pressure, temperature, optical emission, and X-ray imaging diagnostics are mounted on the railgun or along the transport tube. The railgun is designed to be reconfigurable for experimental modification and for ease of diagnostic access. It is capable of producing current densities of hundreds of kA/cm^2, bore pressures of thousands of atmospheres, and launch velocities of over 2 km/s.

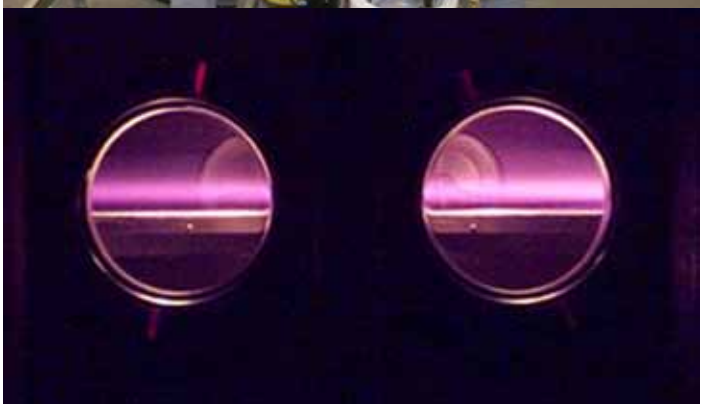
Instrumentation:

Projectile velocities are measured using magnetic field probes and voltage probes spaced along the length of the railgun. Thermocouples and pressure diagnostics are mounted on the rails and insulators inside of the containment. Optical spectrometers and fast framing cameras are used to observe the launch. A dual-axis X-ray imager is located in the transport tube to image the projectile before it is destroyed in the multilayered steel plate target. Signals from the probes are recorded in a multichannel digitizer system and analyzed using computer software. Rails and insulators are removed from the bore for analysis using scanning electron microscopy, high-resolution optical imagers, profilometers, X-ray diffraction, and other detailed materials diagnostic tools.

Plasma Applications Laboratory

Code 6752
(202) 767-7531
NRL, Washington, DC





Function:

Conducts research related to the production of plasmas, plasma characterization, and the interaction of plasmas with materials. The research facility is aimed at developing a comprehensive understanding of plasma-based materials processing applications ranging from etching to deposition to surface activation.

Description:

The laboratory has several chambers operating under both high and ultrahigh vacuum conditions. The systems have numerous access ports for plasma diagnostics and the ability to accommodate a range of materials-processing approaches. Plasma production capabilities include RF-generated sources, magnetrons, and electron beams, including the NRL-developed Large Area Plasma Processing System (LAPPS), which can generate square meter plasma sheets with higher efficiency and better control than other techniques presently used in materials processing. The system shown above is one of the LAPPS chambers where a 1 to 3 kV electron beam, confined by a 100 to 300 G magnetic field along the axis, is used to produce plasmas in a variety of gas backgrounds. A stage located inside the chamber, on which a material can be placed, is moved close to the plasma sheet for processing.

Instrumentation:

A variety of plasma and particle collection diagnostics is used. These include Langmuir probes and RF probes to measure plasma density, plasma potential, electron temperature, and the electron energy distribution; a dual energy analyzer/quadrupole mass analyzer to interrogate the flux of ions and neutrals at surfaces; and optical diagnostics to measure excited species. Numerous transient recorders, power supplies, RF generators, digital multimeters, electrometers, and amplifiers are also available.

Space Physics Simulation Chamber (SPSC)

Code 6755
(202) 404-1022
NRL, Washington, DC

Function:

Creates controlled, reproducible conditions representative of the near-Earth space plasma environment. The device is used for the study of ionospheric, magnetospheric, or solar wind plasma phenomena, testing/calibration of space-qualified diagnostic instruments for orbital or suborbital missions, spacecraft charging, large-volume plasma generation, and other topics requiring a low-pressure environment.

Description:

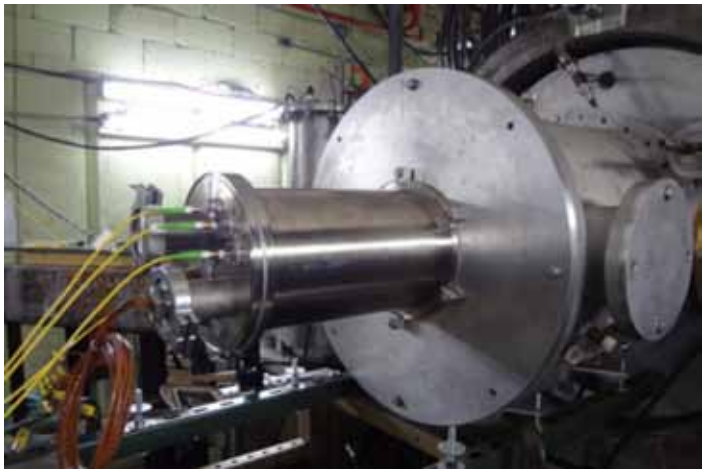
Plasmas with diameter ~0.75 m are produced within two integrated vacuum chamber sections: a 1.8-m-diameter, 5-m-long stainless steel main chamber and a 0.55-m-diameter, 2-m-long source chamber section. Water-cooled electromagnet coils provide an axial magnetic field of up to 250 G in the main chamber and up to 1000 G in the source chamber section. A base pressure near 10^{-7} torr is maintained by pairs of cryogenic and turbomolecular vacuum pumps. Three large-volume plasma sources are available: a microwave discharge plasma source (plasma densities $\boldsymbol{n}$ ranging from 10^5 to 10^9 cm^{-3} and electron temperatures $\boldsymbol{T}_e$ ~ 0.5 eV), a thermionic discharge plasma source ($\boldsymbol{n}$ ~ 10^5–10^{12} cm^{-3}, $\boldsymbol{T}_e$ ~ 0.1–2 eV), and a helicon source ($\boldsymbol{n}$ ~ 10^9–10^{13} cm^{-3}, $\boldsymbol{T}_e$ ~ 2–5 eV). Access for electrical, diagnostic, and manipulator vacuum penetration is available over most of the SPSC volume.

Instrumentation:

A full range of plasma diagnostics is available, including internally heated Langmuir probes, emissive probes, ion energy analyzers, impedance probes, AC magnetic field probes, and pressure probes. Numerous transient recorders, power supplies, digital multimeters, electrometers, network and spectrum analyzers, and amplifiers are available. The instrumentation is General Purpose Interface Bus (GPIB)-controlled using LabVIEW™ software.

Gamble II Facility

Code 6770
(202) 767-8373
NRL, Washington, DC



Description:

The facility's 300-kJ Marx generator is a large capacitor bank capable of producing a voltage of several-megavolts. The voltage pulse is then both compressed in time duration and increased in current through a succession of water dielectric pulse-compression sections that charge a pulse-forming line, all separated by closing switches. Eventually, a high-power pulse is delivered across a vacuum diode. This pulse can be applied directly across a load (such as a gas column or wire) or can be used to produce powerful electron or ion beams. These high-power beams are then allowed to interact with X-ray converters or to propagate to a variety of targets. The facility is surrounded by thick concrete shielding to contain X rays produced as a result of the high-power pulses.

Instrumentation:

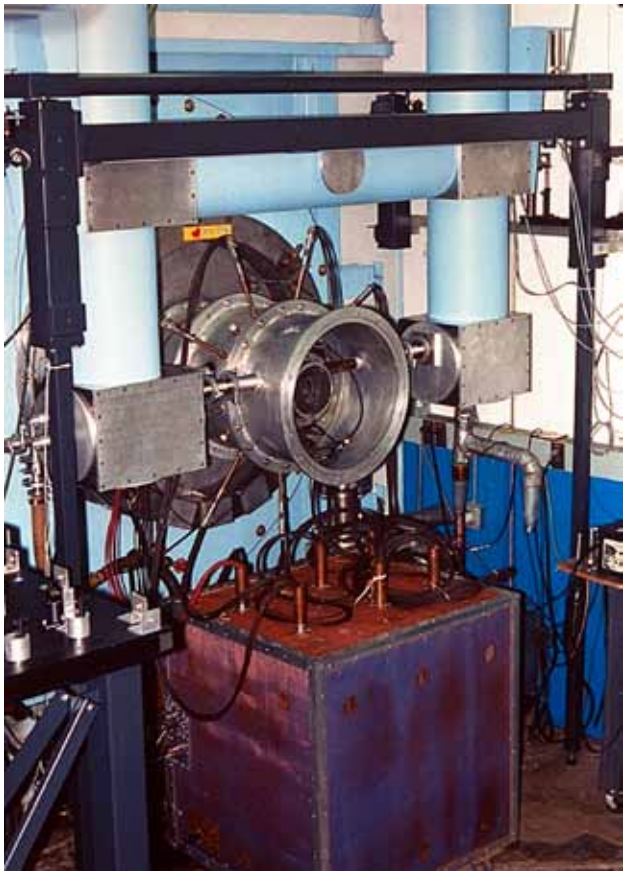
Diagnostics for the generator and the beams are monitored in a shielded room located outside the radiation area. Diagnostics include sophisticated computer-controlled transient recorders to record analog signals, numerous electrical, optical, X-ray, and neutron diagnostics, and nuclear activation monitors.

Function:

Gamble II produces a high-voltage (2 MV), high-current (1 MA), short (100 ns) pulse of energy of either positive or negative polarity. This terawatt power pulse is used for many Navy, DoD, and Department of Energy research programs including nuclear weapon effects simulation, advanced hydrodynamic radiography, and detection of special nuclear materials. Intense electron beams from Gamble II can interact directly with a target or generate bremsstrahlung to expose test articles to an intense X-ray pulse or to produce a small, intense X-ray source for radiography. Intense ion beams can interact directly with targets or produce characteristic gammas that can be used to probe for special nuclear materials. Another mode of operation uses a plasma opening switch to increase the voltage to 4 MV and reduce the pulse width to 10 ns. The photograph is from an experiment in which a proton beam strikes a support strut of a telescope and induces mechanical vibrations to simulate its response to an intense pulse of ~keV X rays in space.

Hawk Facility

Code 6770
(202) 767-7153
NRL, Washington, DC



Function:

Hawk produces a high-current (750 kA) pulse with a microsecond rise time into a vacuum inductor. The energy stored in the inductor is transferred to a radiation or particle-beam load by using a plasma opening switch (POS). These inductive energy store (IES) generators represent a new approach for generating high-power pulses for Navy, DoD, and Department of Energy applications, including nuclear weapons effects simulation, inertial confinement fusion, and dense Z-pinch X-ray and neutron sources. The device is used primarily as a research test bed for IES technology and for fundamental research into the physics of radiation source and POS operation.

Description:

The facility consists of four Marx banks in an oil-filled tank, connected in parallel, with an output voltage of 720 kV when the capacitors are charged to 90 kV each. In this case, the Marx bank stores 260 kJ of electrical energy. The discharge of the capacitors into the system inductance (600 nanohenry (nH)) results in a sinusoidal current with a 1.2-μs quarter period and an amplitude of 850 kA. A POS is used to conduct the generator current during most of this rise time (typically for about 1 μs) while the energy is transferred from the capacitors to the circuit inductance. The POS then opens quickly (in less than 100 ns) allowing the current to flow to a downstream load, such as an electron-beam diode, for example. The facility is surrounded by thick concrete shielding to contain X rays produced as a result of the high-power pulses.

Instrumentation:

Diagnostics for the generator and POS are monitored in a shielded room located outside the radiation area. Diagnostics include sophisticated computer-controlled transient recorders to record analog signals, various electrical, optical, X-ray, and nuclear activation monitors, and plasma diagnostics, such as interferometers and charged particle detectors for measuring quantities of interest in the POS.

Mercury Facility

Code 6770
(202) 404-5324
NRL, Washington, DC

Description:

Mercury is a six-stage IVA. The oil-immersed Marx bank comprises 36 2.2-μF, 100-kV capacitors (396 kJ at 100-kV charge). The erected Marx discharges into four parallel coaxial water capacitors, also immersed in oil, that make up the 36-nH intermediate store (IS). Each IS discharges into three 5.5-Ω coaxial water-pulse-forming lines (PFLs) through a laser-triggered gas switch. Each of the 12 50-ns-long (two-way transit time) PFLs is switched out through self-closing water output switches into a coaxial water output line that connects the PFL to an induction cell through a coaxial oil-filled elbow. Two PFLs feed each of the six induction cells, one from the top and one from the bottom. The voltage on each induction cell is added up in vacuum along a magnetically insulated transmission line to obtain the final voltage. Thick concrete walls surround the generator to contain X rays and neutrons.

Function:

Mercury is NRL's newest pulsed-power generator facility. It is a state-of-the-art 2-TW magnetically insulated inductive voltage adder (IVA). It can operate at -6 MV, 300 kA; -8 MV and 200 kA; and +5 MV and 325 kA, all with a 50-ns pulse width. Mercury is a focal point of research for several areas, including X-ray source development for both high-resolution flash radiography (in support of the U.S. Stockpile Stewardship Program) and nuclear weapon effects simulation, active detection of fissile material, IVA power-flow research and development, and particle-beam source and transport research for various applications.

Instrumentation:

A full array of electrical diagnostics is monitored on a bank of transient recorders in an electrically shielded room located outside the radiation-shielded area. Complementing the electrical diagnostics is a full set of time-resolved and time-integrated radiation diagnostics, as well as a complete suite of nuclear diagnostics. The generator operation is computer controlled.

High-Frequency Microwave Processing of Materials Laboratory

Code 6793
(202) 767-2469
NRL, Washington, DC

Function:

Conducts research on high-frequency microwave processing of materials using a high-power, continuous-wave (CW), 83-GHz, quasi-optical beam system for rapid, selective sintering, heat treatment, modification, coating, and joining of ceramics and metals, and production of nanocrystalline metals and ceramics.

Description:

A free-space-propagating, quasi-optical beam of intense polarized millimeter-wave radiation is produced by an 83-GHz, 15-kW, CW industrial gyrotron and injected into a sealed processing chamber (1.5 m long × 1.2 m high × 0.9 m wide) where it is focused onto the workpiece. Beam intensities up to 10 kW/cm^2 can be achieved, the beam power is variable up to 15 kW, and the pulse length is variable from 1 s to CW operation. Minimum spot size (0.5 cm), area illumination (20 × 20 cm), and strip illumination (0.5 × 20 cm) of the workpiece can be achieved using focusing mirrors. Various processing atmospheres or vacuum can be used and workpieces can be heated rapidly to temperatures exceeding 2000 °C. Specialized chambers for pressure-free and pressurized sintering and joining are available. Uniaxial pressure up to 0.25 GPa can be applied to the workpiece during processing.

Instrumentation:

The Gycom Ltd. 15 kW gyrotron and associated DC power supply and cryogen-free superconducting magnet are controlled and monitored by a LabViewTM PC-based system that acquires and analyzes a wide range of instrumentation outputs and safety interlock signals. Workpiece temperature diagnostics include single- and two-color pyrometers, and K- and S-type thermocouples. The applied pressure can be regulated hydraulically during processing. The workpiece can be monitored in real time and recorded by a video camera in the processing chamber.

Laboratory for Microwave and Particle Beam Generation and Applications

Code 6793
(202) 767-2469/(202) 767-4004
NRL, Washington, DC

Function:

Conducts research on microwave generation, terahertz gyrotrons, microwave and millimeter-wave processing of materials, microwave-generated plasmas, and high-power electron beam generation for a free electron laser (FEL) injector.

Description:

Microwave and higher frequency radiation sources include two 83 GHz, 15 kW gyrotrons; an 11.4 GHz Magnicon source, a terahertz gyrotron, and two 6 kW CW magnetron-based S-band microwave generators. Ancillary components include 3 T and 12 T cryogen-free magnets; a 36 KV, 4 ADC power supply, a 70 kV, 10 A, variable pulse length, several MIG-type and electron guns for gyrotrons, and 12” and 18” diameter multimode chambers for S-band materials processing and plasma generation. This laboratory also includes an electron gun test stand that is used to study the performance of gridded thermionic electron guns in order to develop a thermionic injector suitable for the Navy IR FEL program. Key components of this electron gun include a rep-rated hard tube HV modulator and a kilowatt dual frequency RF amplifier (700 to 714 MHz plus its third harmonic). The goal is to demonstrate ~1 nC electron bunches at 700 MHz with low emittance and short bunch length.

Instrumentation:

Microwave and a-wave frequency and power diagnostics; temperature diagnostics for materials processing experiments include single- and two-color pyrometers, and K- and S-type thermocouples; high speed digital oscilloscopes; vacuum equipment. The thermionic electron gun lab includes a fast Faraday cup combined with 16 GHz data acquisition, and slit-based emittance diagnostics.

Intense Laser Interaction Physics Laboratory

Code 6795
(202) 404-7568
NRL, Washington, DC

TFL Laser System

K-TFL Laser System

Function:

Conducts ultra-high-power, ultra-high-intensity laser-plasma, laser-electron beam, and laser-solid interaction studies that include fundamental strong-field physics experiments, and new imaging and diagnostic techniques. Conducts experimental studies of femtosecond, intense laser pulse interactions with nonlinear media such as propagation and breakdown in air and water, novel radiation generation for remote sensing and countermeasures, and nonthermal material modifications.

Description:

The facility consists of the Titanium:sapphire Femtosecond Laser (TFL) and the kilohertz Titanium:sapphire Femtosecond Laser (k-TFL) laser systems, and the associated interaction chambers and diagnostics. It operates at a repetition rate of 10 Hz (TFL) and 1000 Hz (k-TFL) at the laser wavelength of 0.8 μm. The laser pulse length is <50 fs for both systems, and the pulse energy is >600 mJ, providing >12 TW of pulsed laser power for the TFL. The k-TFL has a peak power of >350 GW. The final compression of the output laser pulse is separated from the laser amplifiers to provide multiple beamlines for convenient switching between experiments. Frequency doubling of the laser provides unique femtosecond laser pulses at 0.4 μm for underwater propagation studies.

Instrumentation:

Several laser plasma and electron beam diagnostic tools and techniques are available. These include laser diagnostics, autocorrelators, FROG (frequency-resolved optical gating), interferometers, optical and X-ray spectrometers, optical and X-ray streak cameras, gated optical imagers, infrared linear and 2D sensor arrays, X-ray diodes, magnetic electron spectrometers, and several pulsed and continuous-wave (CW) probe lasers.

Directed Energy Laser Physics Laboratory

Code 6795
(202) 404-7658
NRL, Washington, DC

Function:

Conducts experimental studies of high-energy lasers (HEL) for directed energy (DE) applications. These include the study of HEL beam combining architectures such as the incoherent combining of high-power, single-mode fiber lasers; HEL atmospheric propagation physics of turbulence, aerosol scattering and absorption, and thermal blooming effects; HEL interaction with optical components; the mitigation of atmospheric propagation effects through adaptive optics; and laser power beaming of unmanned aerial vehicles. Laboratory and field experiments are conducted for these studies.

Description:

The facility consists of a set of four high-power, single-transverse-mode, continuous-wave (CW) ytterbium fiber lasers, and a CW, high-power (700 W) neodymium yttrium aluminum garnet (Nd:YAG) laser. The power of the four fiber lasers are 1 kW, 1.6 kW, 1.6 kW, and 2 kW, for a total power of 6.2 kW. The excellent beam quality (M^2 ~1) at these unique and state-of-the-art power levels enables long-range propagation with minimal beam divergence. The facility laboratory has a propagation length of over 20 meters, extendable to longer distances with reflective optics, and has high-power laser and beam diagnostics. The laboratory also has aerosol generation equipment to simulate maritime aerosol conditions for HEL-aerosol interaction experiments. Field experiments at multiple-kilometer ranges are performed at DoD facilities around the country.

Instrumentation:

We have a variety of diagnostics that are used to characterize the operation and propagation of high power, single-mode fiber lasers with wavelengths near 1.07 microns. These include power meters up to 10 kW cw, a fiber-coupled spectrometer, ccd cameras and software to monitor beam quality, a high-speed Phantom ccd camera, custom targets to reduce speckle, computer systems to control up to four fiber lasers, a target tracking system with fast steering mirrors, high accuracy remote-controlled mirrors, high efficiency InGaAs photovoltaic arrays for power beaming, image analysis software and algorithms, low-absorption fused silica optics, probe lasers, a water-based aerosol generator, and aerodynamic particle sizer.

Electronics Science and Technology Division

Solar Cell Characterization Laboratory

Optoelectronic Scanning Electron Characterization Facility

Ultrafast Laser Facility (ULF)

Infrared Sensor Characterization Laboratory

Millimeter-Wave Vacuum Electronics Fabrication Facility (MMW-VEFF)

Ultraviolet Photolithography Laboratory for Submillimeter-Wave Devices (UV-PL)

Compound Semiconductor Processing Facility

Atomic Layer Deposition System

Epicenter

Power Electronics Characterization Facility

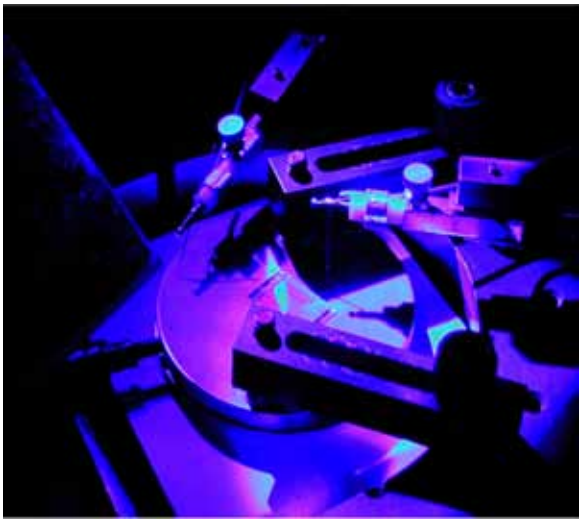
Laboratory for Advanced Materials Synthesis

Advanced Silicon Carbide Epitaxial Research Laboratory

High Pressure Laboratory

Solar Cell Characterization Laboratory

Code 6810
(202) 767-2533
NRL, Washington, DC



Function:

Measures, characterizes, and analyzes photovoltaic materials and devices. The primary focus is the measurement and characterization of solar cells for portable power applications for both terrestrial and space applications. Includes capability to measure solar cell response to exposure to natural and manmade radiation environments. These facilities are used by a range of customers, both commercial and government, for performing experiments ranging from in-depth basic studies to large-scale product qualification campaigns.

Description:

This facility is unique in its combination of measurement, analysis, and modeling capabilities. The laboratory contains the in-house expertise to assess a photovoltaic technology, design and implement the most effective characterization test plan, and analyze the results to produce an in-depth materials characterization and device performance evaluation. Furthermore, for space applications, using the displacement damage dose analysis technique developed within the laboratory, the experimental radiation results can be rapidly translated into accurate predictions of device performance in essentially any radiation environment, particularly that of Earth orbit.

Measurement Capabilities:

The solar cell laboratory boasts a wide array of measurement capabilities. The central feature is a TS Space Systems Triple-zone Close Match Simulator that has three independently controllable light zones—300 to 700 nm, 700 to 1200 nm, and 1200 to 2400 nm—and that produces one-sun, airmass-zero (AM0) illumination with 2% uniformity over a 28 in^2 area with better than 0.5% spectral fidelity from 300 to 2400 nm. In addition, the laboratory contains a Spectrolab X-25 Mark II solar simulator providing one-sun, AM0 illumination with 2% uniformity over a 78 in^2 area with 2% spectral fidelity from 300 to 1600 nm.

The laboratory also contains a custom-built spectral response system ranging in wavelength from 340 to 2400 nm with specialized light and electrical biasing configuration, allowing individual subjunction measurements within multijunction devices to be measured. The spectral response system is complimented by an electroluminescence (EL) measurement system with a similar measured wavelength range. The laboratory also contains diode dark-current measurement systems, a deep-level transient spectrometer, and a state-of-the-art Hall Effect System.

Radiation Facilities:

NRL maintains in-house radiation facilities and has longstanding relationships with facilities at many other government laboratories, providing access to virtually any desired radiation test environment. Focusing on the natural space radiation environment, NRL has established specialized test chambers enabling exposure of multiple large-area solar cells to electron and proton irradiation over a wide range of particle energies and fluxes.

Optoelectronic Scanning Electron Characterization Facility

Code 6810
(202) 767-2533
NRL, Washington, DC

Function:

Provides unique testbed for in-suite electrical, optical, and structural analysis of semiconductor materials and devices with nm-scale resolution. Facility is customized for steady state and transient studying of the electrical and optical activity of crystallographic defects in solar cells and photodiode detectors.

Description:

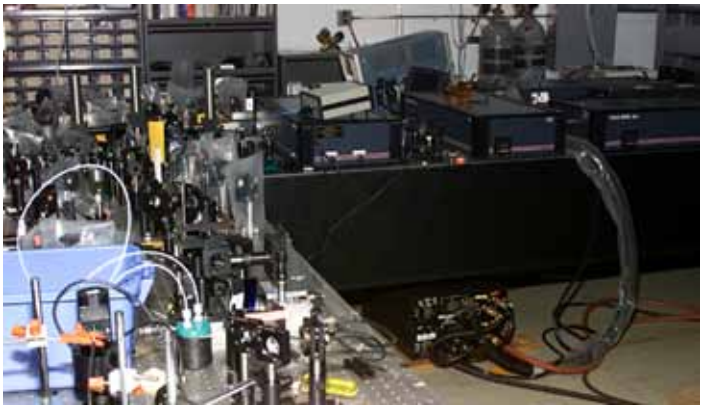
Facility is based on SEM (Vega3 XMH) equipped with LaB6 electron source, which offers high probe current stability combined with high spatial resolution. It includes electron beam-induced current (EBIC), cathodoluminescence (CL), and annular backscattered electron detector systems. SEM has continuous flow liquid He/N_2 cold electrical stage to analyze specimens at variable temperatures. The column of SEM is customized to fit an ultra-high-speed electrostatic electron beam blanking unit for e-beam pulsing, allowing transient measurements. A pulse generator integrated with a blanking unit controls the pulse width and period of the electron beam. The large chamber provides the ability to perform fine automated data collection over 5-in.-diameter specimens.

Measurement Capabilities:

- Electrical detection unit measures qualitative and absolute steady state/transient electron beam-induced current as well as dark I-V signals from 20 fA to 20 mA (EBIC).
- Optical detection unit allows cathodoluminescence and electroluminiscence panchromatic/monochromatic imaging and spectroscopy in the range of 300 to 1700 nm.
- Ultrafast e-beam blanker is able to produce pulses as short as 150 ps in duration with 100 ps pulse decay time.
- Liquid He/N_2 cold stage (5 to 400 K) with atomic scale vibration noise level.
- Annular backscattered electron detector scintillator type (YAG crystal).

Ultrafast Laser Facility (ULF)

Code 6810
(202) 767-5461
NRL, Washington, DC



Description:

The ULF's equipment has recently been used to perform experiments that measure ultrafast photophysical processes on organic macromolecules and in organic solid-state thin films designed for photonics applications. An optical apparatus has been configured to characterize photophysical mechanisms using transient pump-probe spectroscopy at either a single frequency or using a multicolor continuum. A separate apparatus is used to measure the picosecond timescale photo-induced emission process following ultrashort pulse excitation. An ultrafast terahertz spectrometer is under construction, which will be used to measure the low-frequency vibrational response of organic solids and liquids. The ULF is also devoted to understanding the effects of space radiation on microelectronics circuitry. Sub-picosecond laser pulses are used to simulate the interaction of space radiation with semiconductor material (Si, GaAs, InAs, etc.). The ultrafast pulsed laser permits the study of space radiation effects in microelectronics in a highly controlled manner, and thus complements experiments performed at accelerator facilities. The ULF has proven invaluable to the space industry for troubleshooting microelectronic circuits for space applications.

Function:

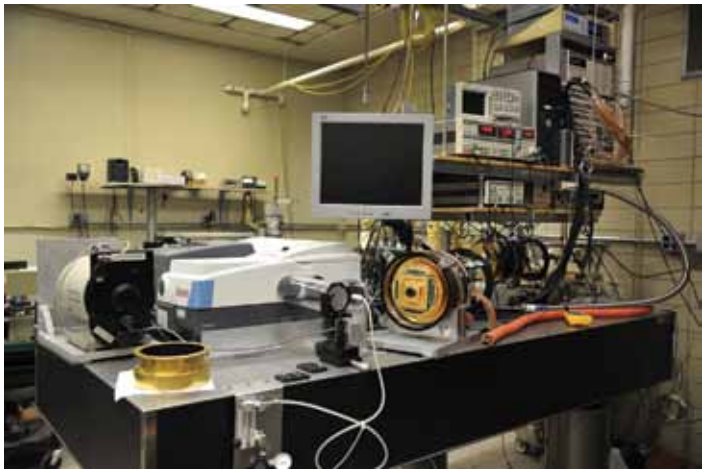
Supports a broad range of basic and applied research that includes understanding primary photophysical processes in molecules, molecular films, and supramolecular systems; characterizing the low-frequency (terahertz) vibrational response of molecules; and simulating the effects of space radiation with state-of-the-art microelectronic circuitry. The Ultrafast Laser Facility (ULF) supports NRL research programs and collaborative research projects with outside universities, industry, and government institutions. Customers from the space electronics industry use the ULF as a tool to optimize circuit designs for space applications.

Instrumentation:

The ULF contains laser systems capable of producing laser pulses in a temporal range between 20 fs and 2 ps. The core femtosecond system consists of an amplified titanium sapphire laser that is coupled to two tunable optical parametric amplifiers. This system generates tunable femtosecond pulses from the mid-infrared to the ultraviolet part of the spectrum. A second titanium sapphire oscillator is available for applications requiring high laser pulse repetition rates. The ULF also maintains a synchronously pumped cavity-dumped dye laser system, which produces picosecond laser pulses in the visible. A time-correlated single photon counting apparatus provides a sensitive measurement of fluorescence signals. The ULF contains the optical apparatus and spectroscopic instrumentation to perform a wide variety of ultrafast experiments.

Infrared Sensor Characterization Laboratory

Code 6810
(202) 404-4548
NRL, Washington, DC



Function:

Supports the development of advanced infrared (IR) sensor materials with in-depth material and device characterization capabilities. Focus is on mid- (3 to 5 μm) and long-wave (8 to 14 μm) IR sensor material based on III-V bulk alloys and type-II superlattices (T2SLs). Naval applications include missile defense, nighttime surveillance, infrared search and track, and tactical dual-band imaging.

