



# Office of Naval Research Basic Research Program

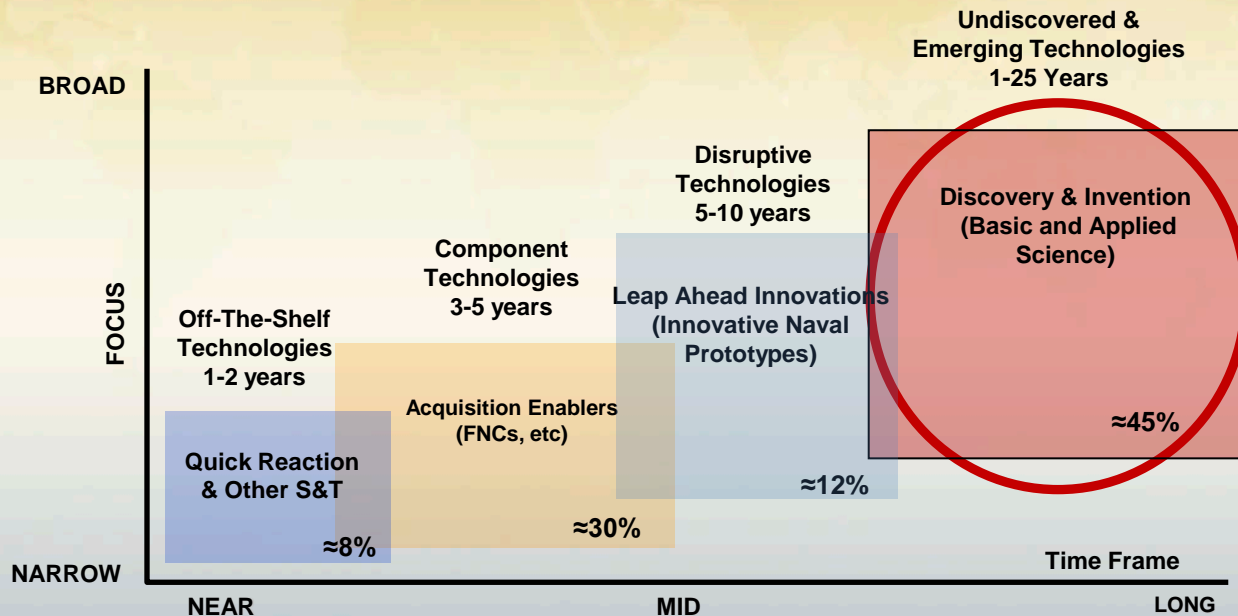


## ONR Discovery & Invention 5 Mar 12

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## University Research Initiatives

URI funds promising new research, stimulates innovation, and attracts outstanding researchers to naval-relevant research projects.

## In-House Laboratory Independent Research

ILIR/IAR programs are focused on providing quality research and revitalizing the competency of the technical workforce.

## Defense Research Science

DRS portfolio objectives are: (1) Develop scientific and fundamental knowledge; (2) Provide the basis for future Navy and Marine Corps systems; and (3) Maintain the health of the defense scientist and engineer workforce.

# ONR FY12 Basic Research (6.1) Spending Authority

**\$577,372K**

\$18,092

- ILIR
- URI
- NWC
- NRL
- ONR

\$113,157

\$30,434

\$301,211

\$114,478

**Defense Research Sciences (ONR Core, NRL, Navy Warfare Centers)**—Primarily investments in basic research that will increase fundamental knowledge, foster opportunities for breakthroughs, and provide technology options for future Naval capabilities and systems. A portion goes to S&E education, career development, and outreach

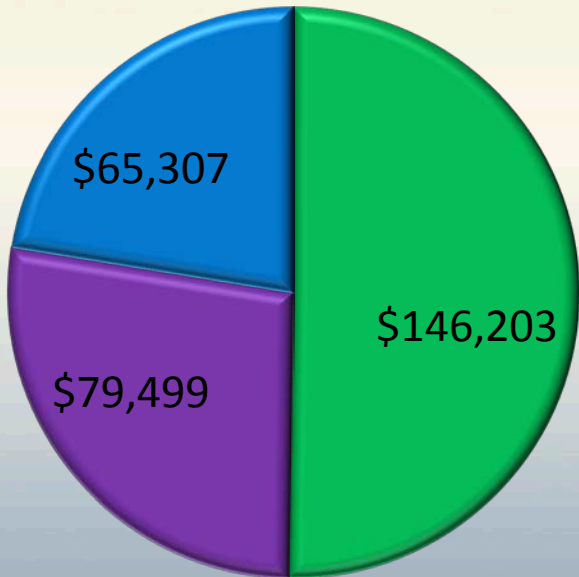
**University Research Initiatives (URI)**—Wide-ranging university research efforts (MURI); university research equipment support (DURIP), and national recognition of exceptionally talented young scientists and engineers (PECASE)

**In-House Lab Independent Research (ILIR)**—ONR-sponsored research of particular interest to individual naval labs & warfare centers

# ONR FY12 Applied Research (6.2) Spending Authority

**\$291,008K**