Description:

Combined with shared NRL facilities, the IRSCL is designed for assessment of key material and device properties of IR sensor material to provide critical feedback to device designers and growers. The IRSCL also has facilities to package processed dies for device characterization in cryogenic Dewars from 25 to 300 K. Device measurements are highly automated, allowing for rapid feedback for both internal development of new device structures and for the transition of these structures to industrial growth and fabrication foundries supported by externally funded programs.

Instrumentation:

The core of the IRSCL is composed of two Lakeshore cryogenic MTD-150 test Dewars that can be quickly configured to accept 68- or 100-pin leadless chip carriers. ZnSe windows provide IR access from 0.6 to 18 μm, cold-shielded with f-stops from f/1 to f/5. The Dewars connect to a Keithley 7002 switching mainframe with 10 ultra-low offset current (< 1 pA) 10-channel scanner cards. In conjunction with instrumentation including an HP 4155 semiconductor parameter analyzer, Agilent E4980A LCR meter, Stanford SR830 DSP lock-in amplifier, and a Nicolet 6700 FTIR spectrometer, we can fully characterize the dark current, quantum efficiency, and operating biases of a die of over 60 dual-band devices in a single day. For more in-depth analysis, we can do the same measurements as a function of temperature over a 25 to 300 K range, allowing us to isolate separate different dark current mechanisms using bandstructure and transport simulation. IR transmission from 2.5 to 25 μm with sample temperatures from 10 to 300 K is performed using a Janice ST100 cryogenic Dewar held in the sample compartment of the Nicolet 6700 FTIR. A Lakeshore 9500 Cryogenic Hall measurement system equipped with a superconducting magnet allows for temperature and field-dependent Hall measurements from 2.2 to 310 K and 0 to 9 Tesla. The Lakeshore system includes software to perform Quantitative Mobility Spectrum Analysis (QMSA), an algorithm codeveloped at NRL that fits the field dependence of the Hall conductance to extract the mobilities, densities, and carrier types of multiple carriers often present in heterostructure materials.

Millimeter-Wave Vacuum Electronics Fabrication Facility (MMW-VEFF)

Code 6850
(202) 404-2799
NRL, Washington, DC

Function:

Fabricates millimeter-wave amplifiers based on vacuum electronics, including traveling wave tubes, klystrons, and gyro-klystrons. The fabricated devices are used for research on new ways of generating broadband, high average power millimeter-wave radiation (30 to 300 GHz frequencies) for emerging radar, EW, and communications applications. The MMW-VEFF also supports research on high current density electron sources and electron beam propagation.

Description:

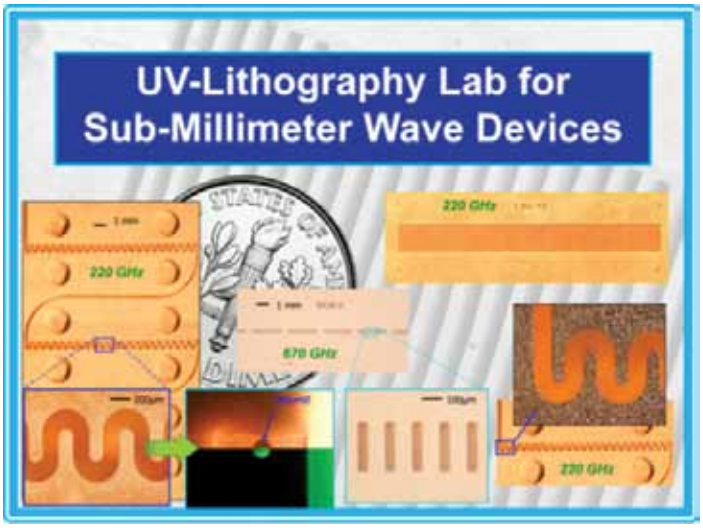
The MMW-VEFF is used to transform theoretical electromagnetic and beam dynamics concepts for devices into functioning real-world prototypes. In a typical process, computer-based solid models of electrodynamic beam-wave interaction structures are created, based on the theoretical physics design. These solid models are used to generate cutting tool path programs, which in conjunction with the computer-numerically-controlled (CNC) milling machine and lathe, are used to form complex three-dimensional metallic interaction circuits and other component parts. After chemical cleaning, the parts are inspected with a hybrid optical/contact probe coordinate measuring machine. Parts made by CNC mills or lathes are most suitable for Ka-band (26.5 to 40 GHz) devices. For higher frequencies, including W-band (75 to 110 GHz), wire and electric discharge machines (EDMs) are typically used in the fabrication process for additional precision. The completed components made by the various techniques are joined together via hydrogen/vacuum brazing using high-purity noble metal alloys. Completed vacuum electronic devices are evacuated, baked-out, and delivered for high-power electromagnetic testing.

Instrumentation:

The MMW-VEFF employs a CNC milling machine and a CNC lathe, both having a cutting accuracy of 5 µm. The facility also utilizes wire and EDMs for force-free cutting of metallic structures with 30-µm feature sizes and 2-µm accuracy. A controlled-atmosphere hydrogen/high-vacuum brazing furnace is used for the contamination-free joining of metallic parts, ceramic metallization, and ceramic-to-metal bonding over the 600° to 1700 °C temperature range.

Ultraviolet Photolithography Laboratory for Submillimeter-Wave Devices (UV-PL)

Code 6850
(202) 404-4510
NRL, Washington, DC



Function:

Conducts microfabrication of all-copper (up to 1000 µm deep) vacuum electronic amplifier circuits and other passive components from 100 GHz to 1 THz using ultraviolet photolithography techniques.

Description:

We have developed high-precision microfabrication techniques that allow us to fabricate quasi-3D all-copper circuits with low millimeter-wave losses and high power handling capabilities for applications in vacuum electronic amplifiers and passive devices that operate in the 100 to 1000 GHz frequency range. We use SU-8 photoresist in layers up to 1 mm thick in combination with a unique process invented and patented at NRL for fabricating high-precision electron beam tunnels at the same time as the circuits. These microfabrication processes are used to create amplifiers with record-breaking power densities and bandwidth, providing the enabling technology to meet the next generation of Naval requirements in all-weather radar, secure high data rate communications, and imaging. The process can also be used to fabricate submillimeter-wave passive devices such as filters (combline, interdigital, etc.), waveguides, and couplers, and microfluidic structures for high heat flux thermal management.

Instrumentation:

Newport 500W Ultraviolet flood source, mask aligner, Buehler grinder/polisher, copper electroforming system, Heidelberg maskless ultraviolet photoresist exposer, and Muegge plasma etcher.

Compound Semiconductor Processing Facility

Code 6850
(202) 404-4616
NRL, Washington, DC

Function:

Provides a research environment for hands-on fabrication of novel structures for fundamental investigations of new compound semiconductor materials, devices, and circuit concepts. Also, provides a service facility for electron-beam lithography, scanning electron microscopy, and fabrication of devices and circuits.

Description:

The facility mostly consists of a 2750 ft^2 clean room area (Class 10,000) with HEPA filtration, temperature/humidity control, and an independent air handling system with single-pass capability. A full-time technician is assigned to the clean facility for maintaining the equipment, training new users, and assisting the hands-on users on specialized runs. State-of-the-art microwave and optoelectronic devices are processed in the clean facility using gallium arsenide, gallium nitride, and indium phosphide material systems. Lines with feature size as small as 20 nm can be fabricated with a Raith electron beam microscope, located in a separate, vibration-free area.

Instrumentation:

Principal capabilities include (1) standard photolithography—photoresist spinner and bake ovens, microscope, mask aligners operating in the mid-UV and deep-UV (DUV) range, and a DUV flood exposure system; (2) metallization—e-beam evaporation for standard metals; (3) dry etching—reactive ion etching (RIE), inductively coupled plasma (ICP), and plasma etching; (4) silicon nitride deposition—plasma enhanced chemical vapor deposition; (5) fine line patterning via electron-beam lithography; (6) scanning electron microscopy; and (7) other capabilities—contact alloying, profilometer, rapid thermal annealing (RTA), annealing furnaces, and gold plating.

Atomic Layer Deposition System

Code 6870
(202) 404-4574
NRL, Washington, DC

Function:

Deposition of thin films at low temperatures (generally less than 300°C). These thin films include metal oxides, including high k dielectrics, semiconductors as well as some metals.

Description:

The facility uses atomic layer deposition (ALD), which is a conformal, layer by layer deposition process that produces high quality films on flat surfaces as well as in high aspect ratio structures. Since the growth is layer by layer, very precise control is possible to thicknesses of less than 1 nm. The unique capability of this system is a specialized precursor cell, which allowed the deposition of a new form of Ag, consisting of a mosaic structure of 2D islands separated by 4-nm air gaps. This material is a metamaterial, exhibiting strong plasmonic behavior. This facility also includes research on III-V/high k dielectric interfaces, where ALD combined with an in situ pregrowth hydrogen plasma treatment has been used to form MOS devices with low gate leakage current and significantly improved electrical interfaces. Another application of the high k dielectric capabilities include carbon nanotube (CNT) based field-effect transistors, in which ultrathin high k dielectric films of HfO_2 on CNTs achieved high k values and high breakdown resistance while maintaining ballistic transport through the nanotubes. Current deposition of new high k dielectrics, including VO_2, is also under way.

Instrumentation:

The facility consists of a Beneq TSF200 ALD system, which is capable of thermal ALD, remote and direct plasma ALD, as well as an ozone generator for reactive oxygen species. Thin films of Al_2O_3, ZnO, AZO, and HfO_2 are being deposited using thermal, plasma and ozone deposition. A unique feature of this system is a custom-designed hot precursor cell (HS500), capable of depositing materials using precursors with a narrow temperature stability range. This cell is currently used for Ag and Pt metal deposition. This system also includes a separate load lock with up to 200 mm sample transfer with turbo pump, capable of vacuum to 10^{-8} Torr. This load lock is equipped with a Woollam M2000-Insitu Model D ellipsometer, which has a wavelength range of 190 to 1690 nm, allowing optical measurements in situ and under UHV conditions.

Epicenter

Code 6870
(202) 767-3665
NRL, Washington, DC

Function:

Fabricates and analyzes heterostructures that are used in ongoing electronic, magnetoelectronic, and optoelectronic device efforts.

Description:

Advances in molecular beam epitaxy allow the Epicenter to address the control of the structure of solids on the monolayer-length scale. This flexibility in the fabrication of semiconductors allows quantum mechanical control of electronic wave functions, which allows the electronic and optical properties of semiconductors to be engineered for particular device applications. Heterostructures formed from III-V semiconductors with 6.1 Å lattice spacing (GaSb, AlSb, InAs, and related alloys) are grown in the Epicenter. These heterostructures have the potential to define a new state of the art in applications that include >100-GHz high-speed logic circuits, terahertz transistors, sensitive infrared detectors, and mid-infrared semiconductor lasers. III-Mn-V ferromagnetic semiconductors and ZnMnSe, ZnCoSe, and ZnFeSe dilute magnetic semiconductors are also fabricated in the Epicenter. The development of these materials should allow the creation of a new class of devices with operating principles that rely on the spin of the electron, commonly referred to as “spintronics.”

Instrumentation:

This facility includes five interconnected ultra-high-vacuum systems for molecular beam epitaxy film growth and film analysis. Three of these chambers are used for molecular beam epitaxial growth of III-V semiconductors, II-VI semiconductors, and ferromagnetic semiconductors. Film analysis is accomplished with a scanning tunneling microscope. The fifth chamber is used for etching semiconductor heterostructures.

Power Electronics Characterization Facility

Code 6880
(202) 404-8542
NRL, Washington, DC

Function:

Provides unique characterization facility for power electronic devices over a large range of voltage, current and frequency. Customized probe stations allow for a variety of on-wafer power electronic device characterization techniques.

Description:

The facility is composed of many customized characterization tools to cover a wide range of power electronic devices with particular emphasis on wide bandgap GaN and SiC devices. This facility has five probe stations for wafer-level device testing and three additional systems for packaged devices to probe fundamental device physics. Ultra-fast pulsed I-V measurements are used to probe charge trapping in GaN devices, which results in reduced circuit performance. To further study trapping, a tunable light source is available to perform photoionization studies to identify specific defect levels associated with charge trap states. In addition, a DC-DC boost converter test circuit has been fabricated on a probe card to test devices under real operating conditions, enabling rapid prototyping of device geometry and layer structures. To study reliability, a cooled CCD camera is used to capture electroluminescence (EL) images under high voltage stress conditions, which can be used to spatially resolve the location of defects associated with device failure before catastrophic failure, thus preserving the device for further analysis.

Measurement Capabilities:

- DC I-V measurement and C-V measurement from room temperature to 300 °C
- High voltage (20 kV), high vacuum wafer prober with electroluminescence imaging capability.
- Quiescent voltage pulsed I-V stress testing, up to 65 V with 200 ns pulse width, for measurement of dynamic on-resistance.
- Ultra-fast pulsed I-V (10 ns resolution) and transient I-V capability with nA resolution.
- High voltage (400 V) capacitance measurement capability from fF to nF at 100 kHz to 10 MHz.
- On wafer probe card DC-DC boost converter test circuit for high voltage power switching testing.
- Temperature dependent Hall measurement from 77 K to 500 K on packaged parts.
- Tunable UV light source with 300 W Xenon lamp and 1/4 m monochromator to provide monochromatic illumination from 250 nm to 1000 nm.

Laboratory for Advanced Materials Synthesis

Code 6880
(202) 767-3672
NRL, Washington, DC

Function:

NRL's primary site for the exploration of crystal growth via metal-organic chemical vapor deposition (MOCVD). Current research activities include the growth of wide bandgap semiconductor materials and device structures for use in power electronics, RF communications, radar, and optoelectronics. Materials used in this activity are gallium nitride (GaN) and related alloys such as AlGaN and InGaN. Research activities range from basic research studies of materials and crystal growth to more applied investigations involving devices.

Description:

The MOCVD growth of homoepitaxial or heteroepitaxial films of GaN, InGaN, and AlGaN is performed on lattice matched and mismatched substrates such GaN, SiC, sapphire, and silicon. The growth is accomplished by the reaction of metalorganic precursors that typically contain the column III metal, e.g., $Ga(CH_3)_3$ or $Al(CH_3)_3$, and the organometallic or hydride precursor of the column V element, e.g., NH_3. Depending on the semiconductor being grown, the reactions take place at pressures 5% to 50% of ambient over a substrate heated in the range of 500° to 1100 °C. Growth rates are typically determined by the column III precursor flux, which is controlled by the temperature and pressure of the sources and the mass flow rate of the high purity carrier gas flowing through the source, and range from 0.2 Å/s to 10 Å/s. The crystal quality is a direct function of growth parameters such as the pressure used for deposition. The epilayers can be doped n- or p-type with dopants such as Si or Mg. Through knowledge and control of the growth process, different types of structures containing complex heterojunctions can be grown. The equipment is housed in a specially designed and constructed building for the chemicals used in the growth process.

Instrumentation:

The facility houses two state-of-the-art reactors for growth of GaN and its technologically important ternary compounds. Each reactor is equipped with in situ process monitoring equipment to aid in the growth of complex device structures. An additional reactor is reserved for gallium arsenide or indium phosphide growth and for growth of the technologically important ternary compounds of gallium arsenide. The laboratory has an integral safety system including gas detectors and alarms.

Advanced Silicon Carbide Expitaxial Research Laboratory

Code 6880
(202) 767-3098/767-3672
NRL, Washington, DC

Function:

The premier research laboratory in the DoD for exploration of growth of the wide bandgap semiconductor silicon carbide (SiC) using high-temperature chemical vapor deposition and a hot-walled geometry. Current research aims at establishing tight control of point and extended defects in thick epitaxial layers for use in high-voltage, high-current power electronic devices. Research activities range from basic research studies of materials and crystal growth to more applied investigations involving devices.

Description:

Homoepitaxial growth of SiC layers on SiC substrates is accomplished by the reaction of silane and propane at temperatures between 1500° and 1800 °C and pressures of 50 to 200 mbar. Growth rates are varied from 2 µm/h to 15 µm/h. The crystal quality is a direct function of the substrate preparation and growth conditions used, such as the ratio of carbon to silicon atoms in the gas phase. The epilayers can be doped either n- or p-type from 1×10^{14} cm^{-3} to 5×10^{18} cm^{-3} using dopants such as nitrogen or aluminum, respectively. In situ growth monitoring with mass spectrometry and laser-based reflectance techniques permits study of the growth environment. Through knowledge gained from these studies and control of the growth process, different types of complex structures can be grown. The equipment is housed in a specially designed and constructed laboratory space for the chemicals used in the growth process.

Instrumentation:

The laboratory comprises two adjacent facilities: the Growth Facility and the Immediate Characterization Facility. The Growth Facility is centered about an Epigress/Aixtron VP508 high-temperature chemical vapor deposition reactor that is widely used in the SiC community to deposit homoepitaxial SiC epilayers on SiC substrates. The Immediate Characterization Facility hosts tools that permit researchers to rapidly characterize epitaxial wafers, providing feedback to growth efforts.

High Pressure Laboratory

Code 6880
(202) 767-0827
NRL, Washington, DC

Function:

NRL's primary site for: 1) the discovery of new metastable high pressure (HP) forms, 2) the creation and/or retention of nano-architecture microstructures in materials for improved performance, 3) the growth of crystals of metastable materials, 4) and the improvement of modeling through experimental verification. Current research aims at the development of new approaches for high pressure sintering, including transparent nanocrystalline spinels, nanostructured thermo-electric materials, nanocomposite magnets, and other composite nanoceramics. Research activities range from basic studies of phase transitions and formation new metastable phases with unique properties to more applied research of new HP crystal growth and sintering.

Description:

The sintering of nanocrystalline powders without increasing the initial grain size and resulting in unique properties of the nanoceramics. The approach includes a few key steps. The commercially procured nano powder is initially treated in an inert atmosphere furnace and subsequently transferred to a glove box without exposure to the ambient. The green body is then compacted inside the glove box and inserted in a high pressure cell assembly with internal furnace while in the glove box. These steps prepare and maintain active surface of the nano powders. The third step is applying quasi-hydrostatic pressures to the high pressure cell in the range of 4.0 to 5.0 GPa for few hours. During this step, the green body is partially sintered at room temperature. Subsequent sintering at 4.0 to 5.0 GPa and 600 °C results in a fully transparent nanocrystalline spinel.

Instrumentation:

NRL houses state-of-art equipment includes a HPHT apparatus, dry-glovebox with attached high temperature furnace, and several controlled atmosphere furnaces/reactors. Originally designed for industrial scale diamond growth, the pressless split-sphere multi-anvil HPHT apparatus at NRL is the most compact, efficient, and economical among known diamond-producing devices. Importantly, the extreme pressure and temperature environment required for diamond growth makes the apparatus a versatile scientific research and development tool by allowing the application of pressures higher than 6 GPa (870,000 psi) and temperatures of 2500 °C for sustained operation. The HPHT apparatus at NRL has been updated with computer control of pressure and temperature and control of pre-pressure environment.

Center for Bio/Molecular Science and Engineering

Micro Fabrication Facility for Microfluidics

Quadruple Time-of-Flight Mass Spectrometer

Advanced Microscopy Facility

Automatic X-ray Diffractometers

Micro Fabrication Facility for Microfluidics

Code 6910
(202) 404-6027
NRL, Washington, DC

Function:

Provides milling and fabrication machines used to create micromixing and microfluidic components in glass and plastic for a wide variety of applications. Supports projects in the Chemistry Division, the Laboratory for Computational Physics and Fluid Dynamics, and the Center for Bio/Molecular Science and Engineering.

Description:

The facility consists of a 7-ton Denkey HM-7 electric injection mold machine, a Haas CNC Minimill, a Techno-Isel CNC mill, a Potomac Photonics laser ablation system, and a KLA-Tencor P-15 Profilometer. The Haas Minimill has reproducibility and accuracy to 0.0002 in. The laser ablation system has a user-friendly software interface with vision and measurement capability. Designs can be imported from Autocad or other computer-aided design (CAD) software. Resolution is 0.25 µm and accuracy is 1 to 2 µm. Ablation depth can be less than 1 µm, depending on the material. Additional instrumentation is available for 3D imaging and printing, including Objet Connex500 3D printer, MicroSpy Profile Optical Profilometer, a Kevence Digital Microscope, a Next Engine 3D Scanner, and a Summa S75 Printer Cutter.

Quadrupole Time-of-Flight Mass Spectrometer

Code 6910
(202) 767-0394
NRL, Washington, DC

Description:

The QSTAR®XL Hybrid LC/MS/MS System is a high-performance, hybrid quadrupole time-of-flight mass spectrometer designed for protein identification and characterization and drug metabolism studies. The unique flexibility to switch between the standard API NanoSpray™ source and the new oMALDI™ 2 ion source makes the QSTAR®XL System the preferred choice for proteomics. Specific scan modes such as precursor ion scanning, enabled by the patented LINAC™ Pulsar collision cell technology, identify the type and location of post-translational modifications or drug metabolites with outstanding specificity and sensitivity.

Function:

Generates superior quality mass spectrometry (MS) and tandem mass spectrometry (MS/MS) data from both atmospheric pressure ionization (API) and matrix-assisted laser desorption ionization (MALDI) techniques.

Features:

- Enhanced ion optics for highest sensitivity and reliability.
- Excellent mass accuracy and stability yield unequivocal molecular weight and high-quality structural information.
- Unique, patented LINAC™ Pulsar collision cell technology enables the most sensitive product ion and precursor ion scan capabilities for metabolite, protein and peptide, and post-translational modification determination.
- Maximum flexibility with a comprehensive selection of interchangeable, application-specific ion sources; new oMALDI™ 2 source for increased sensitivity.
- Sensitive and rugged IonSpray™, TurboIonSpray®, and atmospheric pressure chemical ionization (APCI) ion sources for routine low-level drug metabolism identification and characterization.
- New NanoSpray™ ion source for capillary liquid chromatography (LC) provides increased sensitivity and throughput for protein and peptide identification and characterization.
- New PhotoSpray™ source for analysis of low-molecular-weight, highly polar compounds via atmospheric pressure photoionization.
- Extended MS and MS/MS mass range (6,000 and 40,000 m/z) expands scope of protein and peptide studies.

Advanced Microscopy Facility

Code 6930
(202) 767-0951
NRL, Washington, DC

Description:

The facility includes electron microscopes, a darkroom, and adjacent biochemical laboratories for sample preparation and additional chemical/physical characterization of proteins, lipids, DNA, and cells.

Function:

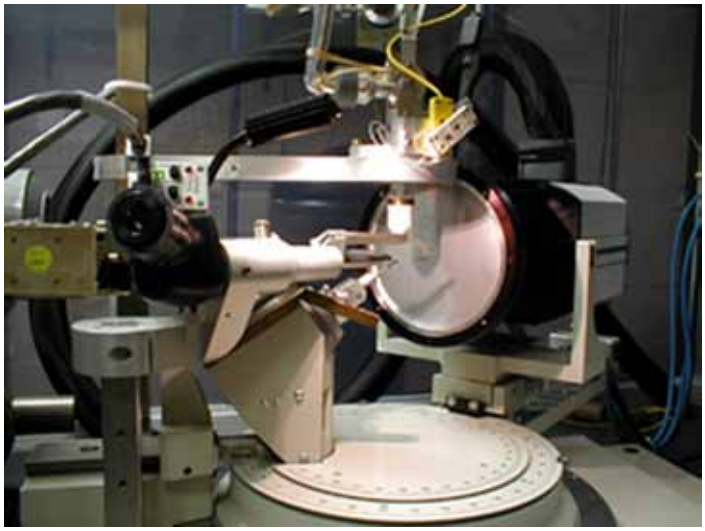
Provides a facility for high-resolution studies of complex biomolecular systems. The goal is an understanding of how to engineer biomolecules for various applications, including sensors, self-assembled lipid microstructures, patterned surfaces, and biomaterials.

Instrumentation:

- Leo 1455 digital scanning electron microscope
- Hitachi H8100 analytical electron microscope (AEM)
- TopoMetrix Explorer atomic force microscope (AFM)
- Digital Instruments Dimension 3100 AFM
- Zeiss LIBRA-120 energy filtering transmission electron microscope
- Scanning probe microscope capable of multimode atomic force
- Microscopy and scanning tunneling microscopy (STM)
- Nikon C1 Confocal Microscope System
- Scanning-tip AFM capable of imaging large samples using contact mode, noncontact mode, lateral force mode, and force modulation mode
- TopoMetrix Aurora nearfield scanning optical microscope (NSOM)
- Optical equipment
- Confocal fluorescent microscope
- Continuous wave (CW) fluorimeter and microscope
- Optical and fluorescence microscopes
- Balzers BAF400 freeze fracture apparatus
- High-speed ultracentrifuges
- High performance flow cytometer with cell sorting

Automatic X-ray Diffractometers

Code 6930
(202) 767-0656
NRL, Washington, DC



Function:

Carries out atomic-resolution single-crystal X-ray diffraction analyses and powder diffraction. Examines a wide range of materials from small inorganic molecules to macromolecular biological compounds and powder, fibers, or films.

Description:

The site includes laboratories for sample preparation and purification. Laboratory facilities are also provided for crystal growth. Three automated X-ray diffractometers are available for data acquisition. Two of these may be operated over a range of sample temperatures (80° to 400 °K). High-speed computational facilities are in place for structure solution and analyses.

Instrumentation:

- A Bruker PROTEUM diffractometer consisting of a Platinum-135 charge-coupled device (CCD) area detector mounted on a three-circle goniometer. This equipment is coupled to a Bruker Micro-STAR-H rotating anode (Cu-Kα X-ray source) using high brilliance Helios X-ray optics.
- A Bruker APEX CCD area detector mounted on a three-circle goniometer using a sealed tube Mo-Kα X-ray source, an incident beam graphite monochromator, and a Mono-CAP X-ray optic.
- A D2 Phaser powder diffractometer equipped with a LYNXEYE™ detector for collection of high-speed high-quality X-ray powder diffraction data.

Acoustics Division

Shallow Water Acoustic Laboratory

Laboratory for Structural Acoustics

Structural Acoustics In-Air Facility

Rail-based Broadband Synthetic Aperture Ocean Measurement System

Geoacoustic Physical Model Fabrication Laboratory

Acoustic Communications Measurement Systems (ACOMMS)

High-Frequency Acoustic Flow Visualization Sonar Systems

Instrumentation Suite for Acoustic Propagation Measurements in Complex Shallow Water Environments

Autonomous Acoustic Receiver System

Salt Water Tank Facility

Underwater Acoustic Time-Reversal Mirror

300-Hz and 500-Hz Autonomous Acoustic Sources

Sediment Geo-Probe System

Drifting Echo Repeater

Shallow Water Ship Acoustic Signature System

Sono-Magnetic Laboratory (SOMALab)

Fabrication Workshop

Low Frequency Sound Tube

Measurement Laboratory

Shallow Water High-Frequency Measurement Systems

Shallow Water Acoustic Laboratory

Code 7136
(202) 404-3840
NRL, Washington, DC

Description:

This facility includes a large concrete pool (250,000 gal of deionized water) equipped with high-resolution, computer-controlled target source and receiver manipulators. It is used for high-frequency acoustic scattering characterization of scale-model submarines and deactivated mine targets. The pool has a deep, sandy bottom and a high-resolution Cartesian nearfield acoustic holography (NAH) scanner to accommodate the controlled acoustic study of buried and near-buried mines.

Function:

Supports experimental research where high-frequency acoustic scattering and surface vibration measurements of fluid-loaded and non-fluid-loaded structures are required. Typically, ultra-high-precision measurements are conducted in this pristine laboratory environment when acoustic interactions with sediments are important.

Instrumentation:

Network-based automated data acquisition and process control including extensive use of robotic scanners. Other attributes and resources include broadband source/receiver systems; compact measurement ranges using nearfield sources, receivers, and projection algorithms; multiaxis Doppler vibrometers for noncontact surface motion measurements of porous media water interfaces; multiple workstations to support acquisition analysis, calculations, and visualizations; and structural acoustics codes: SARA2D, SARA3D, ANSYS, NISA, FEMLAB, and SONAX.

Laboratory for Structural Acoustics

Code 7136
(202) 404-3840
NRL, Washington, DC

Function:

Supports experimental research where acoustic radiation, scattering, and surface vibration measurements of fluid-loaded and non-fluid-loaded structures are required. Typically, ultra-high-precision measurements are conducted in this pristine laboratory environment using submarine hull backing impedance simulators, torpedoes, scale-model submarine structures, and deactivated mine targets.

Description:

The large measurement pool—the core research capability for in-water structural acoustics studies—is 55 ft in diameter, 50 ft deep, and contains 800,000 gal of deionized water. The entire tank is vibration- and temperature-isolated. The laboratory is instrumented with precision measurement systems that include large workspace in-water robotic scanners capable of generating nearfield acoustic holography (NAH) radiation and scattering databases.

Instrumentation:

Network-based automated data acquisition and process control including extensive use of robotic scanners. Other attributes and resources include compact measurement ranges using nearfield sources and receivers; multiaxis laser Doppler vibrometry (LDV) for noncontact surface motion measurements; extensive interferometric fiber-optic sensor instrumentation; matrix processors that support MIMO control applications; multiple workstations and file servers to support acquisition, structural acoustics calculations, and visualizations; and structural acoustics codes: SARA2D, SARA3D, ANSYS, NISA, FEMLAB, and SONAX.

Structural Acoustics In-Air Facility

Code 7136
(202) 404-3840
NRL, Washington, DC

Function:

Supports experimental research where broadband acoustic radiation, reflection, transmission, and surface vibration measurements are required. Typically, ultra-high-precision, highly spatially sampled measurements are conducted on scaled submarine structures, satellite payload fairings, active and passive material systems for sound control, and new transducer and sensor systems.

Instrumentation:

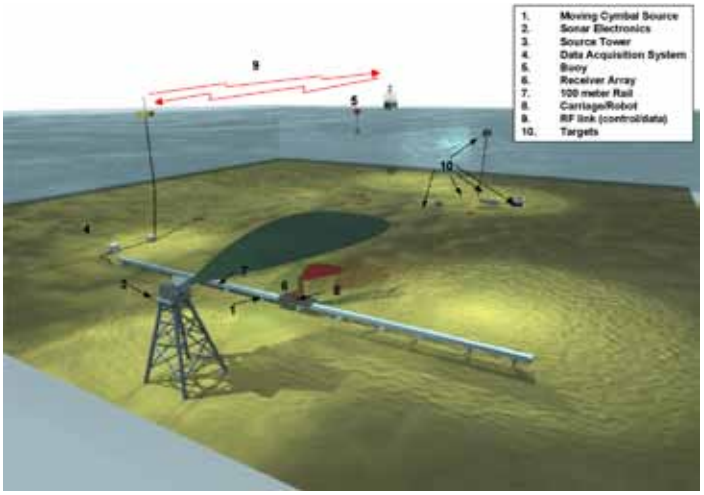
Broadband source/receiver systems; large workspace (3D) robotic scanners for NAH; scanning laser Doppler vibrometry (LDV); multiple workstations to support acquisition, analysis, calculations, and visualization; and structural acoustic codes: SARA2D, SARA3D, ANSYS, NISA, FEMLAB, and SONAX.

Description:

The large, acoustically treated facility is 50 ft × 40 ft × 38 ft high. The laboratory is instrumented with precise acoustic and vibration measurement systems. These include large workspace robotic scanners capable of generating nearfield acoustic holography (NAH) radiation, reflection, and transmission databases. In addition, three-axis laser vibrometers are used to generate very highly sampled surface vibration maps.

Rail-based Broadband Synthetic Aperture Ocean Measurement System

Code 7136
(202) 404-3840
Ocean deployed



Function:

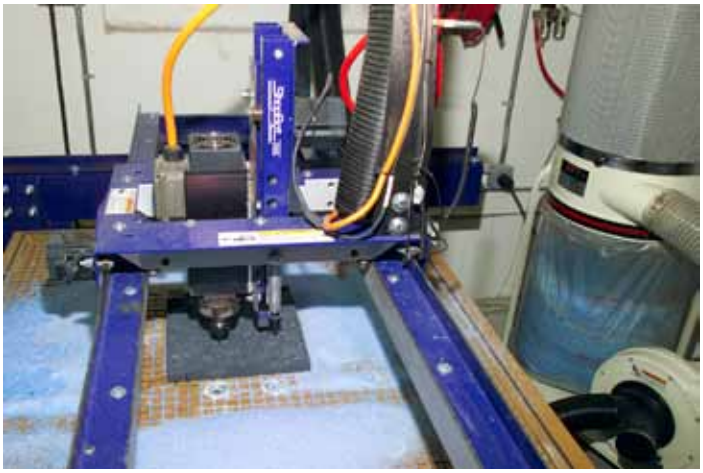
Enables collection of broadband acoustic scattering databases where acoustic sources and receivers can be translated on a precise linear path under program control. Further, the phasing of the source and data acquisition is highly coherent such that scattering data can be processed to form synthetic apertures. This facility supports research in the collection of high-quality scattering cross sections of mines and the associated clutter, with the intent of perfecting techniques required for unmanned undersea vehicles (UUVs).

Description:

The facility is a portable measurement system that can be deployed in an ocean environment. A 100-m-long rail supports a robotic carriage that can be positioned precisely at any point along the rail using an encoder feedback system. The sources and receivers can be attached to the carriage to collect quasi-monostatic data, and a separate source tower enables bistatic scattering data collection. All data acquisition, process control, and signal conditioning are contained within a pressure vessel that sits on the sea floor adjacent to the rail. Bidirectional control and data transfers are made over a dedicated RF link

Geoacoustic Physical Model Fabrication Laboratory

Code 7160
(202) 767-1741
NRL, Washington, DC



Function:

Fabricates three-dimensional rough surfaces (e.g., fractals, ripples) out of materials such as PVC or wax to simulate the roughness properties associated with ocean bottoms. The rough surfaces have been employed in water tank facilities with acoustic sources and receivers to study acoustic scattering and propagation at frequencies up to 500 kHz.

Description:

The facility enables computer-numerically controlled (CNC) fabrication of arbitrary single-valued topographies with submillimeter precision from machinable materials up to 1.2 m × 1.2 m in size and nominally 0.15 m in thickness. A suite of software allows a surface model and machining strategy to be developed for topography specified either explicitly as a digital elevation map or statistically in terms of spectral parameters. Multiple roughing, re-roughing, and finishing strategies are possible, depending on the nature of the surface to be fabricated. Surfaces are fabricated on a three-axis CNC mill equipped with a precision high-speed spindle, vacuum part fixturing ("hold-down"), liquid-free vortex tool cooling, a retractable ball-transfer system for part alignment, and a vacuum dust-collection system. Materials suitable for fabrication include soft metals, plastics, and wood. The facility also allows for submillimeter precision measurement of topographies of existing surfaces using a kinematic-resistive touch-trigger probe.

Instrumentation:

- Computer-numerically controlled three-axis milling machine
- Part fixturing table equipped with a vacuum hold-down system and a retractable ball-transfer system
- 5 HP precision spindle (0–24,000 rpm) accepting tools up to 0.5 in. (outer diameter)
- Vacuum dust-collection system
- Liquid-free vortex compressed-air tool cooler
- Carbide cutting tools as small as 0.01 in. (outer diameter), suitable for metal, plastic, and wood
- Software suite including CAM and surface-generation programs
- Touch-trigger measurement probes and control software

Acoustic Communications Measurement Systems (ACOMMS)

Code 7160
(202) 767-2945
NRL, Washington, DC

Function:

Design and develop adaptive signal processing techniques to improve underwater acoustic communications and networking. Phase coherent and incoherent signal patterns are transmitted from NRL's acoustic projector source systems through the underwater medium to NRL's receiver systems. Improved signal processing techniques are developed and refined to minimize the bit error rate and to evaluate environmental influences on the processor's performance.

Description:

Our acoustic communications research systems enable our team to conduct experiments at frequencies from 3 to 60 kHz. Source signal patterns are designed by NRL, transmitted into the ocean medium, and received at distances out to 15 km. The received signals are processed in situ and recorded for post-experiment data processing. Acoustic Communications Data Storage (ACDS) buoy systems transmit at source levels up to 185 dB. For higher sound pressure levels, an acoustic projector mounted in our 4-ft V-fin towbody develops up to 200 dB. ACDS buoy systems include 8-element vertical line arrays with variable apertures. Our shipboard-based vertical array has a wide aperture of 16 elements and is deployed from a vessel at anchor. Relative position, speed, and depth of our projectors and receiver arrays are carefully controlled throughout the experiments. Impact of Doppler and signal-to-noise ratio on system performance is measured and algorithms developed to improve performance. Our ACDS systems are normally moored to the sea floor with the acoustic elements suspended in the water column. However, one ACDS system has been modified for attachment to a tow frame, and in this configuration it provides a near-ideal autonomous undersea vehicle (AUV) test platform. Each of the ACDS systems provides semi-autonomous operations for up to 78 hours.

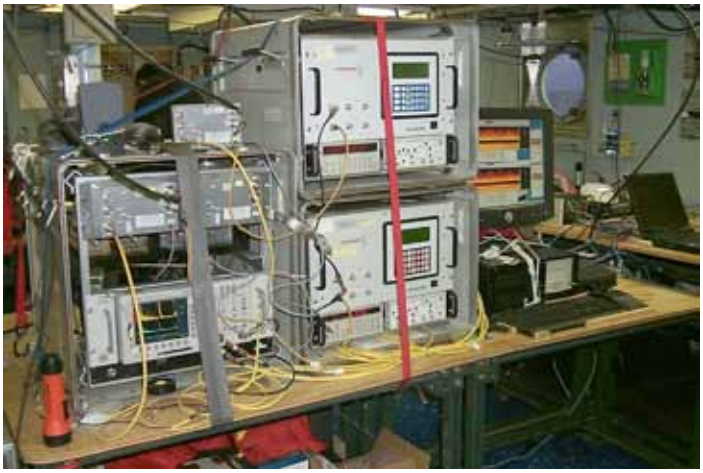
Custom-designed software is used for onboard data monitoring and signal processing. Back in the lab, advanced signal processing algorithms are applied to the recorded signals to extract the phase-encoded bit patterns and to improve communication accuracy.

Instrumentation:

- ACDS buoy systems include three deployed modem systems, a shipboard control station, and wireless local area network (WLAN) communication links. Each deployed modem system includes one acoustic projector (3, 10, or 20 kHz), eight hydrophones, 300 GB of data storage, and three computers. The systems can be moored to the ocean bottom or towed behind a surface vessel.
- Towed source systems include 3- and 4-ft V-fin towbodies mounted with acoustic projectors, driven by 2-kW power amplifiers.
- Shipboard-based receiver system includes a custom 16-channel hydrophone array, signal processing electronics, and data monitoring and data recording equipment.

High-Frequency Acoustic Flow Visualization (HFAFV) Sonar Systems

Code 7160
(202) 767-2945
NRL, Washington, DC



Function:

Flow visualization of fluid processes on the continental shelf, e.g., internal tides, ear instabilities, and nonlinear internal gravity waves (solitons).

Description:

Our HFAFV sonar systems are used to image the fluid processes that perturb the density/sound speed field in the littoral. A patented high-speed transmit-receive switch provides NRL with the receive sensitivity necessary to detect the small-amplitude signals backscattered from particulates and temperature/salinity variability associated with large density gradients in the thermocline. At the laboratory, the data are processed and analyzed with the objective of improving our understanding of the generation and propagation of internal waves and fine structure and their effect on the sound speed field.

Instrumentation:

Two similar systems, differing only in operating frequency:

(1) Matec PR5000 gated sine wave pulse generator and power amplifier, NRL-developed transmit-receive switch, custom-designed transducer (200 kHz)

(2) Matec PR5000 gated sine wave pulse generator and power amplifier, NRL-developed transmit-receive switch, custom-designed transducer (350 kHz)

Also, a personal computer–based data acquisition system, using off-the-shelf analog-to-digital converters and ISIS software from Triton Elics.

Instrumentation Suite for Acoustic Propagation Measurements in Complex Shallow Water Environments

Code 7160
(202) 767-3210
NRL, Chesapeake Beach, MD

Function:

Obtain at-sea measurements to test theoretical and modeling predictions of acoustic propagation in dynamic, inhomogeneous, and nonisotropic shallow water environments. The theories and models predict variations of signal amplitude, coherence, and travel time due to interaction of sound with small- to large-scale volume inhomogeneities within the water column and ocean sediment. The instrumentation suite provides calibrated measurements of these acoustic quantities in the frequency range 50 Hz to 20 kHz.

Description:

The multiple sources and receivers in this instrumentation suite allow measurement of acoustic propagation variability as a function of both time and range over horizontal and vertical apertures. The autonomous systems can operate in severe weather conditions since they have no sea-surface expression, while the RF telemetered receiver system can provide real-time information on acoustic propagation. The acoustic receiver systems each have an operational lifetime up to 20 days at a sampling frequency of 4 kHz. The operational lifetime for each acoustic source is ~25 days at 50% duty cycle. Clocks having rubidium-standard accuracy control all timing functions for the acoustic sources and receivers, including waveform synthesis and sampling of the received signals. This feature permits measurement of absolute travel time and its variations to better than millisecond accuracy and allows data from each of the autonomous receiver systems to be time-synced together for phase-coherent processing.

Instrumentation:

The instrumentation suite consists of several acoustic sources and receiver array systems, augmented by sensors to characterize the oceanographic environment. The current equipment suite is composed of two autonomous arbitrary waveform acoustic sources, two autonomous continuous-wave acoustic sources, three autonomous 32-element acoustic vertical line array receiver systems, one autonomous 96-element acoustic horizontal line array receiver system, and one 32-element RF telemetered acoustic vertical line array receiver system.

Autonomous Acoustic Receiver System

Code 7160
(202) 404-4826
NRL, Chesapeake Beach, MD

Function:

Collects underwater acoustic data and oceanographic data. Data are recorded onboard an ocean buoy and can be telemetered to a remote ship or shore station in real time. The system is configured for command-and-control and data download. It can operate unattended for periods of up to one month.

Description:

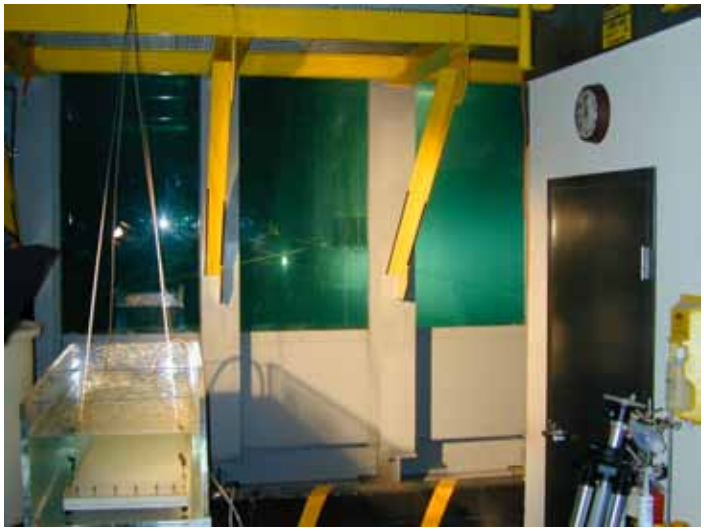
The heart of the Autonomous Acoustic Receiver (AAR) system is the data acquisition unit (DAU) containing the analog-to-digital converters for 64 channels at rates of up to 8192 samples per second. One 64-element or two 32-element acoustic receive arrays can be attached to this DAU. If used vertically, there is also capability to add four tilt/head/depth sensors spaced throughout the vertical array. Once digitized, the data are sent up a 2000-ft fiber-optic umbilical cable to a surface buoy, where they are stored on hard disk. The data can then be telemetered to another location. The line-of-sight link can also be used to send command-and-control information to the system.

Instrumentation:

- 16-bit, 64-channel DAU, 8192 sample per second
- 64-element, 1.25-m spacing acoustic receive array
- 32-element, 2.5-m spacing acoustic receive array
- 32-element, 5-m spacing acoustic receive array
- 2000-ft fiber-optic double-armored umbilical cable
- Battery-powered buoy with enhanced line-of-sight capability
- Command-and-control/data downlink station with GPS-linked steerable directional antenna (for remote ship or shore station).

Salt Water Tank Facility

Code 7160
(202) 404-4826
NRL, Wahington, DC



Function:

Provides a controlled environment for studying complex bubble-related processes found in the ocean. It is an experimental pool facility for studies of underwater acoustics, fluid dynamics, and air-sea interface environmental topics, under saline conditions. This facility is currently being used to study the acoustics of bubbly media.

Description:

The main salt water tank measures 20 ft × 20 ft × 12 ft high, with four 12 × 8 ft windows on each of the vertical walls. The water is recirculated every 10 h through particulate and UV filters, and the tank contains a high-capacity water chiller for controlling temperature. A separate chiller independently handles air temperature. Catwalks and a gantry provide access around and over the main tank, and a three-axis computer-controlled positioning system with four independent stages places and moves equipment within the tank. The tank is contained within a thermally insulated 50 × 26 ft laboratory area furnished with an overhead crane, a staging area, and a 20 × 10 ft room for instrumentation and data analysis.

Instrumentation:

- Acoustic sources, amplifiers, and hydrophones spanning 1 Hz to 700 kHz
- Environmental sensors to measure water temperature, salinity, dissolved gas concentrations, and surface tension
- Digital holographic imaging system to size particles down to ~5 μm
- Two high-speed digital cameras providing image acquisition up to 2000 full frames per second
- LabVIEW-based data acquisition system with laboratory-wide network access
- Brickwall filters, digital and analog oscilloscopes, data loggers, and power supplies.

Underwater Acoustic Time-Reversal Mirror

Code 7160
(202) 404-4826
NRL, Chesapeake Beach, MD

Function:

Records underwater acoustic signals and can time-reverse and rebroadcast these signals. This provides the ability to focus and scan acoustic energy for the detection of underwater objects. The signals can be emitted from guide sources or received in the form of ocean reverberation.

Description:

The heart of the system is a 64-element transducer array that can alternately operate as a receiver array or an array of acoustic sources. The time-reversal functionality involves the capability to record signals, reverse them in time, and then rebroadcast them. This provides, for example, the capability to have a received signal returned to its point of origin where it will focus in both time and space. The importance of the concept is that this can be accomplished without detailed knowledge of the complex multipath structure produced by the ocean waveguide. Applications include enhanced echos from target objects, such as submarines or ocean mines, and reduced clutter echos from the ocean bottom or ocean surface.

Instrumentation:

- 64 6-in. spherical source/receive elements in a linear array with 1.25-m spacing (78.75 m aperture)
- Array elements independently controllable over the 500 to 3500 Hz frequency band
- A data digitization and recording system
- A pressure vessel to enclose system electronics for bottom-moored deployment
- Fiber-optic umbilical cable for connection between pressure vessel and ship/surface buoy.

300-Hz and 500-Hz Autonomous Acoustic Sources

Code 7160
(202) 767-3210
NRL, Chesapeake Beach, MD

Function:

Provides acoustic researchers with autonomous, bottom-moored sound sources that provide precise, highly stable frequency transmissions at GPS-trackable times. The accuracy of the sources enables research into environmental perturbations of sound propagated through ocean media.

Description:

The equipment consists of two sources, one centered at 300 Hz and another at 500 Hz. Each source uses a pressure-compensated flexural bar projector. The sources have a bandwidth of ±10% about the center frequency. The accuracy of the transmit time and transmit frequency is controlled by a rubidium oscillator that can be disciplined to the GPS satellite system before deployment. The output level is adjustable with a maximum output of 183 dB. Pucks of D-cells contained in two pressure housings provide energy. The systems are rated to 200 m. A full complement of pucks allows the sources to operate for 21 days at a 50% duty cycle and output level of 181 dB. Each system has an internal rubidium oscillator, and PC-104 electronics for timing and frequency generation. The systems are capable of continuous-wave, frequency modulated (FM) waveforms and arbitrary pseudo-random waveforms. Waveform types can be mixed within a transmit schedule, being limited only by the projectors, available programmable system memory, and energy levels desired.

Instrumentation:

There are two independent systems. Each system consists of an EAI projector, Seascan signal generator/system, PC-104 electronics, and Webb Research assembly. One operates at 300 Hz and the other at 500 Hz. Each system includes a pressure-compensated projector, two pressure housings, and internal programmable electronics for transmit frequency and waveform, plus timing control.

Sediment Geo-Probe System

Code 7160
(202) 404-8620
NRL, Chesapeake Beach, MD

Function:

Provides wideband in situ measurement capability of compressional wave speed and attenuation and their spatial variability in marine sediments.

Description:

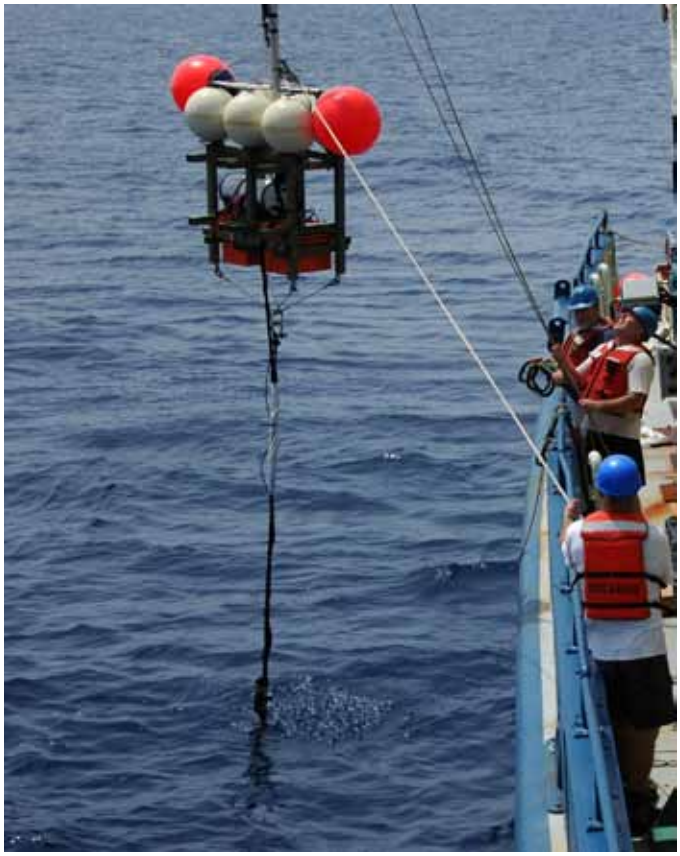
In situ ground-truth measurements of sound speed and attenuation are needed to validate geoacoustic inversion algorithms or high-resolution subbottom profiling techniques that are being used for bottom characterization. The wideband capability provides unique measurements of frequency dependency of sound speed and attenuation in various types of marine sediments. In addition, tomographic measurements of sediment sound-speed variability can be used to validate bottom scattering models. The system can be used to characterize large geological provinces in survey mode since the required measurement time per site is about 10 minutes.

Instrumentation:

The geo-probe system has four probes populated with 1-inch-diameter ring transducers (Channel Industries) and a data acquisition unit with networking capability. The data acquisition unit can be preprogrammed or controlled through a standard oceanographic CTD cable. Wideband pulses (3 to 150 kHz) are generated and recorded with a sampling rate of 1 MHz. The system can be deployed at depths up to 1500 m and probe lengths can be varied up to 2 m. The source and receiver arrays on each probe allow spatial variability measurements of compressional wave speed and attenuation by using acoustic tomography.

Drifting Echo Repeater

Code 7160
(202) 404-8620
NRL, Chesapeake Beach, MD



Function:

Supports low- to mid-frequency active sonar research for target detection and classification in littoral environments. Tests and validates new signal processing algorithms by using simulated targets with proper scattering kernels in multi-static configurations.

Instrumentation:

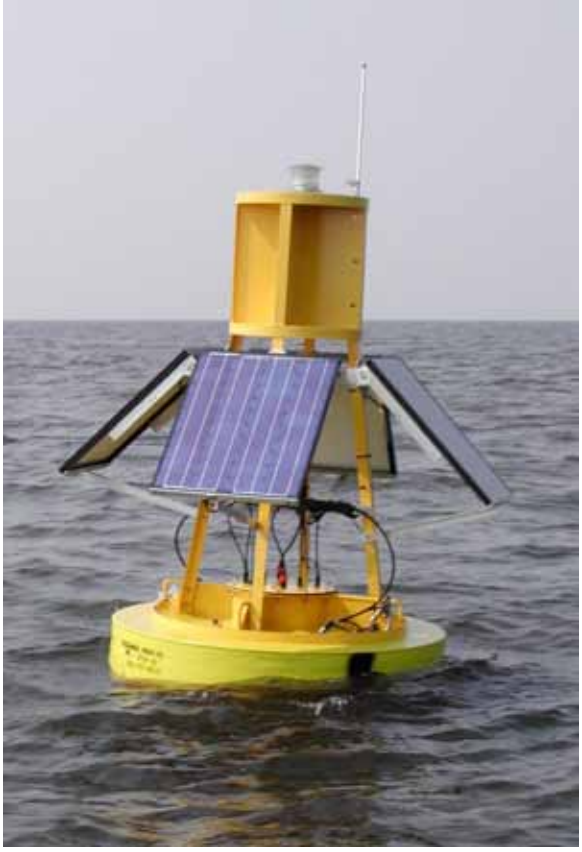
The drifting echo repeater system has a wideband (240 Hz to 20 kHz) acoustic source, an 8-element vertical line array, and an 8-element Mills-Cross horizontal array. Acoustic data are sampled at each channel with a 20 kHz sampling rate and monitored in real time by using a wireless local area network (WLAN). High-accuracy GPS positioning is used to track the drifting system location in real time.

Description:

The drifting echo repeater system is a research tool to simulate targets with predefined scattering characteristics. Its in-buoy signal processing capability provides flexibility to perform match-filtering, beamforming, and acoustic time-reversal in real time. Recently, it was used in mid-frequency (1.5 to 3.5 kHz) bistatic active sonar sea tests at ranges up to 15 km. The system can be used in drifting or moored configurations. The data storage and power budget provide two days of continuous recording of 16 channels and 10% duty-cycle sound transmission.

Shallow Water Ship Acoustic Signature System

Code 7160
(202) 404-8149
NRL, Chesapeake Beach, MD



Function:

Measures ship acoustic signatures in shallow water channels and at port entrances for detection and identification purposes. The system is the acoustics component of NRL's Modular Sensor System (MSS), which is designed to provide track information and local identification of vessels as they approach U.S. ports.

Description:

The system is composed of two components: a buoy with two acoustic barrier lines and a monitoring system on shore. The acoustic lines contain hydrophones to form a barrier stretching out from the central buoy. The buoy is solar powered but also contains a rechargeable battery pack capable of running the buoy for 1 to 2 weeks; this is inside the central well along with the buoy's electronics. The monitoring system is composed of a computer. Communications are by Ethernet-link radio. The system is composed totally of commercial off-the-shelf (COTS) components with the exception of the NRL-developed array interface electronics. The buoy system is capable of fully independent operation, including detection and acoustic data acquisition of passing ships. More frequently, the onshore monitoring system cues the buoy to acquire data based on information passed to it from the MSS. The hydrophone sensitivities, A/D gains, channel selection, sampling rate, and data acquisition period are all remotely programmable.

Instrumentation:

The COTS buoy includes a radar reflector and has an omnidirectional antenna and a self-powered strobe mounted on top. It is two-point moored to prevent twisting the acoustic lines. The lines are each 1 km long and have six hydrophones each. Inside the buoy's central well are power management, array interface, and A/D data acquisition electronics, a computer with a solid-state drive, an Ethernet-link radio, and the battery pack. The monitoring system is composed of a computer, a radio, and a directional antenna.

Sono-Magnetic Laboratory (SOMALab)

Code 7160
(202) 404-4826
NRL, Washington, DC

Function:

Conducts research on the interaction between arbitrarily directed magnetic fields and the motion of weakly conducting fluids under the influence of acoustic fields. This interaction causes an induced magnetic field capable of being detected with a flux-gate magnetometer.

Description:

The facility is a double-hull Faraday cage constructed from steel plate and beam of the very high magnetic-μ HY-80 steel. The experimental chamber, or inner room, measures 2.5 m × 2.5 m × 4.5 m and is connected by insulated 50-cm-diameter cylindrical waveguide conduit to an external acoustic source chamber that is electromagnetically isolated from the remainder of the facility. Acoustic signals are propagated through the waveguide conduit such that prescribed particle velocities are induced within a 1 m x 1 m x 2 m Plexiglas tank atop a vibration-damped optical bench at the center of the experimental chamber. A set of three-axis Helmholtz coils is used to control the direction and magnitude of magnetic field. Induced magnetic fields from the interaction between the mechanical vibration of a conducting liquid and the Helmholtz coils are detected on a magnetometer.

Instrumentation:

- High-μ HY-80 Faraday cage
- Acoustic source waveguide
- 1 m × 1 m × 2 m Plexiglas tank
- Non-magnetic vibration-damped optical table
- Flux-gate magnetometer
- Acoustic sources and amplifiers
- Filtration and refrigeration system for experimental fluid.

Fabrication Workshop

Code 7160
(202) 404-4826
NRL, Washington, DC

Function:

Supporting the laboratory-based work in Code 7160's various tank and experimental facilities, together with demands from at-sea testing, this facility provides a means for scientists to design and fabricate experimental components.

Description:

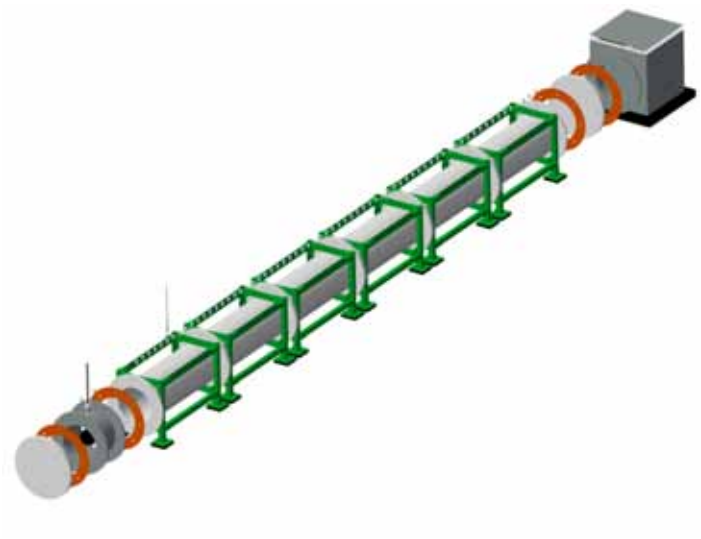
This is a small-scale facility readily available to research scientists experienced in experimental fabrication. A dedicated workstation can be used for component design, whereupon suitable CAM files can be generated and transferred to state-of-the-art fabrication machines. The two major components of this facility are a Haas Super Mini-Mill 2 with a vacuum chuck system, and an Objet Connex 500 3D printer capable of printing in a wide range of materials. For simpler work requiring a quick turn-around, standard manual machines are also available.

Instrumentation:

- Haas Super Mini-Mill 2
- Objet Connex 500 3D printer
- Dedicated workstation running AutoCAD
- Manual milling machine
- Manual lathe
- All other standard shop equipment

Low Freqency Sound Tube

Code 7160
(202) 404-4826
NRL, Washington, DC



Function:

Apparatus to experimentally characterize the acoustic properties of materials.

Description:

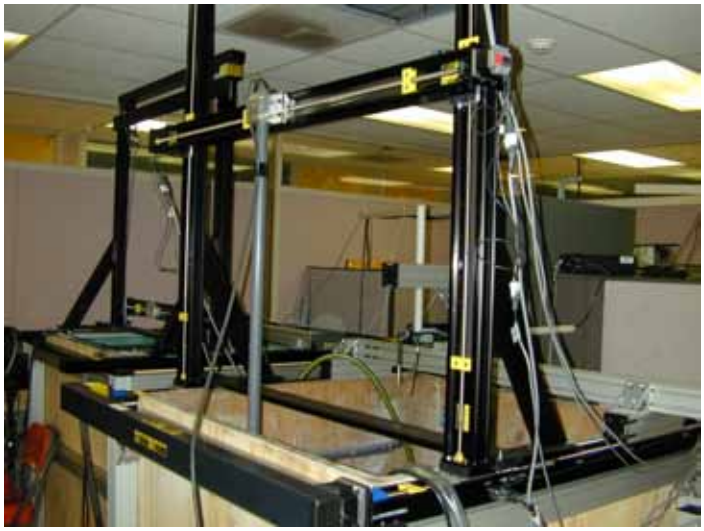
Sound tubes are a standard means of acoustically characterizing materials. A sample of the material is placed in the center of the tube, one end is insonified with an acoustic source, and the subsequent transmitted and reflected acoustic fields are measured with small probe transducers inserted down into the body of the tube at selected positions. The dimensions of sound tubes are commensurate with the frequencies of interest; this facility is unique in that it was designed and built with very low frequencies in mind. The sound tube has a circular cross section of 14-in diameter, is 6.7 m long, and has steel walls with a thickness of 1 in. End terminations of the tube are either reflective solid steel plate or a volume of acoustic absorber. The water within the tube can be de-gassed a priori with an external water heater, and further degassed in the tube itself with a vacuum pump. A series of access ports along the top of the tube provide insertion points for small probe hydrophones that can be slid in-and-out to any radial distance to measure the internal sound field.

Instrumentation:

- ITC-1001 4-in. spherical acoustic sound source
- ITC-1007 6-in. spherical acoustic sound source
- ITC-3001 8-in. planar directional acoustic sound source
- RESON TC-4013-1 miniature reference hydrophones
- RESON EC6061 VP1000 preamplifier modules

Measurement Laboratory

Code 7160
(202) 404-4826
NRL, Washington, DC



Description:

The Measurement Laboratory contains two 4-ft × 4-ft × 4-ft water tanks equipped with overhead X-Y-Y-Z positioning systems for precise equipment placement. Each tank is equipped with its own LabVIEW-based data acquisition system and can run independently. Small-scale acoustics experiments can be fully automated and left to run for extended periods of time.

Function:

Instrumented water tank facilities for small-scale acoustics experiments. Experiments can be fully automated.

Instrumentation:

- B&K 8103 and 8105 transducers for use as sources and receivers
- B&K 4939-A-011 free-field microphones with 2670 preamplifiers
- B&K NEXUS conditioning amplifiers
- SRS SIM910 amplifiers
- Frequency Devices 90PF high roll-off hi-lo-band-pass filters
- Velmex X-Y-Y-Z positioning systems
- Ultratek PCIAD1650 16-channel 50MHz ADC
- Ultratek PHA16T 16-channel phased board
- Function generators, digital oscilloscopes, power supplies, etc.

Shallow Water High-Frequency Measurement Systems

Code 7184
(228) 688-5235
NRL, Stennis Space Center, MS

Description:

These systems cover the 18 to 200 kHz frequency range. System control and data acquisition are carried by fiber-optic cables that terminate in a portable instrumentation van where the data are digitized and recorded on optical disks.

Instrumentation:

These systems include high-resolution source and receiver combinations that operate in shallow to very shallow (7 to 30 m water depth) coastal areas.

Function:

Supports a broad range of shallow-water high-frequency research programs, from acquiring a fundamental understanding of the physics of shallow-water propagation and boundary interactions to applied mine countermeasure and torpedo issues. The development of these systems has made NRL a leader in high-frequency shallow-water environmental acoustics research. Scattering and propagation measurements have been conducted in areas from the Gulf of Mexico to the Mediterranean. The data have been used in synthetic aperture sonar and torpedo simulations and design.

Remote Sensing Division

Naval Prototype Optical Interferometer (NPO)

Free Surface Hydrodynamics Laboratory

Optical Calibration Facility

Naval Prototype Optical Interferometer (NPOI)

Code 7210
(202) 767-0669
Lowell Observatory, Flagstaff, AZ

Function:

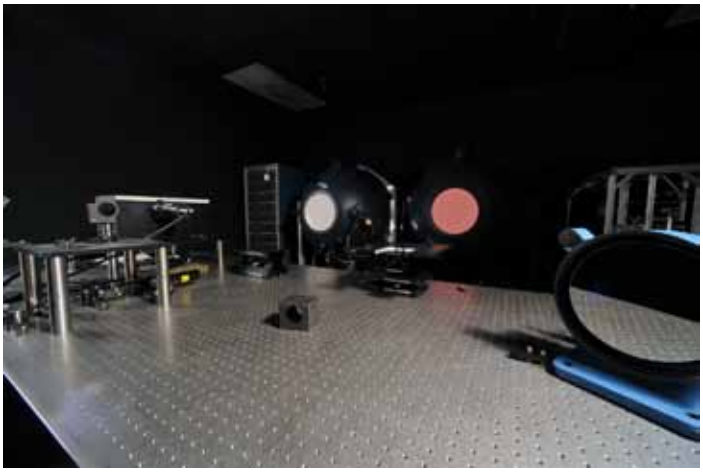
Used for astrometry and astronomical imaging, the Naval Prototype Optical Interferometer (NPOI) is a distributed aperture optical telescope. It is operated for astrometry by the U.S. Naval Observatory. Research into optical imaging and astronomical research is conducted by NRL.

Description:

The NPOI is a Y configuration of optical sidereostats. The inner fixed stations are used for astrometry while stations on the outer arms, out to an eventual separation of more than 300 m, are used for imaging stars. The stations are connected by vacuum beamlines. Fast delay lines in the main control building and long delay lines outside are used to adjust the optical phases to allow coherent combinations of up to six sidereostats.

Optical Calibration Facility

Code 7230
(202) 767-0949
NRL, Washington, DC



Function:

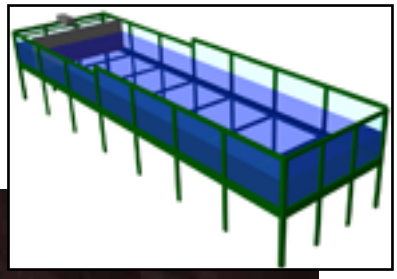
Establishes and maintains procedures for calibrating in-water radiometers, hyperspectral imagers, low-light imagers, and reflectance standards. Such calibration is needed for both research use of the sensors and to maintain traceability to National Institute of Standards and Technology (NIST) calibration devices and standards.

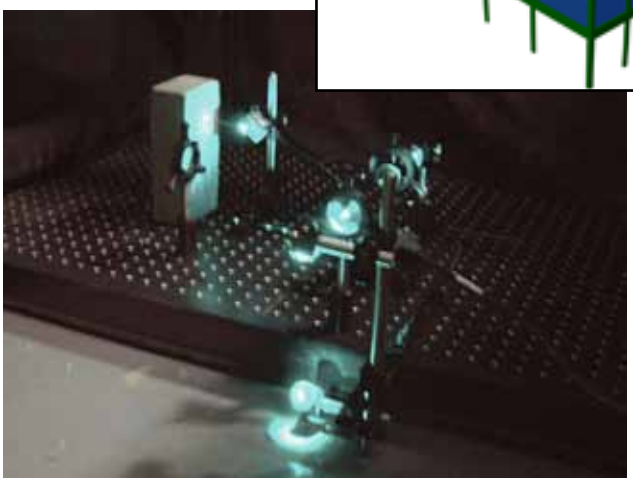
Description:

The facility consists of a precise optical bench with monochrometers, calibration lamps, and calibration spheres required to establish wavelength and intensity calibrations of spectral sensors and reflectance standards spanning the spectrum from the near UV through the short wave infrared (SWIR). It uses several integrating spheres tailored for the calibration of hyperspectral land and water imagers as well as low-light sensors. All components are cross-calibrated to a NIST Standard FEL lamp using a stable reference detector. The laboratory has participated in NASA “round-robin” comparisons of national ocean-color calibration facilities and has consistently yielded errors of less than 2%. It has been used to calibrate a variety of multispectral and hyperspectral sensors developed at NRL, academia, other government labs, and private industry. Most notably, it was used to calibrate the Hyperspectral Imager for the Coastal Ocean (HICO), which is the first spaced-based hyperspectral imager designed specifically for the coastal ocean, and has been operating on board the International Space Station (ISS) since September 2009.

Free Surface Hydrodynamics Laboratory

Code 7233
(202) 767-0501
NRL, Washington, DC





Function:

Investigates processes and interactions at the air-sea interface, and compares measurements to numerical simulations and field data. Typical phenomena of interest include breaking waves, subsurface turbulence, bubble dynamics, aerosol production, surfactant effects, and heat and gas transport. Special emphasis is placed on determining surface expressions of subsurface flows by using infrared methods.

Description:

The laboratory has a glass wall wave tank with dimensions 8.5 (L) × 2.3 (W) × 0.75 (H) meters, which is fitted with a computer-controlled wavemaker, turbulence generator, and towing carriage.

Instrumentation:

The lab is equipped with high sensitivity infrared cameras, a high speed video system, a particle image velocimetry system, and a Langmuir trough.

Oceanography Division

Ocean Sciences and Remote Sensing Research Facility

Environmental Microscopy Facility

Ocean Dynamics and Prediction Network

Ocean Color Facility

Real-time Ocean Observations and Forecast Facility (ROOFF)

Littoral Measurements Facility

Salinity Temperature and Roughness Remote Scanner (STARRS)

Field Staging Facility

Ocean Optics Instrumentation Systems

Autonomous Underwater Vehicle Laboratory

Ocean Sciences and Remote Sensing Research Facility

Code 7300
(228) 688-4670
NRL, Stennis Space Center, MS

Function:

A 52,000 ft^2 state-of-the-art building designed to house NRL's Oceanography Division, part of the Ocean and Atmospheric Science and Technology Directorate. The Oceanography Division consists of two branches: (1) Ocean Dynamics and Prediction and (2) Ocean Sciences. The division's mission is to develop oceanographic models of the ocean and littoral areas for operational use; investigate and describe the physical processes that couple and control the ocean; and develop capabilities to use remotely sensed data to describe and measure the oceanographic processes of the open ocean and littoral areas and the investigation of microbiologically influenced corrosion of military assets.

Description:

The building was designed for carrying out research into ocean processes. The laboratories, office spaces, and conference rooms are wired for high-speed computer networking within the building and to the DoD High Performance Computing (HPC) national network. The remote sensing laboratories also have direct access to selected satellite data streams.

Instrumentation:

The building contains an environmental scanning electron microscope with an energy dispersive X-ray detector; an Inspect S low vacuum scanning microscope coupled with an energy dispersive X-ray detector; a Quanta 3D 200i dual beam environmental scanning electron microscope with focused ion beam also coupled with an energy dispersive X-ray detector; an advanced seagoing instrumentation and calibration laboratory; a secure data processing laboratory; and a workstation network with multitiered storage area networks (SAN) based on performance and availability, totaling over 1 Petabyte of immediate and fault-tolerant RAID storage. The building's roof features receivers for the Ocean Color Monitor (OCM), Moderate Resolution Imaging Spectroradiometer (MODIS), and Visible Infrared Imaging Radiometer Suite (VIIRS) ocean color sensors, and NOAA polar orbiting satellites.

Environmental Microscopy Facility

Code 7303
(228) 688-5494
NRL, Stennis Space Center, MS

Function:

Provides high-resolution (5 nm) images and elemental composition (for elements heavier than sodium) of hydrated specimens, including biological materials. The facility is essential for demonstrating spatial relationships between microorganisms and substrata and for investigating biofouling, bioremediation, and biodeterioration.

Description:

The Environmental Microscopy Facility is equipped to examine the spatial distribution of micro-organisms in biofilms and their impact on microbiologically influenced corrosion, biomineralization, and bioaccumulation. The environmental scanning electron microscope focused ion beam (ESEM/FIB) coupled with an energy dispersive X-ray detector with a differential pumping system permits 2D examination of viable cells and precise mapping of associated elements. The ESEM/FIB has been used to determine failure mechanisms for welded stainless steels, fiber-reinforced polymers, coatings, sealants, and emulsifiers. The laser confocal scanning microscope provides a 3D examination of microbial substrata relationships. Addition of the Inspect S microscope enables examination of nonconducting samples.

Instrumentation:

- ESEM/FIB equipped with an energy-dispersive X-ray detector and an image acquisition and archive system
- Laser confocal scanning microscope
- Inspect S low vacuum scanning electron microscope.

Ocean Dynamics and Prediction Network

Code 7320
(228) 688-4870
NRL, Stennis Space Center, MS

Function:

Provides general-purpose computer services to branch personnel for program development, graphics, data processing, storage, and backup. Provides network connectivity to other Navy sites, to the DoD High Performance Computing centers, and to the Internet. The computational system enables leading-edge oceanographic numerical prediction research applicable to Navy operations affected by environmental variations at scales of meters to hundreds of kilometers and time scales of seconds to weeks.

Description:

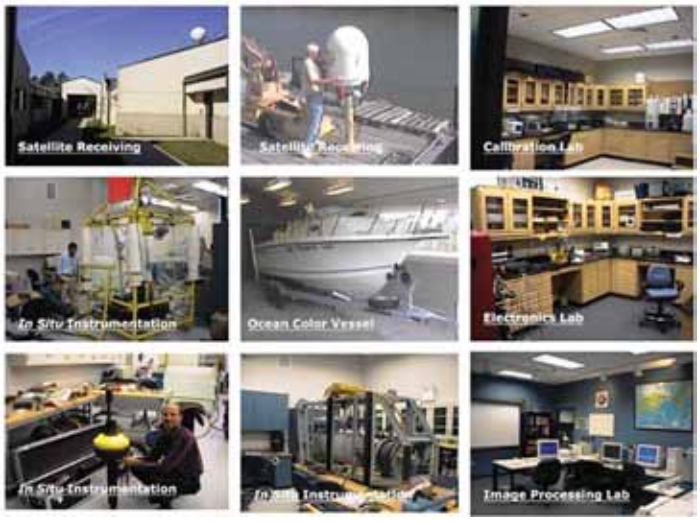
The computational facilities comprise more than 200 UNIX-based computers, over 60 of which are in a parallel grid engine. Additionally, the infrastructure contains more than 100 Windows-based systems. The core network is supported by Linux and Sun Microsystems servers, interconnected via redundant gigabit Ethernet and 4-gigabit fiber channel switches, using the latest technology at both the operating system and network layers. Ten-gigabit outside network connectivity between buildings hauls the aggregate traffic. Backups are performed on site using another tiered solution, a robotic tape library. Outside access is provided by real-time adaptive firewalls and RSA SecurID and CAC authentication mechanisms.

Instrumentation:

- Intel Core I7 and AMD Opteron workstations, Dell Xeon compute and file servers
- Workstations and servers collectively host over one Petabyte of disk storage
- Quantum I2K robotic tape library, 5 LTO4 drives and 744 LTO4 tapes, over 500 Terabytes uncompressed capacity

Ocean Color Facility

Code 7330
(228) 688-4733
NRL, Stennis Space Center, MS



Description:

The laboratory is currently a VIIRS, OCM, and MODIS receive site for real-time data capture and processing of ocean color imagery. Additionally, over 215 GB of satellite imagery is processed daily for areas around the world to support experiments. Real-time ocean color products are used for ship sample collection experiments and integrate with ocean models and forecast systems. These data are used for the development, tuning, and validation of advanced algorithms relating spectral signatures to ocean properties and processes.

Instrumentation:

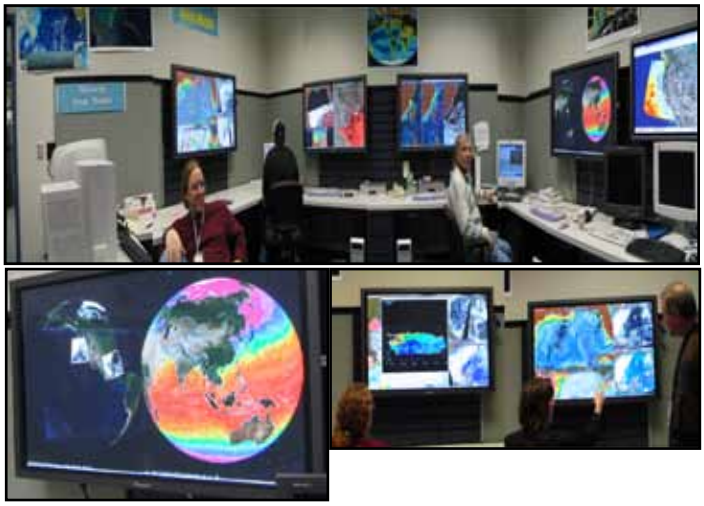
The laboratory has both fixed and shipboard antenna systems to support global experiments. It maintains SAN and Linux clusters and an archive of 200 TB of satellite imagery. The laboratory also maintains advanced at-sea instrumentation and operates a calibration laboratory specializing in bio-optical properties and coastal ocean color. Facilities include spectral absorption, scattering, and reflectance measurement systems, laboratory spectrometers, optical gliders and moorings, and a flow cytometer.

Function:

Maintains a state-of-the-art image processing, instrumentation, and satellite receiving capability. The laboratory is developing advanced algorithms for space and aircraft ocean color sensors (SeaWiFS, MODIS, AVHRR, VIIRS, MERIS, OCM, GOCI, HICO, and CASI).

Real-time Ocean Observations and Forecast Facility (ROOFF)

Code 7330
(228) 688-5587
NRL, Stennis Space Center, MS



Function:

Provides the capability to visualize "ocean weather" for selected ocean regions. The collection of satellite observations with numerical circulation models is visually animated using daily update of observations systems combined with current ocean conditions derived from numerical models. The ROOFF presents monitoring and ocean tracking for physical and bio-optical conditions. This facility supports Navy programs and experiments by visually assembling new ocean products.

Description:

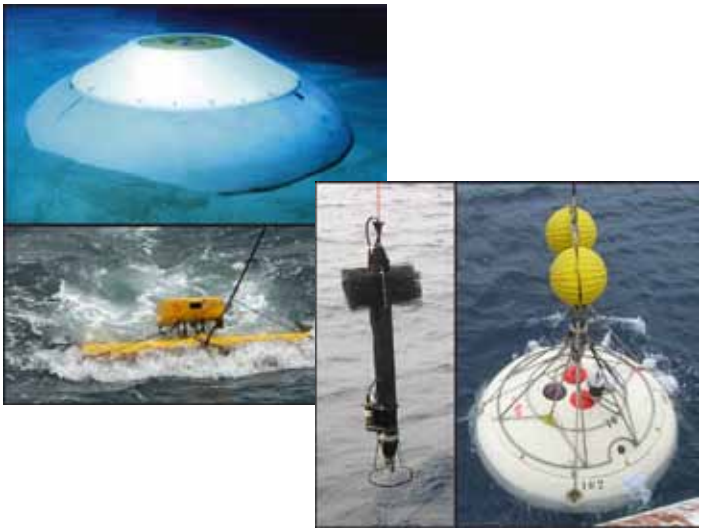
New satellite bio-optical and thermal ocean products are fused with different numerical models of physical properties to define the nowcast and forecast of ocean conditions. The ROOFF hosts the visualization of both the 2D and 3D ocean conditions for areas in which NRL experiments are being conducted (Gulf of Mexico, South Pacific, U.S. West Coast). The ROOFF provides a forum to determine integration of observations and models. The data fusion enables visual testing and validation of ocean products.

Instrumentation:

The ROOFF provides multiple large interactive display systems with specialized visualization software allowing scientists to interact with real-time data from satellites, models, and in situ data. These display systems are linked with the Division's computer systems and updated in real time.

Littoral Measurements Facility

Code 7332
(228) 688-4734
NRL, Stennis Space Center, MS



Function:

Barny units measure ocean currents and sea surface heights on continental shelves and in ocean straits. SEPTR units are similar to Barnys but also record temperature and salinity (TS) profiles and transmit the data in near real time via satellite. The VMP500 is a vertical microstructure turbulence profiler for the measurement of dissipation-scale turbulence in oceans and lakes up to 500 m in depth. The ScanFish MKII is a towed undulating vehicle system for collecting 3D TS profile data of the water column.

Description:

Each Barny consists of a circular outer cement ring for ballast and impact protection, a buoyant main instrument housing, and a pop-up float. Each is equipped with an acoustic Doppler current profiler (ADCP) and wave/tide gauge. The pop-up float that contains the ADCP surfaces on an acoustic command, bringing with it a line for recovering the rest of the unit. Barnys are highly trawl-resistant. They were developed through a cooperative agreement between NRL and the NATO Undersea Research Centre (NURC). SEPTRs contain an additional pop-up float and record temperature, salinity, and optical parameters in addition to current profiles and pressure. The VMP500 is a free-falling probe that takes measurements on a downward trajectory and is capable of measuring full-depth profiles of thermal and kinetic energy dissipation rates, in addition to CTD and velocity fine structure in oceans and lakes. It is lightweight and deployable from small boats. The EIVA ScanFish MKII is a wing-shaped hydrofoil that “flies” through the water with ascent/descent controlled remotely; it is designed for high-speed data collection at either a fixed depth/altitude or on a preprogrammed undulating flight path. This allows for efficient and rapid 3D mapping of mesoscale oceanic features down to 400 m depth with scales ranging from about one meter to many tens of kilometers.

Instrumentation:

Each Barny hosts an RDI ADCP and Sea-Bird 026 wave/tide gauge. Each SEPTR contains a CTD, optical sensors, ADCP, and wave/tide gauge. The VMP contains a pressure sensor, 3-axis, high-accuracy accelerometer, SPM-38-1 shear probes, FP07-38-1 fast thermistors, SBE7-38 microstructure conductivity sensor, and SBE-3F/SBE-4C temperature and conductivity sensors. The ScanFish incorporates a Sea-Bird CTD and can host a variety of fast-response temperature and conductivity sensors and standard optics packages that include sensors such as the AC9, BB3, FL3, and transmissometer.

Salinity Temperature and Roughness Remote Scanner (STARRS)

Code 7332
(228) 688-5487
NRL, Stennis Space Center, MS

Function:

Provides spatially continuous high-resolution surface salinity imagery in a synoptic manner from small aircraft. Its output complements data collected from ship-based and moored systems, puts those data sets into synoptic context, and provides key information for assimilation into predictive models of physical fields including currents, temperature, salinity, and sound speed in the littoral and open oceans.

Description:

STARRS is an imaging sensor that provides complete areal coverage of surface salinity in a swath twice as wide as the aircraft's altitude. The swath is resolved into six cells, and swaths can be quickly flown adjacent to each other. STARRS includes advanced primary and secondary measurement components to assure salinity retrieval with total noise levels less than a few tenths of one practical salinity unit (psu) under a wide range of environmental conditions. The dominant force driving currents in the littoral is due to density differences between water masses. These are caused by the flux of low salinity waters from bays and rivers to the coastal zone, and the contrasts between shelf and open-ocean waters. Similar contrasts drive large-scale open-ocean currents. STARRS' capabilities allow researchers to routinely obtain high-resolution imagery in a synoptic fashion.

Instrumentation:

In the photograph, STARRS is shown mounted to the underside of a Piper Navajo twin engine airplane. In the center is the 1-m-square multibeam 1.4 GHz L-band radiometer; it is based on a low-noise microstrip patch antenna for the primary salinity/brightness/temperature measurement. At left is a two-channel split-window infrared (IR) radiometer for sea surface temperature. At right is a single-beam multichannel C-band radiometer for estimates of sea surface roughness. The IR and C-band secondary subsystems provide useful oceanographic information in their own right, in addition to being key inputs for the retrieval of salinity from the primary L-band system.

Field Staging Facility

Code 7332
(228) 688-4734
NRL, Stennis Space Center, MS

Function:

Facilitates routine maintenance for NRL seagoing measurement systems: ocean current (Barny, SEPTR); ocean temperature and salinity (Scan-Fish); ocean turbulence (VMP), and airborne salinity (STARR). This facility is equipped with high-precision machinery, calibration chambers, and electronic equipment to adjust, repair, and assemble mechanical and electronic components of the systems.

Description:

To achieve a consistently high level of data quality from field experiments, seagoing measurement systems are required to endure harsh marine environments and to operate with their designed measurement capability throughout the deployments. This requires continuous maintenance efforts including calibrations, adjustments, tunings, modifications, and storage for electronic and mechanical components of various seagoing systems during the pre- and post-deployment stages. These functions are conducted in this facility, which consists of an electronic assembly and readiness lab, machine and welding lab, sensor calibration lab, 1500 ft^2 experiment staging area (high-bay), and temperature-controlled storage center. The facility is essential for maintaining the readiness and integrity of the NRL measurement systems.

Instrumentation:

- Bridgeport vertical milling machine; Tradesman bandsaw
- MIG-TIG welding machine (Shopmaster 300)
- Nardini Mascote MS-1440 precision lathe
- 2-ton Presto PSTA2107 pallet stacker
- 2-ton overhead monorail crane.

Ocean Optics Instrumentation Systems

Code 7333
(228) 688-5257
NRL, Stennis Space Center, MS

Description:

The ocean surface photic region is of prime interest to the Navy and NASA as it relates to ocean color from satellite and biological application in numerical modeling. Recently, small, lightweight packages have been developed for use in near-shore coastal waters. NRL also maintains capabilities for open-ocean measurements, airborne remote sensing, and airborne expendable optical systems.

Function:

Provides instrumentation suites for a wide variety of measurements to characterize the ocean's optical environment. These packages have been developed to measure optical characteristics from the bioluminescent potential, optical turbulence, and biological/particle identification of the depths to the radiometric properties of the sea surface.

Instrumentation:

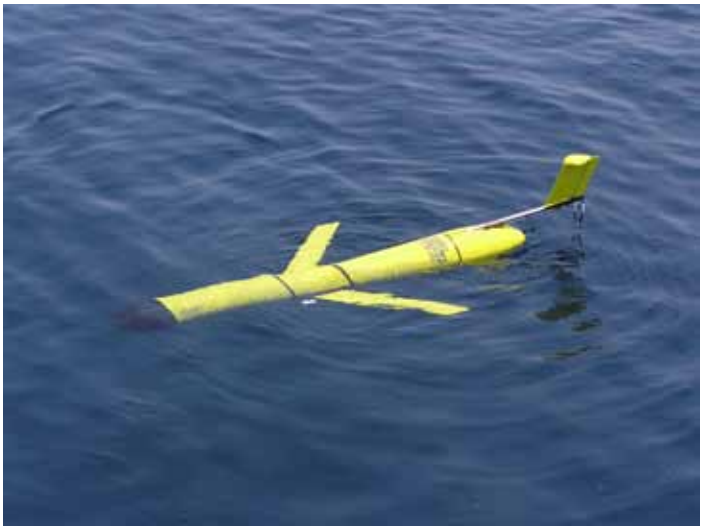
Measurements of the inherent optical properties of attenuation, absorption, and scattering are routinely performed in the field, in addition to the measurement of the apparent radiometric quantities of radiance and irradiance. Instruments include WETLabs AC9 (nine wavelength attenuance and absorption meters); WETLabs ECOVSF and VABAM (angular dependent scattering); Satlantic SPMR (SeaWiFS wavelength radiance and irradiance profiles); Satlantic HTSRB and K-Chain (near-surface hyperspectral near-surface light field); HYDEX (bioluminescence potential); WETLabs SAFire (multiple wavelength); SeaTech CHL a fluorometers; and ASD radiometers (surface-leaving radiance and reflectance).

New capabilities include a large Rayleigh Bénard convective tank to provide a controlled environment capable of generating turbulent microstructures at various repeatable intensities that enables the Oceanography Division to study optical turbulence and a state of the art flow cytometer, Cytosense, that enables NRL Scientists to examine individual phytoplankton and zooplankton in the field that enhances the capability of predicting the acoustical and optical environment.

The integration of these instruments into oceanographic measurement packages and data acquisition systems is an ongoing process at NRL's Ocean Optics facility.

Autonomous Underwater Vehicle Laboratory

Code 7332
(228) 688-4734
NRL, Stennis Space Center, MS



Function:

Studies coastal ocean processes with autonomous underwater vehicles (AUVs). Maintains, tests, ballasts, and prepares for deployment the Slocum Electric Glider AUV built by Webb Research Corporation. Slocums are designed to independently perform wide-area ocean surveys of temperature and salinity for up to about one month.

Description:

Slocum gliders are equipped with temperature/salinity/pressure sensors and with real-time satellite connection to the Iridium network. These gliders, unlike conventional AUVs, have no active propulsion system and instead rely on a battery-induced change of buoyancy and active control surfaces to glide through the coastal ocean from the surface to the bottom and from the bottom to the surface in a sawtooth pattern. This system requires low amounts of power and, therefore, the gliders do not need to carry heavy battery payloads and can be deployed over long-duration missions (>30 days). An altimeter is used to prevent bottom collisions. Two-way communication of data/instructions occurs through Iridium satellite or freewave radio when the gliders are on the ocean surface. The central payload of the gliders can be equipped with various instruments for ocean measurements. The coastal gliders can dive to 200 meters depth.

Instrumentation:

A Slocum glider typically carries an altimeter and a Sea-Bird CTD (temperature, salinity, and depth) as part of a fundamental sensor faculty. Vertically averaged current velocity can be calculated using the difference of the actual glider track with the programmed track and surface current velocity can be calculated using the consecutive GPS fixes while at surface. Additional sensors include Wetlabs BB3 (optical backscattering), FL3 (fluorescence), and AUVB (total volume scattering).

Marine Geosciences Division

Transmission Electron Microscopy Facility

Sediment Physical and Geotechnical Properties Laboratory

Marine Biogeochemistry Laboratory

Computed Tomography Scanning Facility

Digital X-Radiography Scanning Laboratory

Sediment Core Laboratory

Sediment Dynamics Laboratory

Moving-Map Composer Facility

Geospatial Services Laboratory

Transmission Electron Microscopy Facility

Code 7430
(228) 688-5011
NRL, Stennis Space Center, MS

Function:

Performs basic and applied research in areas of marine geosciences, geophysics, physics, and microbiology using microanalytical techniques.

Description:

The Transmission Electron Microscopy Facility has unique instrumentation in its environmental cell transmission electron microscope (EC-TEM) system. The EC is of the closed-cell type and is fully computer-controlled. Unlike EC systems based on the principle of differential pumping, closed-cell EC systems require no modification to the TEM. Confinement of the pressurized environment within the EC is achieved with electron-transparent windows. Since the EC is self-contained within the specimen holder, the TEM can still be used for conventional transmission electron microscopy using conventional specimen holders without compromising resolution and analytical capabilities.

Instrumentation:

The facility has a 300 kV JEOL JEM-3010 transmission electron microscope equipped with an energy-dispersive X-ray spectrometer (EDXS), a Gatan Model GIF200 (Gatan Imaging Filter) for energy-filtered imaging and electron energy loss spectroscopy (EELS), and scanning coils for scanning TEM mode. This TEM has a state-of-the-art environmental cell system with two interchangeable EC specimen holders. The center is also equipped with a 100 kV Hitachi H-600 TEM.

Sediment Physical and Geotechnical Properties Laboratory

Code 7430
(228) 688-5011
NRL, Stennis Space Center, MS

Function:

Provides instrumentation and expertise for geotechnical characterization of sediments of all types and origins.

Description:

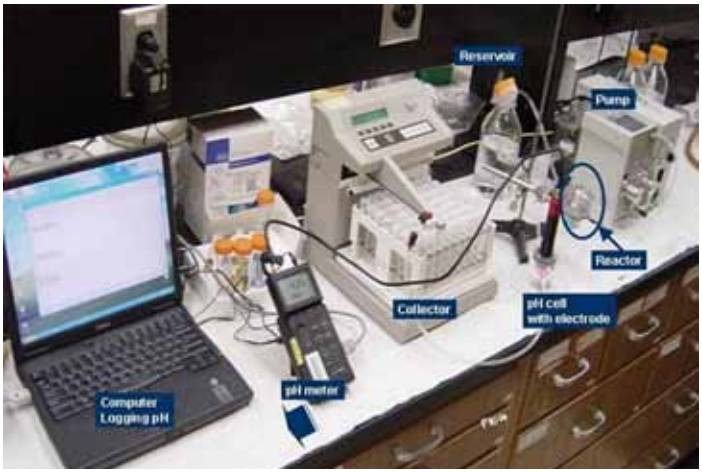
Equipment allows for investigations of strength, deformational, and pore pressure response properties of a variety of sediment types. These include uniaxial compressibility, consolidation and creep effects, uniaxial and triaxial strength and deformation properties, viscous and other effects that depend on the rate of deformation and flow.

Instrumentation:

Triaxial testing devices, including displacement-controlled and load-controlled systems, oedometers, rheometer, variable-rate vane shear device, drying oven, high-temperature furnace, liquid and plastic limit and hydrometer testing equipment.

Marine Biogeochemistry Laboratory

Code 7430
(228) 688-5474
NRL, Stennis Space Center, MS



Function:

Provides instrumentation and expertise for biogeochemical characterization of aquatic sediments.

Description:

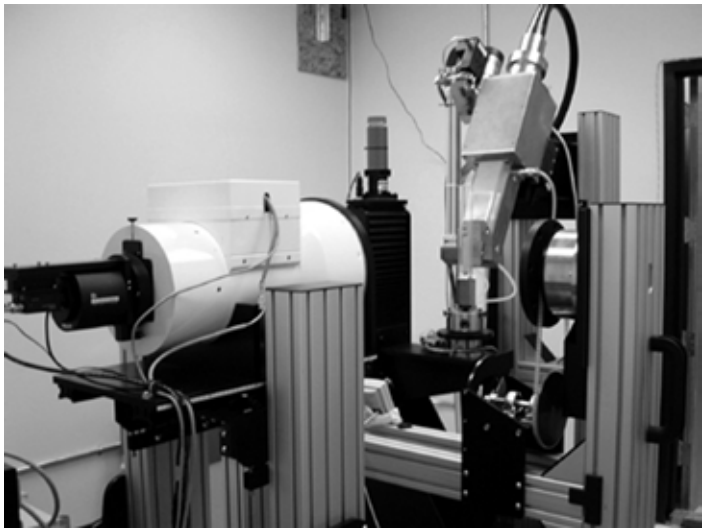
Benthic mesocosms are used to simulate littoral seabed environments for the analysis of redox gradients in burrowed sediments. A miscible-flow reactor is used to investigate the reaction kinetics of a variety of mineral-microbe-water interactions. Spectrophotometers are used to analyze aqueous samples for the concentrations of dissolved species. Molecular biology systems are used to determine mechanisms for microbe-mineral interactions and microbial diversity in aquatic sediments. The Zetasizer is used for nanoparticle characterization.

Instrumentation:

A heparin agarose affinity chromatography (HAAC) spectrophotometer, UV spectrophotometer, molecular biology systems (gel electrophoresis, electroporation, and RNA/DNA hybridization), inductively coupled plasma (ICP) spectrometer, ion chromatograph, Zetasizer NanoZS with titrator, and an anaerobic chamber. A miscible-flow reactor with attached ancillary equipment (see above), centrifuges, and benthic mesocosms.

Computed Tomography Scanning Facility

Code 7430
(228) 688-5473
NRL, Stennis Space Center, MS



Description:

The Computed Tomography (CT) Scanning Facility has the capability to produce high-quality fine-scale images of Navy relevant materials. This capability is equivalent to that of the synchrotron laboratories (~10 µm resolution for 1-cm-diameter earth materials). Additionally, this facility can accommodate small to large samples (5 mm to 9 cm diameter with the HD-500). This facilitates the evaluation of similar systems at many scales, in a relatively short period of time. Furthermore, this facility promotes experiments that require weeks to months, so that processes that occur in dynamic systems over extended time periods can be evaluated (e.g., growth and migration of gas bubbles in mud, drainage/imbibition of water from/into beach sand, and evolution of stratigraphy in response to bioturbation). In these cases, the samples are perturbed (physical conditions are altered), allowed to equilibrate, and then CT-scanned.

Function:

Advances research in the areas of marine geosciences, geotechnical, civil, and chemical engineering, physics, and ocean acoustics by using high-resolution, volumetric, X-ray imaging.

Instrumentation:

The CT facility operates an HD-500 Micro-CT System equipped with a microfocus X-ray tube that operates from 10 to 225 kV and 0 to 3 mA. This state-of-the-art industrial CT enables the production of images with 10 µm resolution for appropriately sized materials. The housing for this system is open, so that large systems (e.g., acoustic impedance tubes, permeameters, compression testers) can be used in conjunction with the CT system. In addition to the high-resolution CT system, the facility is equipped with a Picker Medical CT scanner, which operates at energies to 150 kV, can accommodate large diameter samples (up to ~0.75 m in diameter), and is housed in a portable trailer, making the system useful for field experiments. In each case, the energy spectrum is polychromatic.

Digital X-Radiography Scanning Laboratory

Code 7430
(228) 688-5011
NRL, Stennis Space Center, MS

Description:

The Faxitron 48-in. Cabinet Model 43855C with EZ40M digital line scanner is a fully automated, computer-controlled X-ray system that provides digital X-radiographic images without the need to develop X-ray film, although film can still be used if desired. The cabinet has been customized with ports or tub enclosures on either side to accommodate large core samples approximately 3 meters in length. The system operates with a 130 kV X-ray source and images are automatically imported into a PC desktop system using iX-Pect EZ software.

Function:

Generates digital X-radiographic images of sediment cores that portray density variations, sediment stratigraphy, bioturbation, and inclusions.

Sediment Core Laboratory

Code 7430
(228) 688-5011
NRL, Stennis Space Center, MS

Description:

The multisensor core logger measures profiles of compressional wave velocity, wet-bulk density (by gamma-ray attenuation), electrical resistivity, and magnetic susceptibility directly, and acoustic impedance and porosity indirectly. Sediment cores are opened for visual classification, measurement of undrained shear strength via miniature vane and torvane, and subsampling for physical properties tests. Grain-size analyses for coarse sediments are performed by settling tube or standard sieve analysis, and silt and clay particle size distribution is analyzed by the Micromeritics SediGraph. Average grain densities are measured via gas pycnometry using a Quantachrome Penta-Pycnometer.

Function:

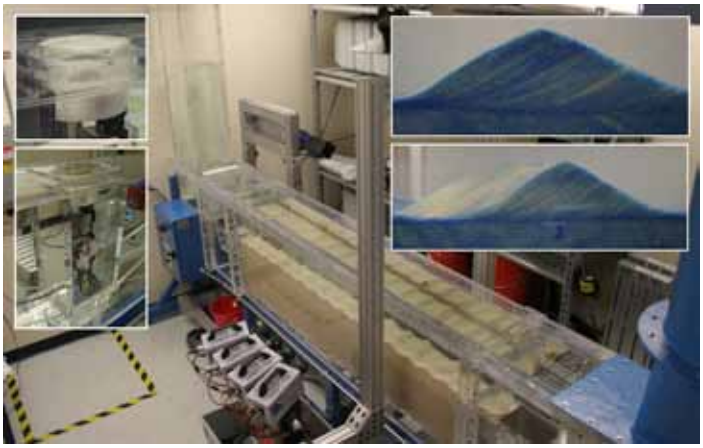
Provides instrumentation and expertise for physical and geoacoustic characterization of marine sediments.

Instrumentation:

A Geotek multisensor core logger, LABCONCO bulk tray freeze dryer, digital macro- and microphotographic imagery systems, and geotechnical testing instrumentation that includes miniature vane shear and torvane, uni- and triaxial consolidation instruments, geoacoustic Hamilton frame, relative density shaker table, and Quantachrome Penta and Ultra pycnometers. Sediment textural analyses are performed using sieves, pipette analysis, an instrumented settling tube, and a Micromeritics SediGraph, Model 5120.

Sediment Dynamics Laboratory

Code 7434
(228) 688-4435
NRL, Stennis Space Center, MS



Description:

The facility is used to perform basic and applied research focused around the physical, mechanical, and acoustical properties of seafloor, estuarine, and riverine sediments. We use a flow tunnel to generate prototype fluid velocities in the presence of natural and synthetic sediments to study fine scale processes in geophysical multiphase flows. We image fluids and sediments with high temporal and spatial resolution.

Function:

Designed to study fluid-sediment processes resulting from oscillating and steady current interactions that include formation of strata during sand ripple migration (right insets) and critical erosion of cohesive sediments (left insets).

Instrumentation:

The facility houses a flow tunnel to generate oscillating flows and steady flows with maximum combined velocities up to 80 cm/s. An electromagnetic current meter inserted in the return flow pipe measures the discharge rate. The oscillating water level is monitored with a novel sensor that provides 0.8 mm accuracy at up to 1000 Hz sampling. The flow tunnel is equipped with 6 temperature probes to monitor fluid and sediment temperature. The main channel cross-section is 25 cm × 25 cm with a 2-m-long test section that contains a 35-cm-deep sediment well. A false floor is used to investigate wall bounded flows and an additional false floor contains an apparatus with a stepper motor capable of vertically positioning a sediment core to 0.1 mm accuracy. Four high speed video cameras are used in conjunction with a high repetition dual cavity Nd:YAG laser (532 nm) to perform particle image velocimetry (PIV) with 100 Hz sampling in planar, stereo, dual-stereo, or tomographic modes. A 2-m articulating arm is used to guide laser light with both sheet optics and volume optics available for illumination. A new profiling acoustic Doppler velocimeter measures three-dimensional velocity components with 1-mm spatial resolution at up to 100 Hz sampling across a 3.5-cm reach. An array of acquisition and processing computers are available and the facility presently houses over 50 TB of data storage.

Moving-Map Composer Facility

Code 7440
(228) 688-4611
NRL, Stennis Space Center, MS

Function:

Develops, tests, and transitions software and algorithms to perform database design, data compression, change detection, data fusion, archival, retrieval, and display. Demonstrates and evaluates prototype and next-generation digital moving-map capabilities, map design systems, and mission planning systems.

Description:

The Moving-Map Composer (MMC) Facility is a 32 × 30 ft laboratory. The facility is divided into five primary work areas to support the principal functions of the MMC team:

- Research into data compression and database design
- Research and development of automated algorithms for change detection and object identification
- Development and transition of mission-specific aircraft optical disks for F/A-18 and AV-8B platforms
- Software and algorithm development in support of Naval mission and map planning
- Developing, testing, prototyping, and demonstrating parallel processing techniques to improve efficiency of existing bathymetric data processing systems.

Instrumentation:

The MMC Facility includes multiple computer platforms running Unix, Linux, Windows NT, and OpenVMS operating systems.

Geospatial Services Laboratory

Code 7442
(228) 688-4995
NRL, Stennis Space Center, MS

Function:

To process, store, and disseminate geospatial data to the Department of Defense and other Federal agencies.

Description:

The Geospatial Services Laboratory serves as the primary datacenter for the NRL Geospatial Science and Technology Branch. It provides 36 racks of computer space with 160 kW of power backup and 300 kW of generator power for current and future IT infrastructure needs. The lab currently operates several key systems including a high-memory compute cluster with 1024 processors, eight Terabytes of memory with ten Gigabit Ethernet networking and a 288 Terabyte high performance storage system. The lab hosts a General Purpose computation capability on Graphical Processing Units (GPGPU) cluster capable of a theoretical maximum of 16 trillion floating-point operations per second. The Geospatial Services Laboratory is designed with R&D in mind; the space is equipped with servers running virtualization software enabling administrators to quickly deploy server and desktop systems to respond to researcher needs. It has been used extensively for R&D testing and geospatial data processing supporting the U.S. Navy, Marine Corps, and intelligence agencies. The lab currently operates an unclassified website on behalf of the National Geospatial-Intelligence Agency that has been used in disaster relief efforts and data services supporting the 2010 Haiti earthquake relief effort, the Deepwater Horizon oil spill cleanup, and the 2011 Japan tsunami. The lab has been relied upon for various U.S. military and intelligence community operations, including providing geospatial web services and data processing capabilities for the 2012 London Olympics and supporting various exercises with Web services and field-deployed portable server racks. Currently, the space is only at approximately 35% of its maximum capacity, enabling this data center to grow to address future needs of the branch and division.

Instrumentation:

Overall, the space currently contains more than 150 servers with 2032 processors, 7680 GPGPU processor cores, more than 12 Terabytes of total memory, and approximately 1.1 Petabytes of storage.

Marine Meteorology Division

Meteorological and Oceanographic (METOC) Research Library

Satellite Data Ingest and Processing System

Meteorological Archival Facility

Environmental Prediction System Development Laboratory

Mobile Atmospheric Aerosol and Radiation Characterization Observatory (MAARCO)

Meteorological and Oceanographic (METOC) Research Library

Code 7501
(831) 656-4738
NRL, Monterey, CA

Function:

This on-site library provides researchers with complete library functions with emphasis on meteorology and oceanography. Copies of scientific texts, reference books, and journals are on hand for the research needs of NRL and Fleet Numerical Meteorology and Oceanography Center (FNMOC) scientists. Interlibrary loans and online library access functions are also provided by the library.

Description:

This on-site library maintains current and past copies of most U.S. and many international journals dedicated to the atmospheric, oceanographic, and computational sciences; copies of NRL and FNMOC technical reports and memoranda; and several reference books and hundreds of scientific texts in the mathematical, physical, and Earth sciences. The facility also provides quiet reading and work areas, and online access to the Ruth H. Hooker Research Library, located at NRL's main site in Washington, DC. NRL Monterey scientists are frequent users of the InfoWeb gateway, which provides online access to a large number of journals and other publications.

NRL Monterey shares the scientific library with FNMOC. The library contains many well-known historical and contemporary books on meteorology and oceanography. The library also serves as a repository for a number of internal technical publications, including technical reports from the laboratories that preceded NRL, namely the Naval Environmental Prediction Research Facility (NEPRF) and the Naval Oceanographic and Atmospheric Research Laboratory (NOARL). The METOC library also maintains historical and current copies of the graduate theses and dissertations written by students in meteorology and oceanography at the Naval Postgraduate School.

Satellite Data Ingest and Processing System

Code 7541
(831) 656-4833
NRL, Monterey, CA

Function:

Collects and processes a unique suite of near real-time global digital data sets from multiple satellite sensors/channels to enable researchers to collocate information for a wide range of meteorological and oceanographic (METOC) applications. This includes near-real-time demonstrations to illustrate the advantages of new and improved products to DoD forecasters and to obtain critical feedback from DoD users. Hardware and software compatibility with Fleet users enhances rapid prototyping and transition to operations.

Description:

The facility receives digital data from six geostationary and 24 polar orbiting sensors. Geostationary satellite data from U.S. Geostationary Operational Environmental Satellite (GOES)-West and GOES-East, Japanese MTSAT, Chinese FY-2D, and European Meteosat-7 and 9 are gathered through the Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the Air Force Weather Agency (AFWA). This suite of satellites provides near-global coverage of visible, infrared, and water vapor channel data using SeaSpace's TeraScan software and new NRL-developed generic satellite processing systems. Global near-real-time polar orbiting visible and infra-red imagery from DMSP, NOAA TIROS, MetOp-A, and National Polar Partnership (NPP) Visible Infrared Imager Radiometer Suite (VIIRS) are delivered through FNMOC/AFWA, NOAA CLASS and the U. of Wisconsin's Cooperative Institute for Meteorological Satellite Studies (CIMSS). Data from NASA Aqua and Terra are delivered through NASA LANCE (Land Atmosphere Near real-time Capability for EOS). Microwave imager data from Special Sensor Microwave Imager (SSM/I) and SSMIS are obtained from FNMOC. Tropical Rainfall Measuring Mission (TRMM) data is collected from the NASA Goddard Space Flight Center. WindSat data is relayed via FNMOC and NRL DC. Microwave sounder data from Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS) are provided by NOAA/ FNMOC, while data from the Advanced Technology Microwave Sounder (ATMS) arrives via AFWA/FNMOC. NRL receives daytime CloudSat cloud radar data from the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University.

Instrumentation:

The facility includes two antennas to capture ~40 GB per day of real-time geostationary data locally and links to receive ~400 GB per day from partners. The satellite data streams flow through hardware to frame and bit-sync the data and are processed on Linux computer cluster-based software programs. Collaborative agreements with FNMOC, AFWA, NOAA, NASA, and CIRA/CIMSS enable NRL to leverage their space hardware and communications infrastructures to provide R&D satellite METOC products to DoD at minimal cost.

Meteorological Archival Facility

Code 7542
(831) 656-4785
NRL, Monterey, CA

Function:

The Bergen Data Center (BDC) provides data archival capability for meteorological and oceanographic data.

Instrumentation:

The facility includes a server, switch, tape library, and tape drives. The Dell PowerEdge R710 server, Spectra T950 tape library, and LTO-5 tape drives are linked together by a Cisco MDS 9148 Multilayer Fabric Switch. The BDC runs Symantek Netbackup Enterprise software for backup, archiving, and tape library management. The tape library currently has 950 tape slots, 870 tapes, and 8 tape drives with each drive having a direct connection to the fiber switch. The BDC has a data transfer rate of about 8 TB per hour. The total online tape storage capacity is approximately 2,175 TB although the T950 can be expanded to more than 30 PB using 24 drives and more than 10,000 tape slots.

Description:

The BDC is a resource for researchers to access meteorological and oceanographic data. From its initial capacity of 31 TB in 1998, the BDC has grown to its present capacity of 2,175 TB with the capability to expand to over 30 PB. It accommodates diverse research requirements, providing archiving of critical data.

Environmental Prediction System Development Laboratory

Code 7542
(831) 565-4785
NRL, Monterey, CA

Function:

Provides connectivity to computational platforms and databases that are necessary for the development, testing, and validation of numerical data assimilation, weather, and ensemble prediction systems. This capability allows for the rapid transition of software development into operations.

Description:

This laboratory enables scientists at NRL to perform basic and applied research in numerical weather and coupled atmosphere/ocean prediction and to take the knowledge learned from this research and quickly apply it to operational data assimilation and prediction systems. The facility allows scientists to use the same software and databases in their research that are used in operations at FNMOC and NAVOCEANO, an important component necessary for the improvement of data assimilation and prediction systems. The high-speed connectivity between computational resources allows scientists to share databases, results, and software. Collocation with FNMOC allows developers to access and use computational resources (controlled by multilevel security operating systems) that will ultimately host NRL-developed environmental prediction systems.

Instrumentation:

The laboratory includes several LINUX clusters including a Cray XE6m with 5,376 processing cores provided by the DoD High Performance Computing Modernization Program (HPCMP) Dedicated HPC Project Investment (DHPI). An upgrade to the Cray is in progress to add 1,056 processing cores with a speed increase from 54 TF to 65 TF. Systems are supported by 2,000 TB of RAID storage and a tape archive facility capable of expansion to over 30 PB. The Division also maintains numerous LINUX servers for individual projects, including a unique Global Ocean Data Assimilation Experiment (GODAE) server hosting data sets suitable for research and development of ocean and atmospheric data assimilation capabilities. These systems, in combination with DoD Supercomputing Resource Centers (DSRC) and FNMOC assets, enable the Division to efficiently develop, improve, and transition numerical weather analysis and prediction systems and coupled air/ocean systems to operational use; and to provide guidance that is used by Fleet forces around the globe. These systems also support basic research in atmospheric processes such as air-sea-ice interaction, atmospheric dynamics, and cloud/aerosol physics, as well as developing environmental applications, tactical decision aids, and probabilistic prediction products.

Mobile Atmospheric Aerosol and Radiation Characterization Observatory (MAARCO)

Code 7544
(831) 656-4725
NRL, Monterey, CA

Function:

MAARCO is designed as a stand-alone facility for basic and applied atmospheric research and the collection of data to assist in validating aerosol and weather models. Its purpose is to enable research on atmospheric aerosols, gases, and radiation (visible and IR light) in areas of key interest, including remote areas, overseas locales, and onboard ships. This complete mobile laboratory facilitates deployment in areas with limited facilities and provides maximum flexibility for integration of additional instrumentation.

Description:

MAARCO is a modified 20-ft × 8-ft climate-controlled container, a standard size certified for shipping. Removable scaffolding on the roof and shelves and racks inside the container facilitate installation, removal, and stowage of instruments for shipping. MAARCO's radiation instruments provide spectral aerosol optical depths and inversion products, direct and diffuse total solar and infrared radiation, and real-time whole-sky images and cloud cover. The aerosol instruments characterize the light-scattering and absorbing properties of atmospheric aerosols and provide data on aerosol particle sizes, aerodynamic shapes, size distributions, concentrations, mass, elemental composition, and particle morphology. The gas monitors measure reactive compounds that modify aerosol particles and provide clues to the air mass origin. The lidar and sounding systems display the vertical structure of clouds and aerosols, produce atmospheric extinction and optical depth profiles, and are valuable for both locating atmospheric layers for aircraft sampling and for assisting in interpreting the visible and IR instrument data.

Instrumentation:

MAARCO contains an integrated suite of meteorology, aerosol, gas, and radiation instruments, and maintains space for guest instrumentation. The radiation suite includes an AErosol RObotic NETwork (AERONET) Sun Photometer, solar and IR radiometers, a Total Sky Imager, and a Micro-Pulse Lidar. A 3-wavelength nephelometer, Aerodynamic Particle Sizer, an optical spectrometer, Scanning Mobility Particle Sizer (SMPS), filter samplers, Photo-Acoustic Soot Spectrometer and Particle Soot Absorption Spectrometers, a tapered element oscillating micro-balance (TEOM) sampler, SO_2 and ozone monitors, and a micro-orifice uniform deposit impactor (MOUDI) sampler and a Davis Rotating Universal size-cut Monitor (DRUM) complete the aerosol and gas suite. Meteorological data are provided by a surface weather station and an upper air sounding system.

Space Science Division

Vacuum Ultraviolet Calibration/Testing Facility

Fermi Gamma Ray Telescope

Neutron Characterization Laboratory

Semiautomatic Probe Station

Gamma-Ray Imaging Laboratory

Large Angle Spectrometric Coronagraph (LASCO)

Helium Resonance Scattering in the Corona and Heliosphere (HERSCHEL)

Rocket Assembly and Checkout Facility

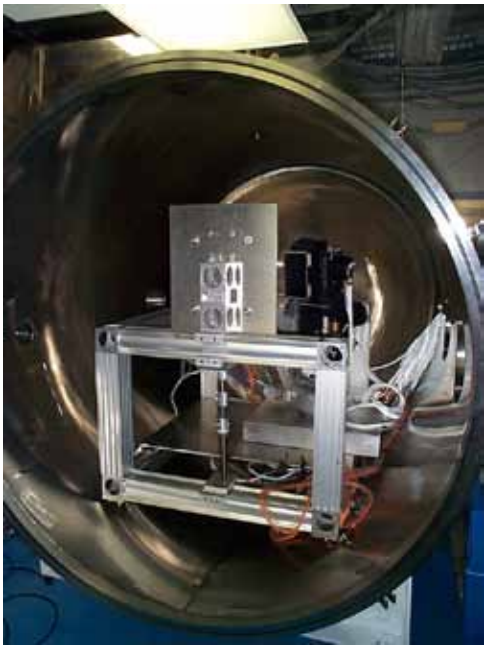
Solar Coronagraph Optical Test Chamber (SCOTCH)

Space Instrument Test Facility (SITF)

Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI)

Vacuum Ultraviolet Calibration/Testing Facility

Code 7634
(202) 767-2441
NRL, Washington, DC



Description:

The Vacuum Ultraviolet Calibration/Testing Facility is a series of clean vacuum chambers capable of generating and detecting UV radiation required for optical calibration of space experiments. It was built to support the optical development, testing, and calibration of the Special Sensor Ultraviolet Limb Imager (SSULI). It has also been used to test and calibrate the six flight Tiny Ionospheric Photometer (TIP) instruments, the High-resolution Ionospheric and Thermospheric Spectrograph (HITS), the Remote Atmospheric and Ionospheric Detection System (RAIDS), the Ultraviolet Imager (UVI), and others. The facility can be easily reconfigured for a wide variety of UV measurements. A silicon carbide reflection diffuser provides diffuse radiation in the far and extreme UV portions of the spectrum, and sensors can be positioned directly in the beam, where higher intensities are required. Calibrated reference detectors monitor the radiation levels during an experiment. Inside the chamber, precision translation and rotation stages allow motion of the test component along four independent axes. To minimize contamination, the end of the vacuum chamber is inside a Class 10000 clean room.

Function:

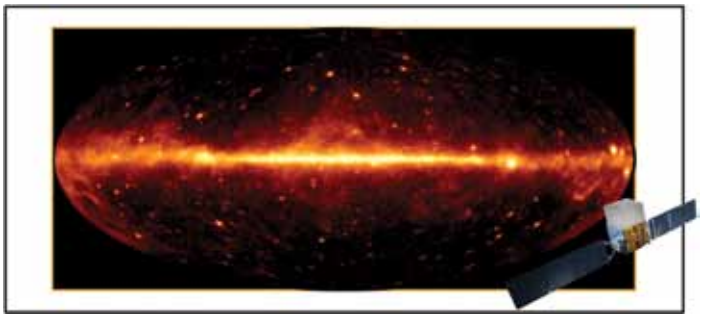
Provides an oil-free, high-vacuum chamber for vacuum ultraviolet calibration and testing of extreme and far ultraviolet sensors. The system is used to determine an instrument's optical characteristics by simulating the naturally occurring diffuse airglow emissions of the Earth's upper atmosphere. It is also capable of performing component-level testing and characterization of an instrument's individual optical components before instrument assembly.

Instrumentation:

The facility consists of two vacuum vessels specifically designed for the fabrication and testing of sensors and components operating in the 80 to 250 nm spectrum. The primary vacuum vessel is a 1.67-m-diameter by 2-m-long stainless steel tank. This chamber is evacuated using oil-free cryogenic, turbo, and roughing pumps with a typical operating pressure of 1×10^{-6} Torr. UV radiation is delivered into this system using two gas discharge lamps, which can be configured for directed beam applications or as a diffuse source or for both simultaneously. One light path passes through a 1.0-m monochromator for the selection of isolated wavelengths for study. The facility has recently acquired four compact UV diathermy lamps, which will provide orders of magnitude higher intensity. Inside the chamber are several motion stages for remote positioning of the instrument or components being tested. Positively charged ions can be injected into the chamber with energies up to 20 eV to test an instrument's susceptibility to a charged environment. A rare gas analyzer monitors outgassed contaminants from the items under test. Another vacuum vessel in the facility includes a chamber for independently testing and assembling far UV sealed tube detectors. The facility also includes a 0.6-m-diameter vacuum chamber for thermal vacuum testing components or small instruments that require simulation of UV radiation.

Fermi Gamma Ray Telescope

Code 7650
(202) 767-6817
NRL, Washington, DC



Description:

The Fermi Gamma Ray Space Telescope carries two instruments covering more than a factor of 10 million in energy across the electromagnetic spectrum. It is the first gamma-ray observatory to survey the entire sky every day, and the first with high sensitivity. Fermi was launched on June 11, 2008, from the Kennedy Space Center, Cape Canaveral, Florida, into a 650-km (400-mile) altitude orbit.

Instrumentation:

The primary instrument, the Large Area Telescope (LAT), is a state-of-the-art, wide-field imaging spectrometer for high-energy gamma rays from approximately 20 million electron volts (MeV) to greater than 300 billion electron volts (GeV). (For comparison, photons of visible light have energies of a few eV.) Its field of view covers approximately 20% of the sky at a time – roughly the same as the human eye – and it surveys the entire sky every three hours. The 3000-kg (6600-lb) LAT was designed and manufactured by a large international collaboration that includes NRL, which designed and built the crystal calorimeter that measures the energies of incident gamma rays.

Function:

Designed to answer a broad range of fundamental questions on the most energetic physical processes from the near Earth environment to cosmological distances: What is the source of gamma ray bursts at large redshift? What are their progenitor objects, and what is the central engine that drives these most energetic explosions? What powers the energetic emission of distant active galaxies? What is the nature of the relativistic jets of material emerging from the cores of these galaxies? What are they made of, and how are they produced? How are gamma rays produced in the strong gravity, powerful magnetic and electric fields, and high rotational velocities of neutron stars? What is the population of these collapsed stars? What is the source of the cosmic rays? What powers solar flares, and how are the transient gamma ray emissions related to ion acceleration and transport in flares?

Neutron Characterization Laboratory

Code 7654
(202) 767-3572
NRL, Washington, DC

Description:

The Neutron Characterization Laboratory uses pulsed neutron beams to explore the material composition of different test objects by measuring the scattered or fission produced neutrons or the characteristic inelastic scattering and captured gamma rays produced by neutrons interacting with the target. Different materials produce different signatures. For example, WMD detection is done by measuring the delayed gamma emission from the induced fission products produced by the thermal neutron absorption and subsequent fission of an atom of uranium or plutonium.

Function:

The Neutron Characterization Laboratory specializes in the study of materials with pulsed neutron sources. Research includes, but is not limited to neutron imaging, radiation effects research, fast neutron radiography, neutron activation analysis, and bulk materials analysis, as well as weapons of mass destruction and contraband detection.

Instrumentation:

The primary instrument at the Neutron Characterization Laboratory is a Thermal Scientific Neutron Deuterium-Tritium (dT) Generator, shown in the photo, which resides in an appropriately secure/shielded experimental staging area. It can produce an isotropic monoenergetic 14 MeV neutron pulse with a maximum yield of 1×10^8 n/s. The neutron generator can be operated in continuous mode or a 250 Hz to 20 kHz pulsed mode with a minimum pulse width of 5 μs. The Laboratory has a variety of neutron detectors. These include liquid and plastic scintillators with pulse shape discrimination capability for fast neutron detection and He-3 and BF3 proportional counters for thermal neutron detection. To measure neutron inelastic scattering and capture gamma rays, a large contingent of liquid scintillator, plastic, sodium iodide, lanthanum bromide, and high purity germanium detectors are available. A dedicated VME-based Struck digital data acquisition system can handle the high count rate environment and large detector arrays that are typical for these types of measurements with 24 drives and more than 10,000 tape slots.

Semiautomatic Probe Station

Code 7654
(202) 767-3572
NRL, Washington, DC

Description:

This probe station can fully characterize devices and full wafers up to 200 mm. The system can be operated remotely and is equipped with a probe card. Since temperature dependency of leakage currents is critical, the stage temperature can be widely changed from 60° to –100 °C. Code 7654 is using the probe station for testing semiconductor-based radiation detectors. The continuing trend of decreasing device geometries of the next generation and greater functionality of radiation detectors is making precise characterization evaluation of semiconductor devices more and more critical.

Function:

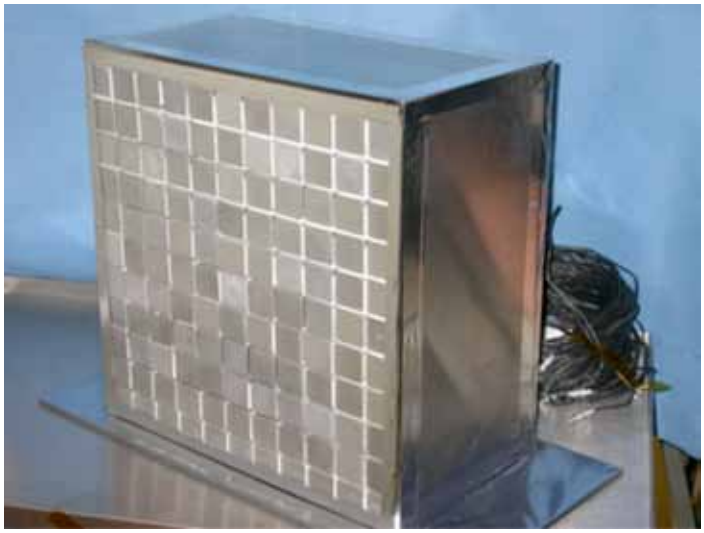
This semiautomatic 200 mm probe station (manufacturer: Cascade Microtech) can address all the DC (current vs voltage) and C-V measurements (capacitance vs voltage) required in process control monitoring, process reliability monitoring, and device characterization of semiconductors.

Instrumentation:

The Cascade Microtech Summit 1100 is a high precision wafer probe station for semiconductor device characterization on a wafer or die level. It can be reconfigurable for multiple applications and test setups: DC (direct current measurements), AC (alternating current measurements), capacitance, wafer level reliability (WLR), and more. The system has excellent EMI shielding for low-noise measurements (>20 dB 0.53 GHz, >30 dB 320 GHz). The stage temperature can be varied over a wide range from 60° to –100 °C (±0.1 °C). Low-current measurements down to nA are possible. The Summit 100 can be configured with a probe card holder. Furthermore, it has auto-alignment and remote control capabilities. The probe positioning resolution is ±1 μm with a repeatability < 2 μm with a stage travel of 8 in. × 8 in. (±203 mm).

Gamma-Ray Imaging Laboratory

Code 7654
(202) 404-1475
NRL, Washington, DC



Function:

The Gamma-Ray Imaging Laboratory designs and tests high-resolution solid-state and scintillation detectors for use in imaging and spectral measurements of X rays and gamma rays. The laboratory facilities include cryostats and electronics to test highly segmented detectors, for position sensitivity in image reconstruction made from silicon or germanium. The data acquisition system can support test configurations with up to 512 channels of low-noise electronics. Initial prototype designs of Compton telescope and coded mask instruments can be demonstrated.

Description:

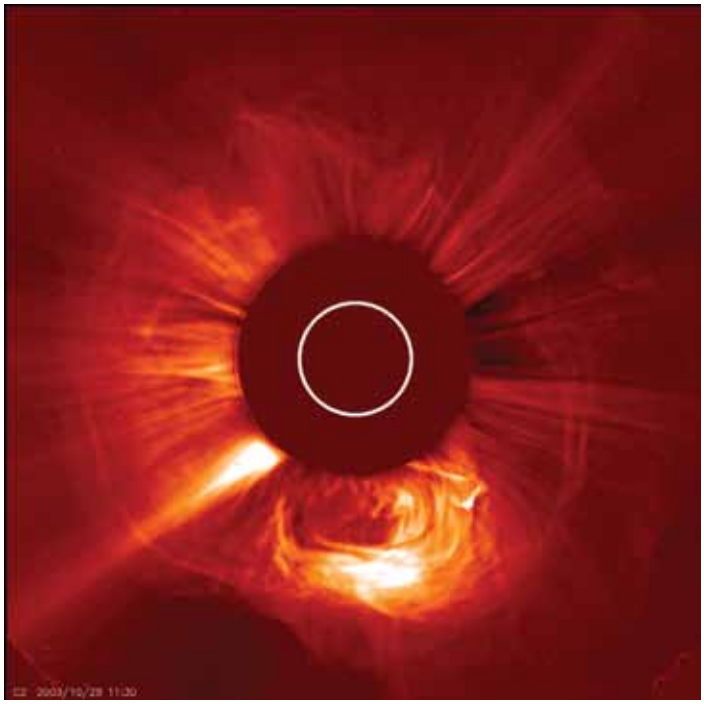
The Gamma-Ray Imaging Laboratory provides the resources necessary to test new detector concepts for high-sensitivity measurements of X rays and gamma rays. Much of the work in the laboratory has focused on developing large arrays of intrinsic silicon, lithium-drifted silicon, or germanium detectors that have been segmented into strips or pixels to provide interaction position information necessary for imaging. These detectors provide significantly improved capabilities for detection of natural gamma radiation on Earth as well as in space: for the measurements of X- and gamma-ray emission in solar flares, and astronomical sources of gamma rays such as novae, supernovae, and active galactic nuclei; and for homeland defense and DoD application in the detection of shielded nuclear materials. Scintillation-based Compton and coded-mask imager concepts can also be tested for both astrophysics and homeland defense.

Instrumentation:

Several cryostats and associated cryogenic systems provide a controlled temperature environment for detector performance testing from 75 K to room temperature. The cryostats provide cold finger mounting of the detector under test and a volume for mounting low-noise electronic at an intermediate temperature. For Compton and coded-mask imagers, 368 3.3 × 3.3 × 7.7 cm sodium iodide (NaI) gamma-ray detectors are available with read-out electronics for testing prototype designs.

Large Angle Spectrometric Coronagraph (LASCO)

Code 7680
(202) 404-1475
NRL, Washington, DC



Function:

Designed to answer some fundamental questions: How is the corona heated? Where and how is the solar wind accelerated? What causes coronal mass ejections, and what role do they play in the evolutionary development of large-scale coronal patterns?

Description:

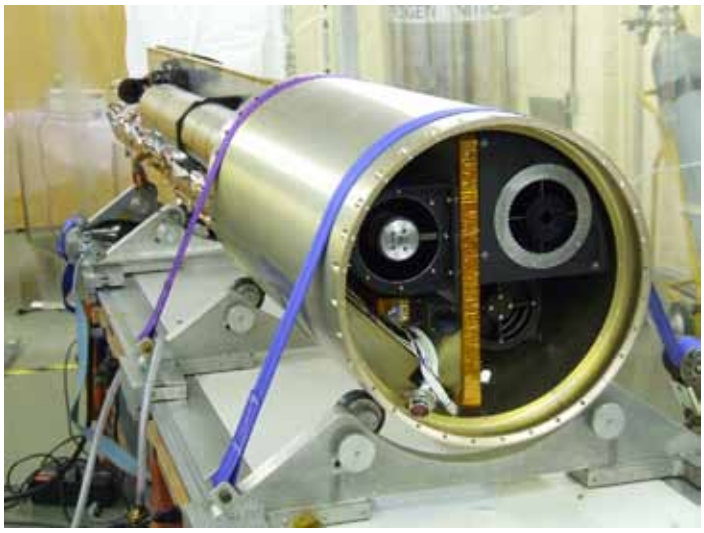
The LASCO and Extreme-ultraviolet Imaging Telescope (EIT) instruments are two of 11 instruments included on the joint NASA/European Space Agency (ESA) SOHO (Solar and Heliospheric Observatory) spacecraft. SOHO was launched on December 2, 1995, at 0808 UTC (0308 e.s.t.) from the Kennedy Space Center, Cape Canaveral, Florida. The spacecraft is located about 1 million miles from Earth, between Earth and the Sun in a halo orbit about the L1 Lagrangian point. This point is where the gravitational and orbital forces are balanced. About 250 images are returned from LASCO and EIT each day, providing unprecedented views of the Sun and its corona, recording the source of major geomagnetic storms.

Instrumentation:

The LASCO instrument is a suite of two coronagraphs that image the solar corona from 2.2 to 32 solar radii (about 1/7 of the distance to Earth). It is convenient to measure distances in terms of solar radii. One solar radius is about 700,000 km, 420,000 miles, or 16 arc min. The EIT instrument images the solar disk to 1.5 solar radii in four narrow wavelength intervals from 17.1 to 30.4 nm. These intervals roughly correspond to ionization temperatures of 60,000 K to 3 MK. LASCO has recorded more than 14,000 coronal mass ejections.

Helium Resonance Scattering in the Corona and Heliosphere (HERSCHEL)

Code 7684
(202) 404-8108
NRL, Washington, DC



Description:

HERSCHEL is an instrument suite imaging the solar corona developed for suborbital spaceflight on Black Brant IX or larger sounding rockets. The first flight of HERSCHEL occurred on September 14, 2009, from White Sands Missile Range, NM. During this flight, images of the solar corona were obtained in linearly polarized visible light, 120 nm, UV light and 30.4-, 28.4-, 18.5-, and 17.1-nm EUV light. Global maps of the density distribution of the free electron component of the solar corona are derived from the polarized visible light images. Global maps of the density and outflow speed of the hydrogen and helium components of the solar corona are derived from the 120 nm and 30.4 nm images, respectively. Temperature and density of the inner corona are derived from the 30.4-, 28.4-, 28.5-, and 17.1-nm images. As variations in the relative abundance of helium to hydrogen observed in situ near Earth is characteristic of the variation in solar wind speed, observations by HERSCHEL of this abundance ratio in the region of solar wind acceleration led to identification of the source regions of the fast and slow solar wind.

Function:

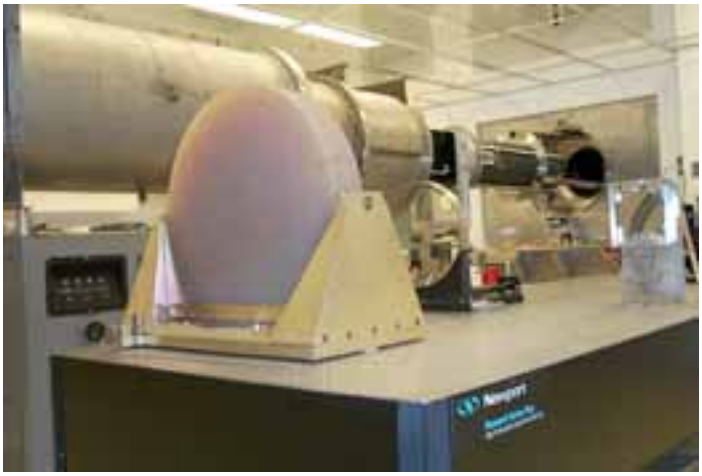
Provides global images of the emission from the three primary constituents of the Sun's corona (hydrogen, helium, and electrons) in the region of solar wind acceleration. Measurements of the relative spatial and temporal distribution of these constituents are needed to distinguish between models of the source of the solar wind. This will lead to improved predictions of variations in the speed and composition of the solar wind at Earth.

Instrumentation:

HERSCHEL is a breadboard-type suborbital flight system based on a 3-m optical bench, up to three CCD imagers of 2000 x 2000 format pixels, and an instrument control and data handling electronics system. The first HERSCHEL was composed of the Ultraviolet and Visible-light Coronagraphic Imager Sounding-rocket CORonagraph Experiment (UVCI/SCORE), the Helium CORonagraph (HECOR), and the HERSCHEL Extreme Ultraviolet Imaging Telescope (HEIT). The UVCI/SCORE is an all-reflecting externally occulted reimaging coronagraph obtaining monochromatic H I and He II images and the visible light pB image from 1.6 R_{sun} to 2 R_{sun}. UVCI/SCORE uses the same telescope optics for each wavelength and was the prototype for the coronagraph being developed for the joint NASA/ESA Solar Orbiter mission. The HECOR is an externally occulted coronagraph that uses a single reflecting optical element (no reimaging optics) to obtain solely the He II coronal image from 1.3 R_{sun} to 3 R_{sun} with the highest throughput possible within the payload envelope. The HEIT is constructed from spares of the NRL EUV Imager and obtains the intensity of the 304 Å He II disk emission necessary for the analysis of the coronal He II resonant scattering, the resonantly scattered He II below the field of view of the coronagraphs, and the thermal structure of the inner corona (with overlap of the coronagraphs inner field of view via differential emission analysis of the EUV Fe IX/X, Fe XII, and Fe XV images).

Rocket Assembly and Checkout Facility

Code 7686
(202) 767-3144
NRL, Washington, DC



Function:

Integrates, tests, and calibrates scientific instruments flown on sounding rocket payloads. The scientific instruments are assembled on an optical bench; the electronic components are installed and tested; and the instrument is moved to the vacuum calibration chamber for spectroradiometric calibration. When removed from the chamber, the payload is ready for shipment to White Sands Missile Range (WSMR), New Mexico, for integration with the spacecraft and launch vehicle.

Description:

The facility consists of six contiguous laboratory modules subdivided into a storage area, a gray room area, and a clean room. The storage area houses spare instrument components and intermittently used ground support equipment. The gray room area contains facilities to clean components before they enter the clean room and equipment used to ship the instrument to WSMR. The Class 100 cross-flow clean room is separated from the gray room by an air shower. The clean room contains three major stations: a clean bench for assembly of subsystems; a 12 × 4 ft optical bench for instrument assembly and electronic test of the instrument subsystems; and, a vacuum chamber for vacuum focus and spectroradiometric calibration. The cryogenically pumped vacuum chamber is designed with a 30-cm-diameter ultraviolet collimator at one end and a roll-off section that accommodates the entire flight instrument centered in the collimated beam at the other end.

Instrumentation:

The facility includes air hood, ultrasonic cleaner, particle counter, oscilloscope, and flight instrument computers.

Solar Coronagraph Optical Test Chamber (SCOTCH)

Code 7686
(202) 767-3144
NRL, Washington, DC

Description:

The large SCOTCH is the primary test chamber located within a 400 ft^2 Class 10 clean room. This completely dry-pumped, 550 ft^3 vacuum chamber is maintained at synchrotron levels of cleanliness. Solar instrumentation up to 1 m in diameter and 5 m in length can be physically accommodated in the chamber. An instrument's optical performance is probed and calibrated with a variety of visible and extreme-ultraviolet (XUV) sources mounted on the chamber's 11-m beamline. The instrument is mounted on a precision pointing table equipped with motorized slides, which allows controlled adjustment of instrument pointing with sub-arc-second precision under evacuated conditions. The main beamline is baffled to eliminate stray reflections from the beamline walls and minimize the effect of light scattered off the instrument surfaces. A solar disk stray light rejection of 10^{-12} was successfully measured in the Large Angle Spectrometric Coronagraph (LASCO) C3 channel.

Function:

Provides a facility for the assembly, test, and vacuum optical characterization of solar and coronal satellite instrumentation under ultraclean conditions.

Instrumentation:

The SCOTCH is instrumented with temperature-controlled quartz crystal monitors and residual gas analyzers for real-time, quantitative measurements of volatile contamination. Various light sources can be introduced at one end of the 11-m chamber. This includes a solar spectrum simulator as well as other visible and XUV sources. The chamber contains an instrument-pointing table capable of supporting payloads with a mass of 75 kg. The precision of the pointing table is less than 1 arc second.

Space Instrument Test Facility (SITF)

Code 7686
(202) 767-3144
NRL, Washington, DC

Description:

The SITF provides a clean, controlled environment for the optical calibration and assembly of modern space-based solar instrumentation. The unique requirements of this instrumentation demand a rigorous approach to contamination control. The instrument vacuum test chamber, the Solar Coronagraph Optical Test Chamber (SCOTCH), forms the primary optical test chamber and is described more fully on the previous page. The instrument handling and assembly is conducted in a Class 10 clean room to reduce particulate generation. Airborne particulate levels are continuously monitored. To prevent hydrocarbon contamination, the clean room air is filtered through activated carbon filters located in the central plenum ducts. The facility also contains a small, well-instrumented thermal vacuum/bake test chamber. This allows characterization of outgassing of components and subassemblies prior to integration in the main instrument structure.

Function:

Enables flight optics and sensors to be assembled and tested under conditions designed to minimize particulate and volatile contamination of the flight hardware. Contamination causes significant optical and detector performance degradation over mission lifetime; by keeping contamination at acceptable levels, we avoid such degradation. The SITF was used for the test and assembly of the Large Angle Spectrometric Coronagraph (LASCO) and the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) for the NASA Solar Terrestrial Relations Observatory (STEREO) mission.

Instrumentation:

The SCOTCH is instrumented with a temperature-controlled quartz crystal microbalance and a residual gas analyzer to monitor chamber and instrument outgassing. Various electrical and liquid nitrogen vacuum feed-throughs are available through ports in the tank. A large retractable bell jar pulls back into the Class 10 instrument clean room to provide access to the instrument pointing platform. To facilitate instrument handling, assembly, and alignment operations, the clean room contains a 1.3 × 7-m vibration-isolated optical bench and an overhead crane adapted for clean room use with a 1-ton load capacity. A variety of calibrated optical sources, collimators, and theodolites are available to support in-air optical test, alignment, and assembly operations.

Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI)

Code 7687
(202) 767-3137
NRL, Washington, DC

The pre-spacecraft integration SECCHI suite (left to right): guide telescope, COR1, EUV1, COR2, and HI.

Description:

SECCHI is a suite of four instruments on each of two spacecraft in orbit around the Sun. They are part of the NASA Solar Terrestrial Relations Observatory (STEREO) mission. The mission, launched in 2006, placed two spacecraft into orbit around the Sun with one moving progressively ahead of the Earth at 22 degrees per year and the other moving progressively behind the Earth at 22 degrees per year. Together the twin spacecraft allow SECCHI to obtain stereographic imagery of dynamically changing and highly energetic plasma structures ejected by the Sun in the direction of the Earth. Upon arrival, the structures strongly affect conditions in the Earth's space environment in ways that affect high frequency communications and precision navigation.

Function:

Solar space instrument used to conduct scientific research on the origin, three-dimensional morphology, propagation through the heliosphere, and impact on the Earth's space environment of large scale and fast-moving plasma structures, known as coronal mass ejections, that are explosively driven into space by the Sun.

Instrumentation:

The four SECCHI instruments are the Extreme Ultraviolet Imager (EUV1), which observes the line emission from highly ionized atomic species in the inner corona to 1.5 solar radii; an internally occulted coronagraph (COR1), which observes extended coronal structures from 1.4 to 4 solar radii in the solar visible light continuum that is scattered by coronal plasma electrons; an externally occulted coronagraph (COR2), which observes extended coronal structures from 2.0 to 15 solar radii in the solar visible light continuum that is scattered by coronal plasma electrons; and a heliospheric imager (HI), which observes from COR2 to the Earth the solar visible light continuum that is scattered by electrons contained in the solar wind plasma structures.

Space Systems Development Department

Precision Radio Frequency Anechoic Chamber Facility

Satellite Mission Analysis Facility

Maritime Navigation Radar Test Range

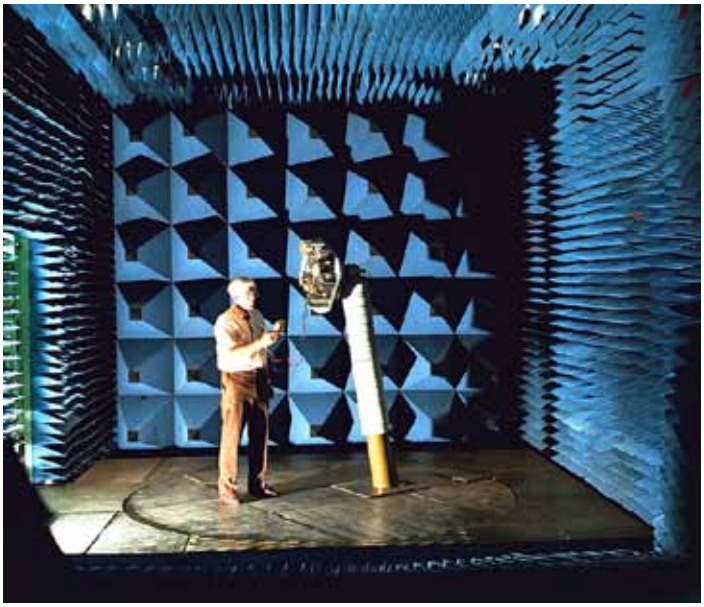
Blossom Point Satellite Tracking and Command Station

Midway Research Center Precision Spacecraft Calibration Facility

Precision Clock Evaluation Facility

Precision Radio Frequency Anechoic Chamber Facility

Code 8122
(202) 279-4338
NRL, Washington, DC



Function:

Performs measurements and calibration of antennas for satellites and aircraft or ground-based systems. The chamber is primarily used for optimizing antenna designs, configurations, and performance on satellites and ground planes. It produces 2D and 3D antenna patterns and swept voltage standing wave ratio (VSWR) measurements in both hardcopy and softcopy format. An associated program called STK (Satellite Tool Kit) can also be used to analyze the data in a simulated environment, using the measured antenna patterns.

Description:

The Precision Radio Frequency Anechoic Chamber is a tapered structure 44 ft long × 14 ft high × 16 ft wide, with a spherical quiet zone 5 ft in diameter. The quiet zone is specified to be isolated from the ambient RF environment outside by 150 dB. The chamber meets the performance specification requirements of free-space voltage standing wave ratio, axial ratio, and reflectivity over the frequency range of 220 MHz to 40 GHz. Reflectivity levels inside the chamber are less than 50 dB from 1 to 40 GHz. The chamber is instrumented for automated measurement capability. The chamber is inside a specially constructed electromagnetic interference facility shielded with 1/8-in.-thick steel plate on all walls, floor, and ceiling. This provides 100 dB attenuation to RF signals from 50 MHz to 100 GHz.

Instrumentation:

Antennas under test receive signals transmitted from the opposite end of the chamber by octave-band source antennas. Synthesizers and amplifiers feed the source antennas. Received signals are routed to an HP8510C network analyzer, where they are processed and sent to the control computer. The Flam and Russell 959 Automated Antenna Measurement System is used to control the HP8510C and the positioners and to perform the analysis and plotting.

Satellite Mission Analysis Facility

Code 8124
(301) 870-3528, ext. 11
Pomonkey, MD

Function:

Compares the on-orbit performance of complex systems against prelaunch and other baseline data. Supports telemetry, tracking, and control (TT&C) and other ground station requirements that cannot be accomplished by established tracking and control networks. The Pomonkey, Maryland, facility can function semi-autonomously since design, fabrication, test, calibration, and support functions are conducted within the facility.

Description:

Pomonkey is a unique field laboratory with associated platforms. The site, located 25 miles south of NRL near LaPlata, Maryland, occupies approximately 58 acres and is owned by NRL. It contains the largest high-speed tracking antenna in the United States and is suitable for low Earth orbit and deep space mission requirements. Other precision tracking antennas are available with apertures ranging from 1 to 9 m. Using special designs, Pomonkey can support operations over a wide band of frequencies from 50 to 25,000 MHz. Real-time signal enhancement and analysis capability has been developed for the facility, and specific operational analysis tools have been implemented to support a wide range of tasks. Operational systems at the facility are linked through several networks in a peer-to-peer environment. A primary network provides access to key systems at NRL and other agencies, while a second network supports operations conducted at the facility. Firewalls and switches protect the integrity of the systems. Precise ephemeris data of all catalogued objects are obtained from the Naval Network and Space Operations Command through automated communications.

Instrumentation:

The facility maintains an inventory of very low noise front-ends, including special feeds, line elements, and amplifiers. These support the standard UHF, L, S, C, X, Ku, and Ka frequency bands as well as deep space frequency assignments. Operation centers house downconverters and other receiving equipment for signal acquisition within these bands. Special radiometric test equipment is used to verify efficiency, gain, and noise temperature of low-noise, high-gain receiving systems. Vector, scalar, and spectrum analyzers are available to ensure performance of newly developed subsystems and components. Fiber-optic links are widely available in support of high-speed connections.

Maritime Navigation Radar Test Range

Code 8140
(202) 279-5187
NRL, Chesapeake Beach, MD

Function:

Provides a Maritime Navigation Radar (MNR) range consisting of 28 MNRs located 8.75 nautical miles east of the NRL Chesapeake Bay Detachment (CBD) on Tilghman Island, MD. These radars are the same as those used on all merchant vessels and represent a precise cross-section of today's actual MNR environment. The range provides the emitters and analysis tools to aid the research of new technologies required to understand and exploit this class of emitters essential in developing comprehensive Maritime Domain Awareness.

Description:

The range includes radars in both S and X bands, radars of nearly every power level and of every antenna size, each fully characterized in terms of detailed signal characteristics, effective radiated power level, antenna size, scan rate, and PRI pattern, and all completely documented and precisely located by means of a differential GPS survey. Available radars include a large selection from both the Furuno and Raytheon families, and somewhat smaller selections from the JRC, Koden, SI-TEX, Anritsu, and Bridge-Master families. Having the ability to quickly, easily, and economically isolate and study any given MNR signal or performance capability, or readily construct and analyze an existing or potential operational scenario, or validate reception or processing capabilities against these low power signals, in an active, real-time environment with accurate ground truth, makes the range a valuable and up-to-date asset for assisting with development of both local and national Maritime Domain Awareness capabilities.

Instrumentation:

Selected radars are remotely controllable, some are instrumented with temperature sensors, and all are radiated for extended periods. Monitoring instrumentation at the CBD in Chesapeake Beach, MD, includes precision track-while-scan radar, advanced electronic intelligence analysis system, precision ESM direction finder, precision optical system, sensor fusing and cueing software, specific emitter identification capability, and comprehensive data collection, processing, analysis, and distribution suites, all modular and tailorable to meet user needs.

Blossom Point Satellite Tracking and Command Station

Code 8140
(301) 870-3582
NRL, Blossom Point, MD

Description:

The 41-acre facility is 40 miles southeast of Washington, DC. The remote location assures interference-free operations and permits low elevation angle satellite communications. BP consists of a satellite mission operations center, multiple antennas, and an existing infrastructure capable of providing space system command, control, and management for all customer classes. BP provides a single interface point to networked ground stations. BP supports aggregate data rates up to 400 megabits per second with a variety of communication protocols. BP provides high-rate data telecommunications services on a global basis using encrypted DS-3 Asynchronous Transfer Mode (ATM) technology. BP is also accessible from the Internet using TCP/IP protocols and established secured firewall techniques. Selected clients have access to the facility's capabilities via a protected server. BP is a fully certified external user of the Air Force Satellite Control Network (AFSCN) and has a communications interface into all AFSCN control nodes.

Function:

The Blossom Point Satellite Command and Tracking Facility (BP) provides engineering and operational support to several complex space systems for the Navy and other users, enabling cost-effective solutions for all programs. BP provides direct line-of-sight, two-way communications services with spacecraft in multiple bands during all mission phases, including concept, mission, and space segment development, launch, early on-orbit operations, and mission data collection. Additionally, BP's capabilities allow coverage through connectivity to worldwide ground station networks.

Instrumentation:

Eight ground system antennas covering L-, S-, C-, and X-band capability. SGLS, STDN, and CCSDS compatible for extensive customer support flexibility. BP uses the government-owned Common Ground Architecture (CGA) software system as the basis for all ground system and mission operations activities. CGA provides standard ground processing services and employs a reusable code base to develop mission unique requirements. The system runs on SUN platforms under the Solaris UNIX operating system.

Midway Research Center Precision Spacecraft Calibration Facility

Code 8140
(703) 551-1992
Midway Research Center – Stafford, VA

Function:

The Midway Research Center (MRC) is a worldwide test range that provides accurate, known signals as standards for performance verification, validation, calibration, and anomaly investigation to support various DoD satellites. The MRC ensures responsive and coordinated scheduling, transmission, measurement, and reporting of accurate and repeatable signals.

Description:

MRC headquarters is located on 162 acres in Stafford County, Virginia, contiguous to Marine Corps Base Quantico. The main site consists of three 18.2-m, radome-enclosed precision tracking antennas and a variety of smaller antennas. It has a large operations building and multiple other equipment and office buildings within a fenced compound. The MRC has the capability to transmit precision test signals, with multiple modulation types, from 20 MHz to 18 GHz (up to 40 GHz in an experimental mode). In addition to the primary site, the MRC is responsible for and controls 158 assets located in 13 countries. These assets include “The Dish” (a 45-m tracking antenna in Palo Alto, California) and “Marlock” (a 25-m tracking antenna system on Guam).

Instrumentation:

The MRC system can be configured to support specific customers and needs. The MRC instrumentation suite includes nanosecond-level time reference to United States Naval Observatory (USNO), precision frequency standards, accurate RF and microwave power measurement instrumentation, and precision tracking methodologies. The instrumentation has been used for millimeter wave (MMW) projects. Classified and unclassified projects are supported. There is extensive computer control of all assets. The communications system handles wideband data, both classified and unclassified.

Precision Clock Evaluation Facility

Code 8150.1
(202) 767-5111
NRL, Washington, DC

Function:

Tests and evaluates high-precision atomic clocks for spacecraft, ground, and mobile applications. Supports performance evaluation, environmental testing, including shock and vibration, and anomaly investigation of on-orbit observed performance.

Description:

The Precision Clock Evaluation Facility (PCEF) consists of time and frequency reference standards for comparison with test units that are made up of five active hydrogen maser frequency standards, three of which are housed in a large environmental chamber for humidity and temperature control. These references provide uninterrupted precise and accurate time/frequency with a stability of about 1×10^{-15} at 1 day. They are used to determine a realization of Coordinated Universal Time (UTC) designated internationally as UTC (NRL) and is precisely traceable to the DoD reference UTC (USNO) by several independent means. Eight spacecraft cesium and rubidium atomic clock-sized thermal vacuum chambers specially designed for short- and long-term testing are used to simulate a spacelike environment (less than 1 × 10-6 Torr) with temperature controlled to <0.1 °C. To support long-term continuous testing in a spacelike environment, the test chambers and time/frequency standard references are operated on a 125 kW uninterruptible power system with diesel backup. Magnetic sensitivity testing of precision frequency standards is performed with two Helmholtz coil systems: a three-axis multicoil system and a single-axis 1.5-m Helmholtz coil.

Instrumentation:

Four NRL-built data collection systems are used within the PCEF. The primary atomic clock measurement/data collection system is a 48-channel, dual-mixer phase measurement system capable of simultaneous measurements of 48 different clocks at 20-s intervals indefinitely. A single-channel, dual-mixer phase measurement system used for special evaluations is capable of measurements as short as 0.01 s. These data systems each have 2 ps of resolution. Software used in these systems was designed and coded by NRL, and includes analysis software with graphics and networking support for commercial products.

Spacecraft Engineering Department

Modal Survey Test Facility

Static Loads Test Facility

Payload Processing Facility

Thermal Vacuum Test Facility

Spacecraft Acoustic Reverberation Chamber Test Facility

Spacecraft Spin Test Facility

Spacecraft Vibration Test Facility

Spacecraft Thermal Analysis, Fabrication, and Test Facility

Proximity Operations Testbed

Class 100 Clean Room Facility

EMI Test Facility

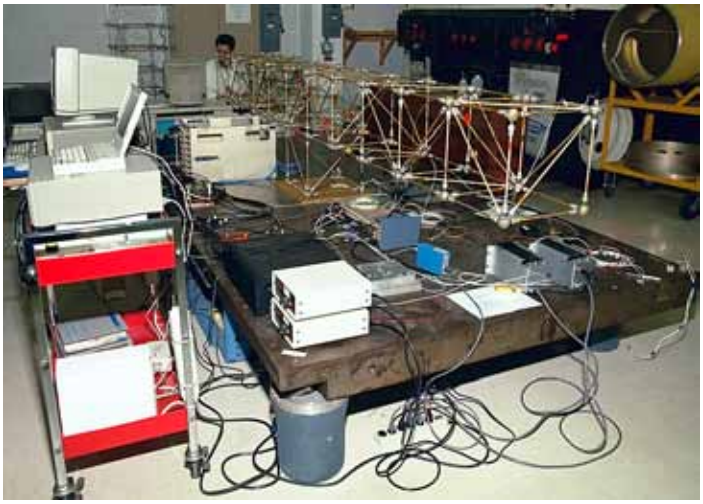
125-ft Tapered RF Anechoic Chamber Facility

20-ft Rectrangular RF Anechoic Chamber Facility

3-ft x 3-ft mmWave Near-Field Scanner

Modal Survey Test Facility

Code 8210
(202) 767-3944
NRL, Washington, DC



Function:

Provides the capability to perform modal survey testing on a wide variety of spacecraft and structures. The data acquired from the test enables the structural analyst to determine the dynamic characteristics of the test article. The test results may be used to correlate finite element models.

Description:

The Modal Survey Test Facility is located wherever the test article can be set up with appropriate boundary conditions. It depends only on sufficient space for mounting the test article and setting up the data acquisition system. The Naval Center for Space Technology's Environmental Test Facility offers space up to and including a structural test floor large enough to handle space shuttle–size payloads. Electromagnetic shakers of 75 and 250 lbf are available to provide excitation for the test.

Instrumentation:

A Hewlett-Packard VXI System with 288 channels of data acquisition provides the means for recording forces and acceleration responses during the modal test. A full complement of accelerometers, force transducers, and signal conditioning is available to support tests of all sizes. Results may be directed to SDRC's I-DEAS®, Matlab®, or other programs for final processing.

Static Loads Test Facility

Code 8210
(202) 767-3944
NRL, Washington, DC

Function:

Provides the capability to perform large-scale structural loads testing on spacecraft and other structures. Results from these tests can be used to verify strength capabilities of the test article.

Instrumentation:

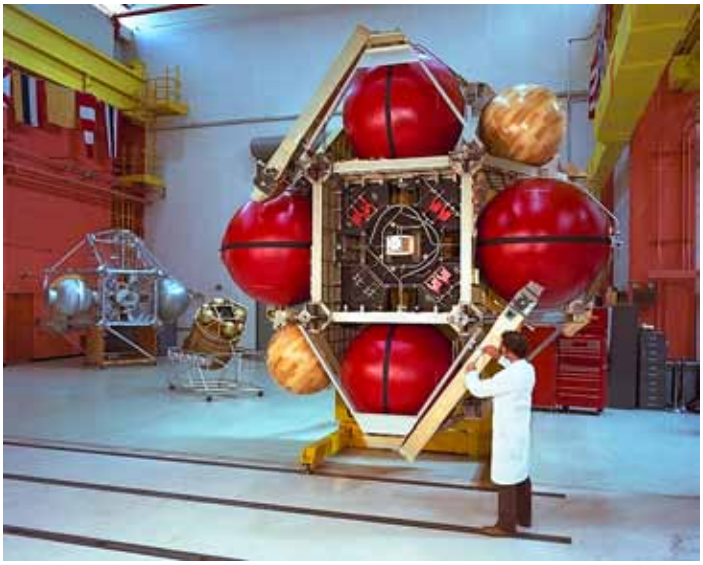
Data acquisition is available for strain gages, linear voltage displacement transducers (LVDT), sonar displacement transducers, and load cells. An OPTUM Megadeck 200 data acquisition system provides the capability for collecting up to 400 strain-gage measurements. An OPTUM Megadeck 5733A 72-channel data acquisition system provides high-speed measurement capability. Facilities for light machining are also available. Additional facilities, hardware, and test equipment are available in the Environmental Test Facility to support testing.

Description:

The Static Loads Test Facility consists of a 40 × 50 ft structural test floor, a structural steel fixture system, and a computer-controlled hydraulic loads application system. The test floor is located in a high-bay facility complete with an overhead crane. The crane has two carriages with 30,000-lb capacity each and approximately 30 ft of hook height. Areas adjacent to the test floor can be used for test article buildup and for test support activities. The test fixture system is an erector-set concept that allows for a wide variety of configurations to fit specific test needs. The load applications system can support up to 20 independent load strings with force capabilities from 3,000 to 100,000 lb.

Payload Processing Facility

Code 8212
(202) 767-0704
NRL, Washington, DC



Function:

Provides a central location for all equipment and auxiliary machinery used to assemble and test space vehicles, subsystems, experiments, and components.

Description:

The Payload Processing Facility (PPF) is a comprehensive laboratory complex housing a high-bay assembly area (13,500 ft^2, 40 ft high), secure assembly support facilities, storage area, lifting equipment, fabrication machinery, and ground transportation equipment. The PPF houses facilities for the following environmental tests: acoustic reverberation, random vibration, thermal vacuum, electromagnetic interference/electromagnetic compatibility/radio frequency (EMI/EMC/RF), optical alignment, modal survey, static loads, and spin balance. In addition, the PPF houses thermal control and reaction control assembly and test facilities, a composites fabrication lab, and a heat pipe lab.

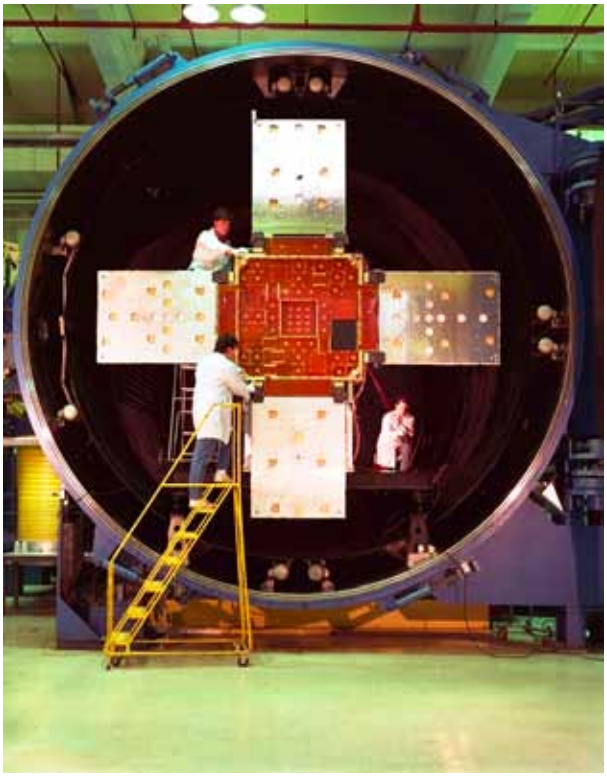
The assembly area serves as the fabrication, assembly, and integration area for spacecraft and flight hardware. Within the assembly area, many activities are performed: structural assembly, wire harness assembly, component and subsystem integration, and mechanical aerospace ground equipment (MAGE) and electrical aerospace ground equipment (EAGE) checkout and debug.

Instrumentation:

The PPF has a large array of mechanical aerospace ground equipment, electrical aerospace ground equipment, and spacecraft equipment/special test equipment (SE/STE) to support the myriad tasks performed during spacecraft assembly. The SE/STE include clean rooms (Class 100 to 10,000), large isolated reaction masses, central heating, ventilation, and air conditioning (HVAC)/humidity control, liquid nitrogen and gaseous nitrogen supply, and extensive electrical power distribution and common grounding for equipment and ordnance.

Thermal Vacuum Test Facility

Code 8212
(202) 767-0704
NRL, Washington, DC



Description:

The Thermal Vacuum (TVAC) Test Facility is located within the Payload Processing Facility. It consists of three large chambers and several small chambers, a machinery room, a network of computers, a 26,000-gal liquid nitrogen storage facility, and an assortment of handling and test fixtures.

Of the three large chambers, chamber #1 is a 16-ft-diameter by 30-ft-long horizontal end-loading cylinder, and chambers #2 and #3 are 7-ft-diameter by 8-ft-tall vertical bottom-loading cylinders. Chambers #1 and #2 are cryogenic pumped, providing an oil-free vacuum environment. Chamber #3 has a diffusion pump system capable of evacuation rates similar to the rates that occur during launch ascent. All three chambers are equipped with gaseous nitrogen conditioned thermal shrouds capable of temperatures between –150 °C and +125 °C. Numerous bulkheads are available for the pass-through of control, communication, power, and telemetry signals to the test setup.

Function:

Provides the capability to accurately simulate the space environment for the verification of thermal control system designs and the determination of thermal performance margins and capabilities of space vehicles, experiments, and subsystems.

Instrumentation:

The facility has both computerized and manual control of the different chambers' thermal environments via the chamber shrouds and heaters, cold plates, and quartz lamps. Separate data acquisition systems exist for monitoring and recording measurements from up to 200 thermocouples, 100 resistance temperature detectors (RTDs), quartz crystal microbalances (QCMs), and residual gas analyzers (RGAs).

Spacecraft Acoustic Reverberation Chamber Test Facility

Code 8212
(202) 767-0704
NRL, Washington, DC

Description:

The acoustic reverberation chamber is located within the Payload Processing Facility and consists of a 10,000 ft^3 test cell (17.2 ft wide × 21.5 ft long × 27 ft high), a 30,000-lb-force electrodynamic vibration shaker, a machinery room, a network of computers and amplifiers, a 26,000-gal liquid nitrogen storage facility, and an assortment of handling and test fixtures.

A sound pressure level of 153 dB, with a range of 32 to 10,000 Hz, is attainable in the chamber. The 30,000-lb-force shaker has a 2-in. stroke and a 2,000 Hz upper limit and is mounted in the center of the chamber floor to provide mechanical vibration excitation in addition to acoustic excitation of test specimens.

Function:

Provides the capability to simulate the vibration and high intensity acoustic noise environment experienced by spaceflight hardware during the launch vehicle ascent.

Instrumentation:

Control of the chamber sound pressure level (SPL) is provided through a Spectral Dynamics 1500 acoustic controller connected to up to 12 microphones suspended within the chamber. For shaker vibration, a Spectral Dynamics 2550 provides control and limiting of up to 32 channels of accelerometer response. The facility has the capability to perform digital data acquisition of up to 300 channels using a HP VXI E1432 digitizer with I-DEAS® postprocessing.

Spacecraft Spin Test Facility

Code 8212
(202) 767-0705
NRL, Washington, DC

Description:

The facility contains two spin balancing machines (one horizontal and one vertical) to handle various types of balancing requirements. Both machines are provided with a plane separation network to obtain correction readings directly in the plane of correction. The spin machines require 100 ft^2 of space and are clamped to a slotted 4-ft-thick reinforced concrete floor for stability. Each machine has a remote control console to operate from a distance of 100 ft during hazardous operations. Various capacity MOI tables are used to verify MOI and center of gravity for units under test.

Function:

Provides the capability to correct unbalances of spacecraft by using dynamic measurement techniques and static/coupled measurements to provide products of inertia. Moments of inertia (MOI) can be determined on MOI tables of various capacities.

Instrumentation:

The vertical spin machine is a Schenk/Trebel model E-6 hydrostatic bearing spin table, has a load capacity up to 18,000 lb, spins at rates of 30 to 300 rpm, and is capable of 2 oz/in. accuracy. The horizontal spin machine is a Schenk/Trebel model FH600 horizontal hard bearing spin table with a capacity of 13 to 1300 lb, spin rates of 50 to 600 rpm, and 100 moz/in. accuracy. MOI tables include Space Electronics models GB8000 (capacity 8,000 lb) and 973-3000 (capacity 3,000 lb). Both have an accuracy of ±0.5% of total MOI. Other MOI tables are ID models with 5-, 50-, 100-, and 200-lb capacities, and an accuracy of ±0.005% of total MOI.

Spacecraft Vibration Test Facility

Code 8214
(202) 767-0705
NRL, Washington, DC

Function:

Qualifies and acceptance tests spacecraft and spaceflight components by simulating the various vibration loading environments present during flight operations and demonstrating compliance to design specifications. Using the facility's electrodynamic shakers, an assortment of quasi-static, vibratory, and shock loads can be generated, and test article characteristics can be quantified.

Description:

The Spacecraft Vibration Test Facility is located within the Payload Processing Facility and consists of four electrodynamic shakers (one 50-klb force, one 30-klb force, two 18-klb force), two slip tables, three individual power amplifiers, and a high-power switching system. One of the 18-klb, the 50-klb, and the 30-klb shakers have an operational range of 5 to 2000 Hz with 2-in. stroke capability.

Instrumentation:

A Spectral Dynamics 2550 provides control and limiting of up to 32 channels of accelerometer response. The facility has the capability to perform digital data acquisition of up to 300 channels using an HP VXI E1432 digitizer with I-DEAS® postprocessing.

Spacecraft Thermal Analysis, Fabrication, and Test Facility

Code 8221
(202) 404-7432
NRL, Washington, DC

Function:

Provides for the analytical thermal design and analysis of any spacecraft. This includes conceptual design, analytical thermal model development, definition of requirements, worst-case environments and design conditions, and temperature predictions for all cases. The facility provides the means to turn an "analytical thermal design" into a working temperature control subsystem ready for flight—i.e., provides the means to go from design and analysis to hardware qualification and acceptance testing and then to orbit.

Description:

This facility provides computer support to accommodate six thermal analysts. The software required to create and run analytical thermal models includes TRASYS/TSS and Thermal Desktop for radiation exchange and orbital flux determination, and SINDA/FLUINT for thermal model formation and temperature prediction. Thermo-optical surface properties of "real" surfaces must be known accurately for reliable temperature prediction. Thus, two types of reflectometers are used to measure short wavelengths for solar absorptions and long-wave infrared for room-temperature emittance. Detailed thermal design and analysis are followed by fabrication and test phases. Capabilities within the facility include fabrication, assembly, and qualification of flight hardware, and flight support. Technicians have expertise in the manipulation of all contemporary and advanced thermal control hardware including, but not limited to, multilayer insulation materials (for thermal blankets) and flight-qualified temperature sensors, thermostats, and heaters. This facility is capable of and has supported the incorporation of specialty technologies such as

- Cryogenic thermal blankets and cryo coolers;
- Diode, loop, constant, and variable conductance heat pipes; and
- Capillary pumped loops and other advanced two-phase systems.

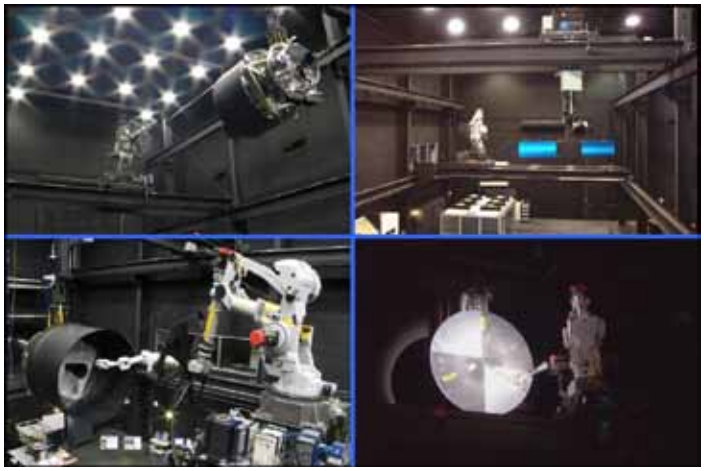
Instrumentation:

A computerized data acquisition and control system (CDACS) is used during thermal testing for the display, collection, storage, and retrieval of temperature and power data, and for the automated control of all power supplies that feed various simulation heaters. The CDACS consists of

- Two workstations with displays;
- Signal conditioners for over 1,000 thermocouple and low-voltage inputs; and
- 40 rack-mounted, digital power supplies with appropriate bus connectivity for output control.

Proximity Operations Testbed

Code 8231
(202) 404-3530
NRL, Washington, DC



Description:

Operated by the Naval Center for Space Technology, the Proximity Operations Testbed is the largest dual-platform motion simulator of its kind in the U.S. It provides full-scale, hardware-in-the-loop testing of flight mechanisms, sensors, robotic manipulators, and control logic under realistic orbital conditions. It also supports the study of other complex motion problems such as ship dynamics under high sea state conditions.

Spacecraft orbit parameters, mass properties, and actuators are modeled in the central computer to enable the simulator to replicate vehicle motion response to both external and internal disturbances. Reaction wheel torques, thruster on/off logic, and torque coil dipoles are continually processed to provide realistic force and torque commands that drive the simulator to respond as a spacecraft would on-orbit. Furthermore, sensors detecting contact loads allow realistic response of the platforms to contact dynamics occurring during capture operations.

Function:

Serves as a national testbed to support research in the emerging field of space robotics including operations in autonomous rendezvous and capture, 3D imaging and inspection, and remote repair and assembly.

Instrumentation:

The testbed consists of two independent eight-degree-of-freedom platforms for simulation of on-orbit relative dynamics, a force/torque sensor for simulation of contact dynamics, and a high-power spotlight for simulation of solar illumination conditions.

Class 100 Clean Room Facility

Code 8232
(202) 767--9168
NRL, Washington, DC

Description:

The facility consists of two self-contained rooms that have a footprint of 44 × 43 × 13 ft and an additional area for mechanical equipment that covers an area 43 × 20 × 13 ft, for a total of 35,776 ft^3. The entire work area is airtight, pressurized, and dust-, temperature-, and humidity-controlled. It has two laminar flow rooms with an air velocity across the entire room of 100 to 120 ft/min. The air is filtered using HEPA filters to an absolute level of 0.3 m. The rooms are environmentally controlled using air conditioning to achieve 65° to 75 °F and 40% to 60% relative humidity. The rooms are maintained at a minimum 0.15 in. of water pressure differential with existing atmospheric conditions. Connected to the Class 100 clean room is the High Bay Clean Room, a Class 10,000, 35 × 35 × 25 ft room with an 18-ft roll-up door. It supports large spacecraft and propulsion system integration and houses the propulsion orbital tungsten inert gas (TIG) welding operations for plumbing systems.

Function:

Provides a Class 100 ultra-clean environment for the cleaning, assembly, and acceptance testing of contamination-sensitive spacecraft components and integration of complete spacecraft subsystems. The facility is used primarily to support spacecraft propulsion systems, but has been used to support all spacecraft electrical, electronic, and mechanical subsystems.

Instrumentation:

The clean rooms are supported by an extensive array of special test equipment (STE) to support the needs of contamination-controlled testing and integration of spaceflight hardware. This STE consists of ultrasonic cleaning equipment, particle counting stations, water purification stations, vacuum drying stations, immersion flush stations, test hardware, electrical checkout stations, rinse stations, inert gas purges, DC power supplies, tooling and fixtures, and high- and low-pressure test panels for helium and nitrogen test gases. This STE has been recently upgraded to include a state-of-the-art spacecraft propulsion testbed with integrated sensor, hardware control, and data acquisition, all controlled via a simplified GUI-based user interface. The testbed has over 70 channels of simultaneous data acquisition at rates of up to 50,000 Hz for measurement of pressure, temperature, flow rates, and electrical signals.

EMI Test Facility

Code 8241
(202) 404-4390
NRL, Washington, DC

Function:

Supports electromagnetic interference/radio frequency interference (EMI/RFI) testing of flight hardware. It is also used to support custom RF testing up to 40 GHz.

Description:

The facility consists of a 23 × 23 ft semi-anechoic main chamber with a 23 × 20 ft antechamber. It is a completely welded steel structure that provides a minimum of 120 dB of shielding effectiveness at 18 GHz and 100 dB up to 50 GHz. The main chamber uses a hybrid anechoic material consisting of wide-band pyramidal absorbers and ferrite tiles for performance from 20 MHz to 50 GHz. A 10 ft high × 11 ft wide sliding bladder type door allows easy access of large test items to the main chamber. The steel floor rests directly on the concrete slab, so floor loading is not an issue. Filtered and transformer isolated AC electrical power is available in both chambers: 100 A, 120/208 V, 3-phase services, and 60 A, 120/240 V, 1-phase services for each chamber.

Instrumentation:

The chamber is equipped with a complete suite of instrumentation to do the full range of MIL-STD-461 EMI qualification testing. Computers with custom-developed software are used for instrumentation control, data handling, and data storage. Additional test equipment is available to do a variety of specialized testing during component design, through system integration and self compatibility.

125-ft Tapered RF Anechoic Chamber Facility

Code 8241
(202) 404-5488
NRL, Washington, DC

Description:

The facility consists of a shielded 31 × 31 × 125 ft tapered anechoic chamber, a staging area serving the chamber, sheet-metal tools, and an assembly area. The back wall of the chamber is covered with 169 absorbing pyramids that are 8 ft in length. The sides, ceiling, and floor in the quiet zone area are lined with 4-ft absorbing pyramids, and the taper is covered with 1-ft wedge absorber. The positioning system consists of a roll axis in the 11-ft tall model tower, over a slide, over an Az/El positioner, and is housed in a 9-ft diameter, 4-ft deep pit. Also in the pit are two scissor lifts that move a section of the floor, allowing the tower to be lowered for the mounting of models and antennas at ground level. An overhead crane facilitates handling of large mockups as well as various model towers.

Function:

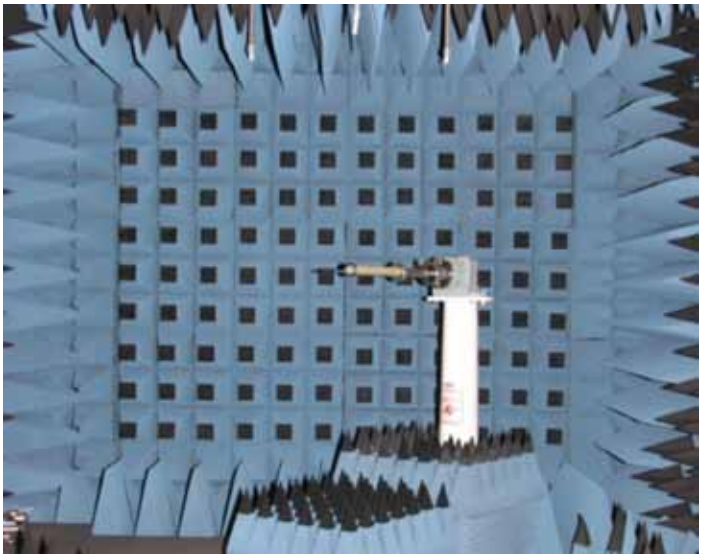
Supports the design, manufacture, and test of antenna systems. The facility is also used as an electromagnetic compatibility/radio frequency interference (EMC/RFI) test chamber.

Instrumentation:

The chamber is controlled by an Agilent PNA-based Orbit FR-959 Measurement System, allowing direct measurements from 100 MHz to 8 GHz, remote-mixed measurements from 2 to 20 GHz, and measurements to 50 GHz with appropriate additional sources and mixers. A dual-port high-speed transmit switch allows single- or dual-polarized (linear or CP) measurements to be made very quickly, and a high-speed 8-port receive switch allows multiple antennas or antenna configurations to be measured in the same cut.

20-ft Rectangular RF Anechoic Chamber Facility

Code 8241
(202) 767-2789
NRL, Washington, DC



Description:

The chamber is controlled by an Agilent PNA-X-based Orbit FR-959 Measurement System, allowing direct measurements from 100 MHz to 50 GHz, and measurements from 75 to 100 GHz and from 140 to 220 GHz using VDI mmWave extender heads that have been optimized to maximize measurement dynamic range. Multiple ports on the PNA-X allow single- or dual-polarized (linear or circular) measurements to be made very quickly, and a high-speed 2-port receive switch allows multiple antennas ports or configurations to be measured in the same cut.

Function:

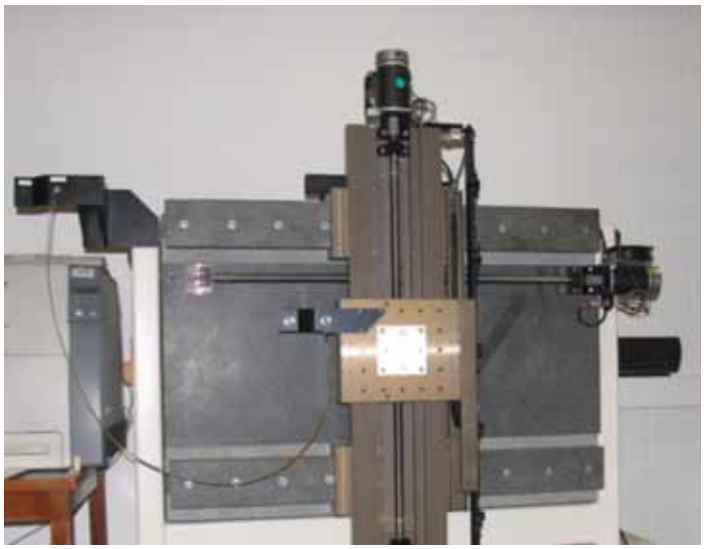
Supports the design, manufacture, and test of antenna systems. The facility is also used as an electromagnetic compatibility/radio frequency interference (EMC/RFI) test chamber.

Instrumentation:

The facility consists of a 10 × 12 × 20-ft (HxWxL) 100-dB shielded rectangular anechoic chamber that shares staging area and other facilities with the 125-ft Tapered RF Anechoic Chamber. The back wall of the chamber is covered with 2-ft pyramidal absorber; the side walls, floor, and ceiling are covered with a mixture of 2-ft pyramids and wedge absorber. The transmit wall is covered with 1-ft pyramidal absorber. The positioning system consists of a roll axis in the model tower, over a manual slide, over an azimuth positioner mounted on the floor. The absorber has unpainted tips to reduce reflectivity at mmWave frequencies, and fiber optic lighting is used to improve RF performance.

3-ft × 3-ft mmWave Near-Field Scanner

Code 8241
(202) 767-2789
NRL, Washington, DC



Description:

The near-field scanner is controlled by an Agilent PNA-based NSI 2000 Measurement System, allowing direct measurements from below 10 GHz up to 50 GHz, and measurements from 75 to 100 GHz and from 140 to 220 GHz using VDI mmWave extender heads that have been optimized to maximize measurement dynamic range. Multiple ports on the PNA-X as well as a dual-port high-speed transmit multiplexer allow single- or dual-polarized antennas to be measured very quickly, and a high-speed 2-port receive switch allows dual-pol probes to be used as well.

Function:

Supports the design, manufacture, and test of medium- to high-gain uWave and mmWave antenna systems.

Instrumentation:

The near-field scanner is an NSI 901V-3×3 custom mmWave scanner, S/N 003 (of 3). It consists of two scanning axes that ride on granite rails supported on air bearings. The rails are mounted to a ~2000 lb vertical granite slab for stability. The scan area is 3 ft × 3 ft, with a planarity of < 0.0002-in. (0.005 mm) RMS and an (x,y) resolution of 0.0005-in. (0.0125 mm), allowing accurate measurements to at least 600 GHz. Absorber treatments are applied as appropriate for each measurement.

General Information

Naval Research Laboratory (Washington, DC)

Location of Buildings at NRL Washington

Location of Field Sites in the NRL Washington Area

Chesapeake Bay Section (Chesapeake Beach, MD)

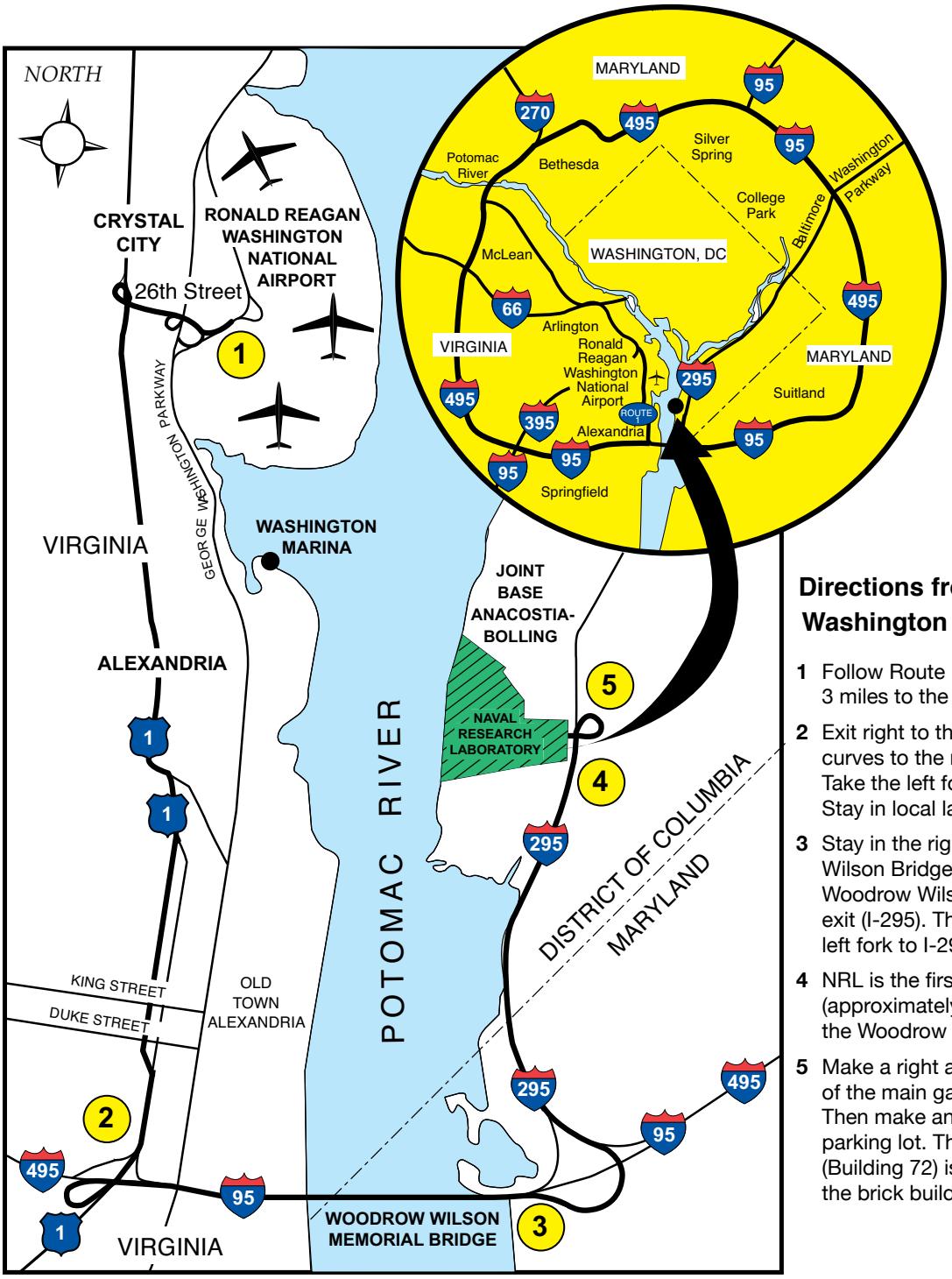
Location of Buildings at the Chesapeake Bay Section

John C. Stennis Space Center (Stennis Space Center, MS)

Naval Research Laboratory Monterey (Monterey, CA)

Key Personnel

Naval Research Laboratory (Washington, DC)

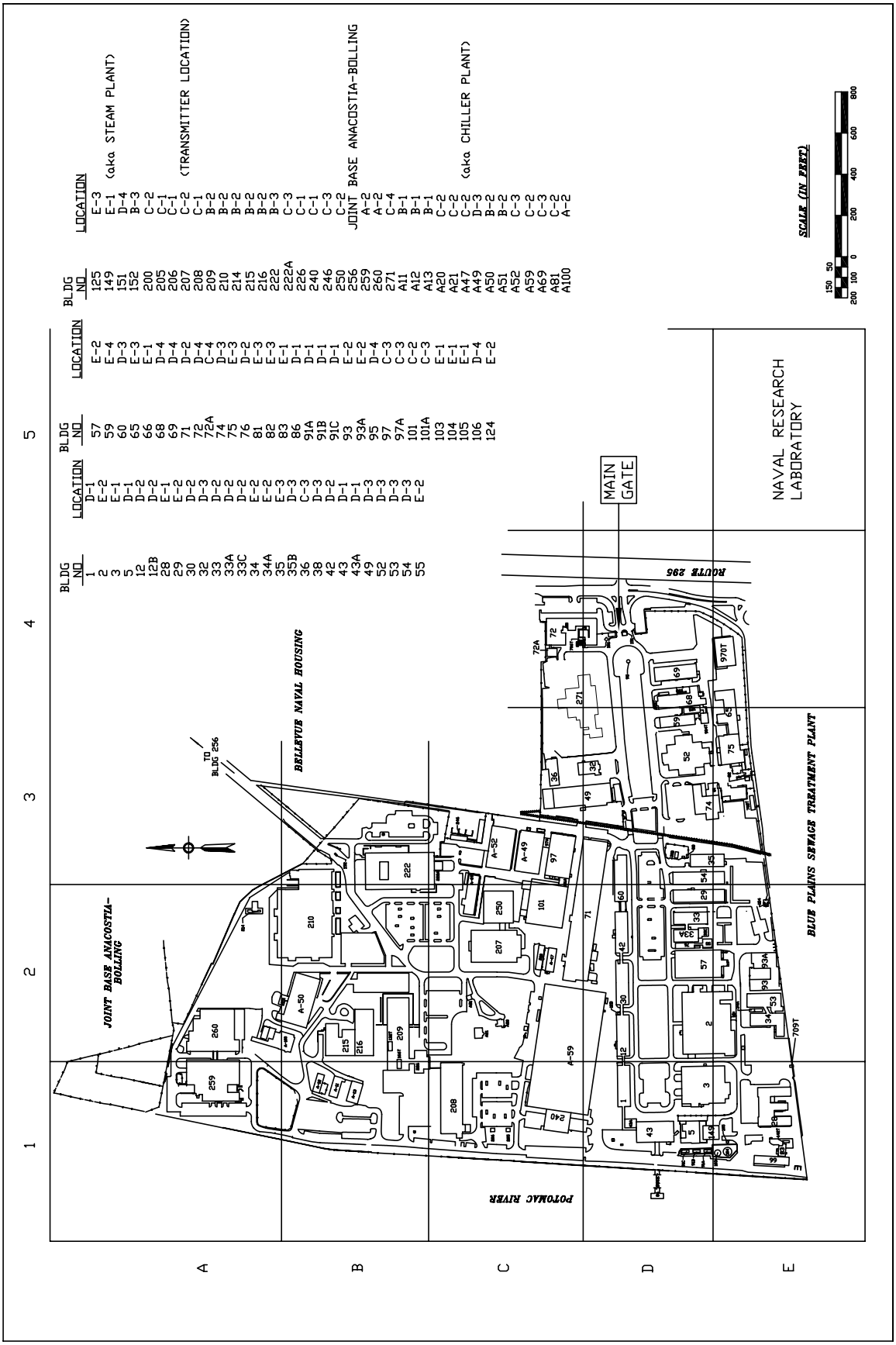


Directions from Ronald Reagan Washington National Airport

1. Follow Route 1 South for approximately 3 miles to the Beltway I-95/I-495.
2. Exit right to the Beltway. This exit curves to the right and then divides. Take the left fork to I-95 (Baltimore). Stay in local lanes.
3. Stay in the right lane on the Woodrow Wilson Bridge. After crossing the Woodrow Wilson Bridge, take the first exit (I-295). This exit divides. Take the left fork to I-295 North.
4. NRL is the first exit off of I-295 (approximately 2 miles) after crossing the Woodrow Wilson Bridge.
5. Make a right at the traffic light in front of the main gate (Overlook Avenue). Then make an immediate left into the parking lot. The Visitor Control Center (Building 72) is located on the corner in the brick building next to the main gate.

Naval Research Laboratory
4555 Overlook Avenue, SW
Washington, DC 20375-5320
(202) 767-3200

Location of Buildings at NRL Washington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271 C-3
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A20 E-1
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A49 D-4
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A51 E-3
A52 E-3
A59 C-3
A69 C-3
A81 C-2
A100 A-2
JOINT BASE ANACOSTIA-BOLLING
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C-2
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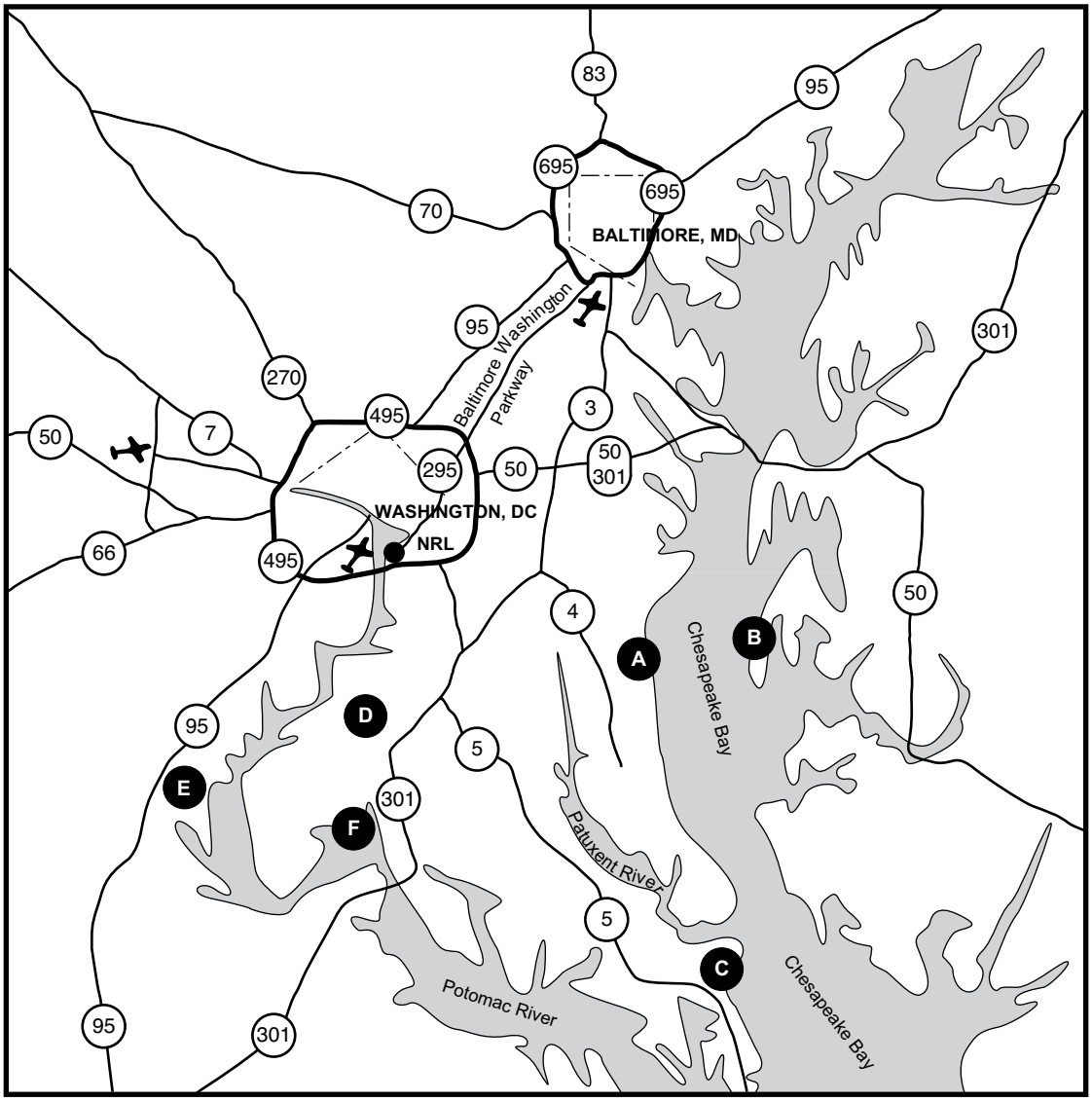
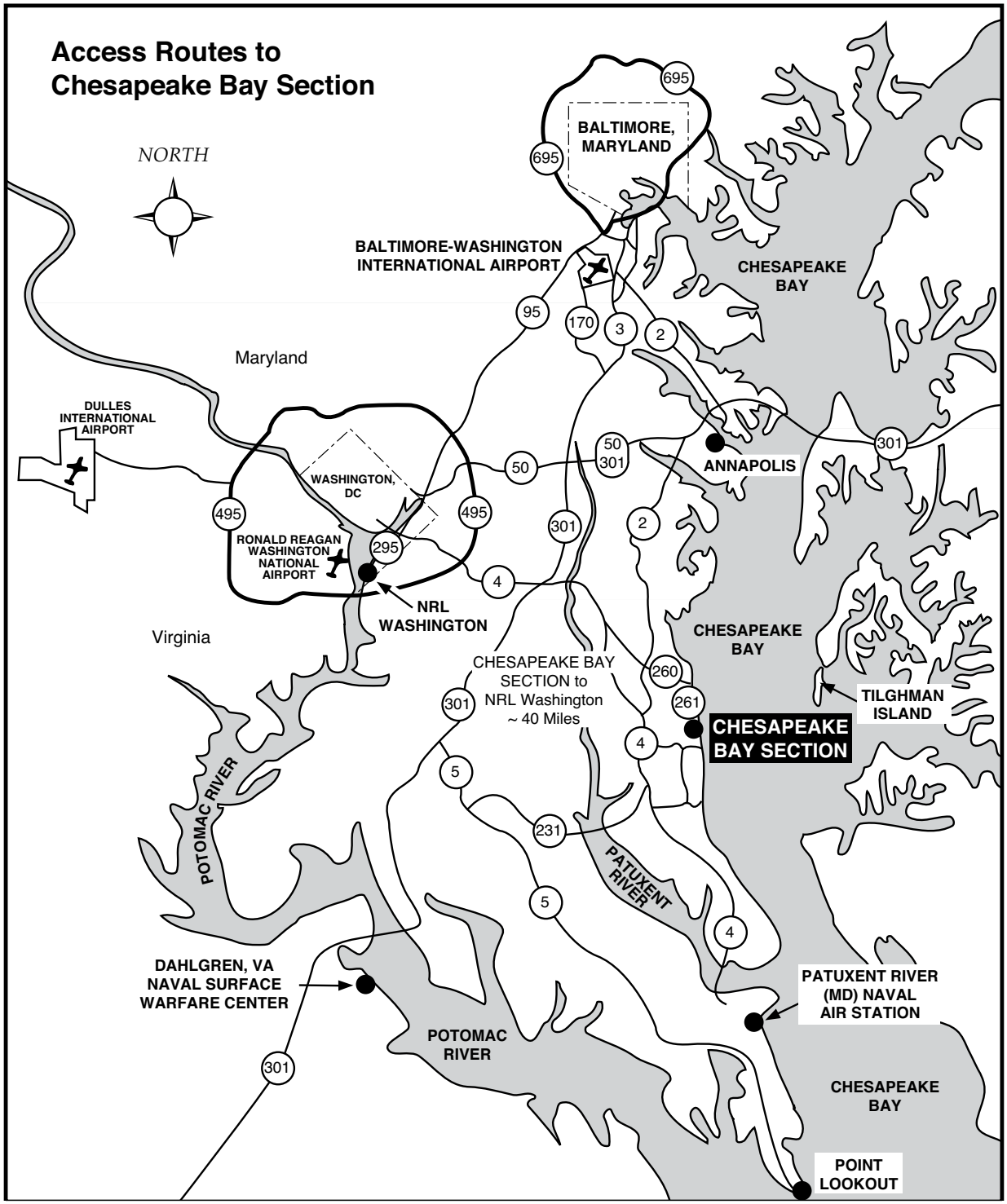
C-2

Location of Field Sites in the NRL Washington Area



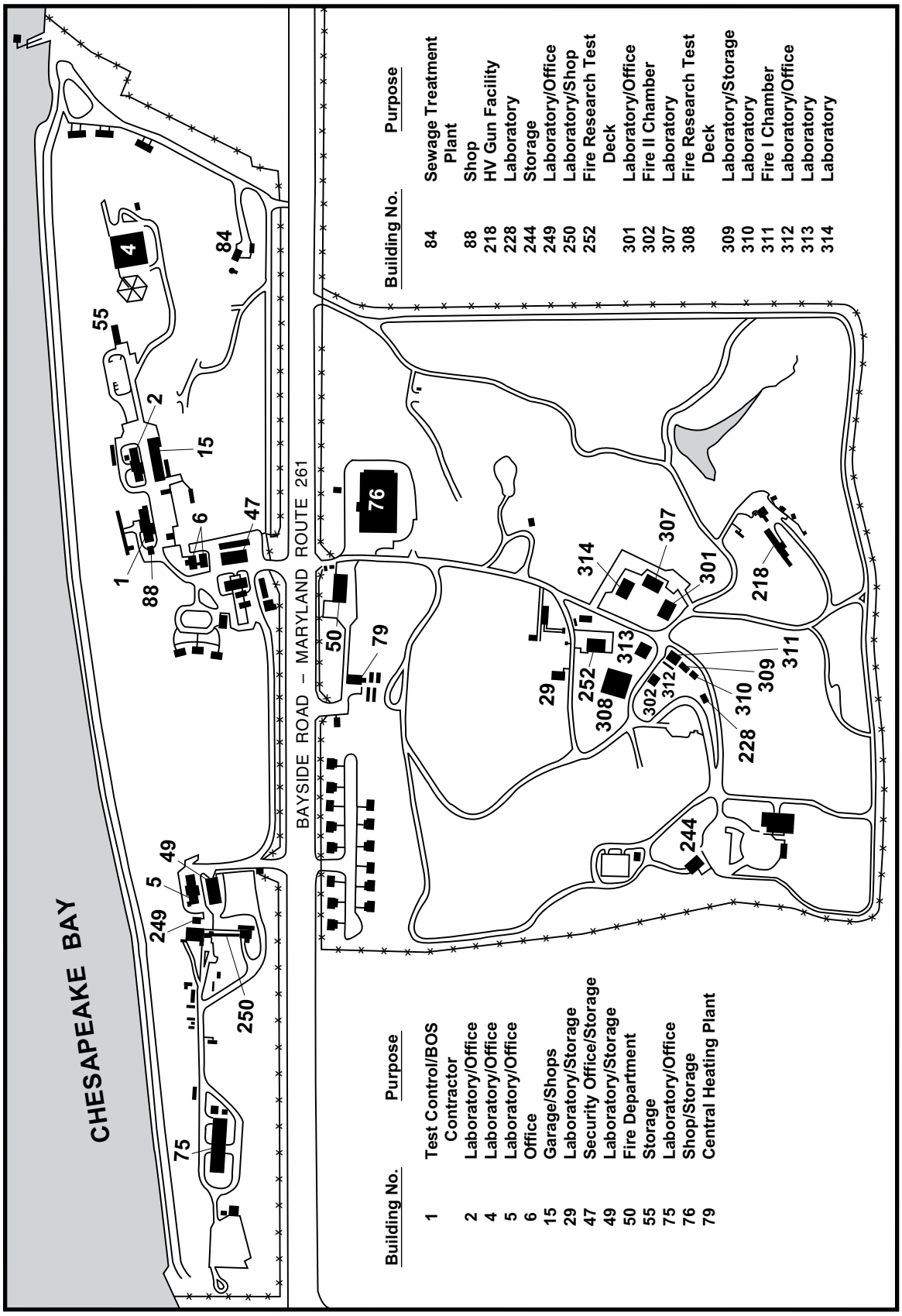
		Location	Approximate Mileage from NRL Washington	Cognizant Code
A	–	Chesapeake Bay Section, Chesapeake Beach, MD	40	3522
B	–	Tilghman Island, MD	110	3522
C	–	Patuxent River (MD) Naval Air Station	64	1600
D	–	Pomonkey, MD	20	8124
E	–	Midway Research Center, Quantico, VA	38	8140
F	–	Blossom Point, MD	40	8140

Chesapeake Bay Section
(Chesapeake Beach, Maryland)



Naval Research Laboratory
Chesapeake Bay Section
5813 Bayside Road
Chesapeake Beach, MD 20732
(301) 257-4002

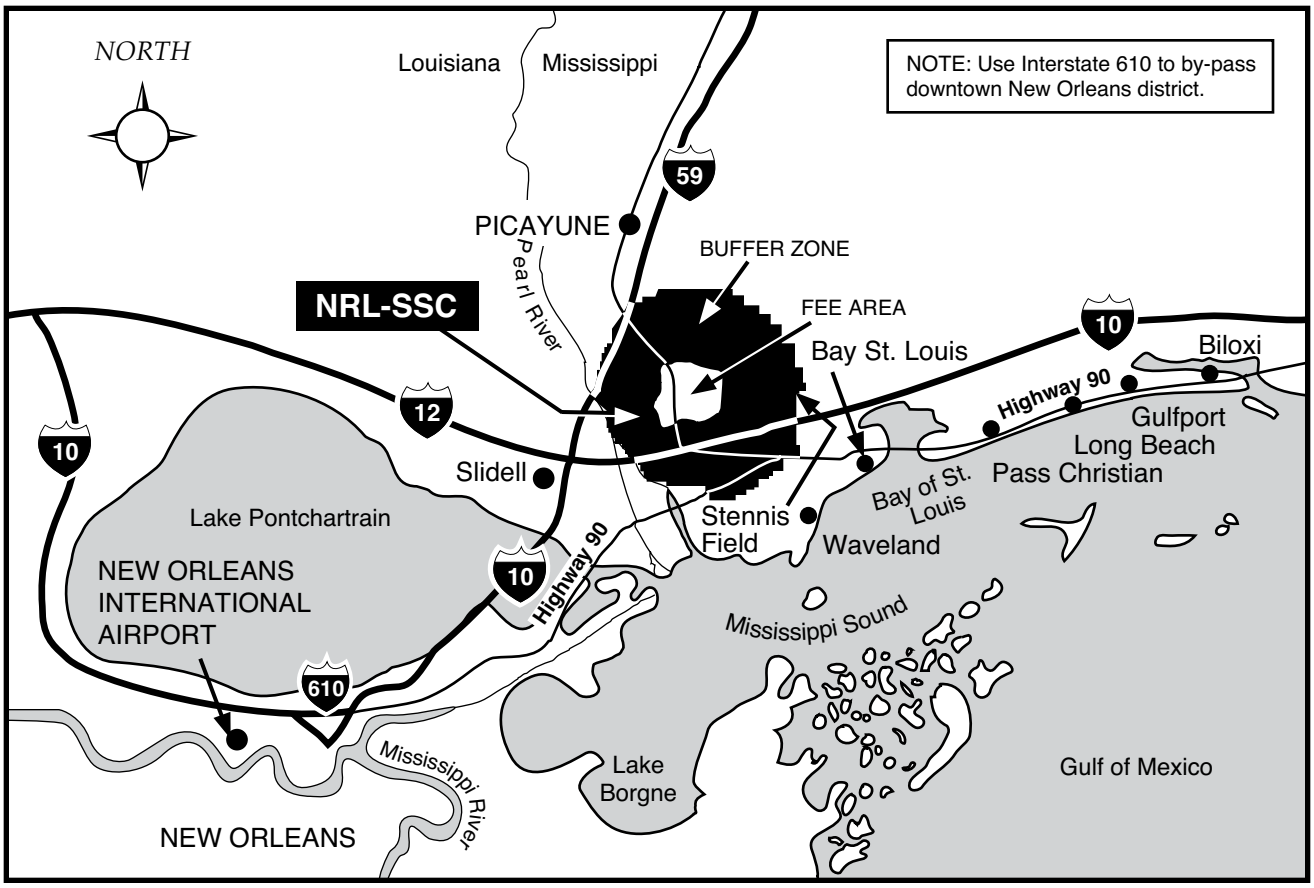
Location of Buildings at the Chesapeake Bay Section



Building No.	Purpose
1	Test Control/BOS Contractor
2	Laboratory/Office
4	Laboratory/Office
5	Laboratory/Office
6	Office
15	Garage/Shops
29	Laboratory/Storage
47	Security Office/Storage
49	Laboratory/Storage
50	Fire Department
55	Storage
75	Laboratory/Office
76	Shop/Storage
79	Central Heating Plant

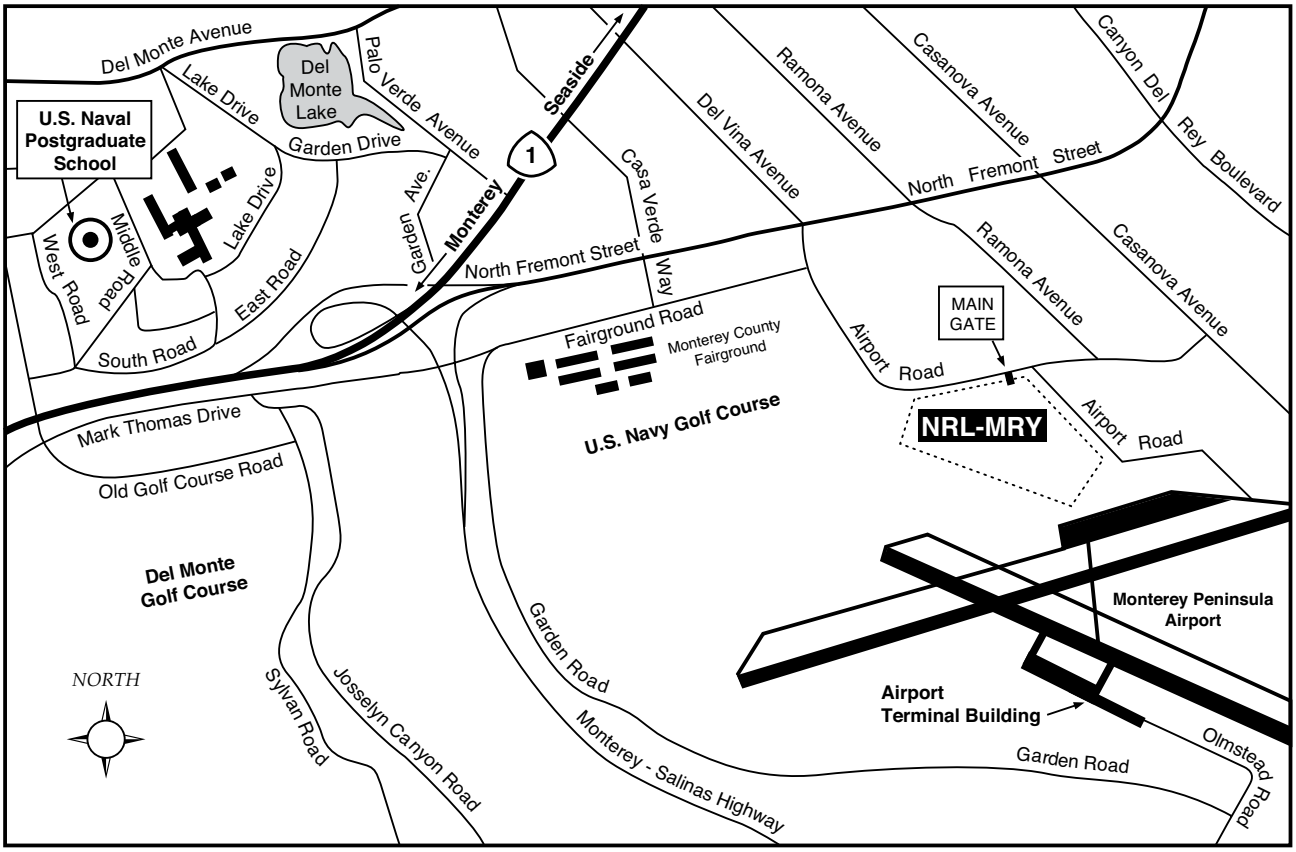
Building No.	Purpose
84	Sewage Treatment Plant
88	Shop
218	HV Gun Facility
228	Laboratory
244	Storage
249	Laboratory/Office
250	Laboratory/Shop
252	Fire Research Test Deck
301	Laboratory/Office
302	Fire II Chamber
307	Laboratory
308	Fire Research Test Deck
309	Laboratory/Storage
310	Laboratory
311	Fire I Chamber
312	Laboratory/Office
313	Laboratory
314	Laboratory

John C. Stennis Space Center
(Stennis Space Center, Mississippi)



Naval Research Laboratory
John C. Stennis Space Center
Stennis Space Center, MS 39529-5004
(228) 688-3390

Naval Research Laboratory Monterey (Monterey, California)



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7 Grace Hopper Avenue
Monterey, CA 93943-5502
(408) 656-4721

Key Personnel

DSN: NRL Washington 297- or 754-; NRL/SSC 828-; NRL/Monterey 878-; NRL VXS-1/Patuxent River 342-

Code		Telephone
	EXECUTIVE DIRECTORATE	
1000	Commanding Officer	(202) 767-3403
1000.1	Inspector General	(202) 767-3621
1001	Director of Research	(202) 767-3301
1001.1	Executive Assistant to the Director of Research	(202) 767-2445
1001.2	Head, Strategic Workforce Planning	(202) 767-3421
1001.3	Executive Assistant for Technology Deployment	(202) 767-0851
1002	Chief Staff Officer	(202) 767-3621
1004	Head, Office of Technology Transfer	(202) 767-3083
1006	Head, Office of Program Administration and Policy Development	(202) 767-1312
1008	Head, Office of Counsel	(202) 767-2244
1030	Head, Public Affairs Office	(202) 767-2541
1100	Director, Institute for Nanoscience	(202) 767-1803
1200	Head, Command Support Division	(202) 767-3091
1400	Head, Military Support Division	(202) 767-2273
1600	Commanding Officer, Scientific Development Squadron One (PAX River NAS)	(301) 342-3751
1700	Director, Laboratory for Autonomous Systems Research	(202) 767-0792
1800	Director, Human Resources Office	(202) 767-8322
1830	Deputy Equal Employment Opportunity Officer	(202) 767-8390
3005	Deputy for Small Business	(202) 767-0666
3540	Head, Safety Branch	(202) 767-2232
	BUSINESS OPERATIONS DIRECTORATE	
3000	Associate Director of Research for Business Operations	(202) 767-2371
3005	Deputy for Small Business	(202) 767-0666
3030	Head, Management Information Systems Office	(202) 404-3659
3200	Head, Contracting Division	(202) 767-5227
3300	Head, Financial Management Division	(202) 767-3405
3400	Head, Supply and Information Services Division	(202) 767-3446
3500	Director, Research and Development Services Division	(202) 404-4054
	SYSTEMS DIRECTORATE	
5000	Associate Director of Research for Systems	(202) 767-3525
5300	Superintendent, Radar Division	(202) 404-2700
5500	Superintendent, Information Technology Division/NRL Chief Information Officer*	(202) 767-2903
5600	Superintendent, Optical Sciences Division	(202) 767-3171
5700	Superintendent, Tactical Electronic Warfare Division	(202) 767-6278
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6000	Associate Director of Research for Materials Science and Component Technology	(202) 767-3566
6040	Director, Laboratories for Computational Physics and Fluid Dynamics	(202) 767-3055
6100	Superintendent, Chemistry Division	(202) 767-3026
6300	Superintendent, Materials Science and Technology Division	(202) 767-2926
6700	Superintendent, Plasma Physics Division	(202) 767-2723
6800	Superintendent, Electronics Science and Technology Division	(202) 767-3693
6900	Director, Center for Bio/Molecular Science and Engineering	(202) 404-6000

*Additional duty

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OCEAN AND ATMOSPHERIC SCIENCE AND TECHNOLOGY DIRECTORATE

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7030	Head, Office of Research Support Services	(228) 688-4010
7100	Superintendent, Acoustics Division	(202) 767-3482
7200	Superintendent, Remote Sensing Division	(202) 767-3391
7300	Superintendent, Oceanography Division	(228) 688-4670
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7500	Superintendent, Marine Meteorology Division	(831) 656-4721
7600	Superintendent, Space Science Division	(202) 767-6343

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Commanding Officer

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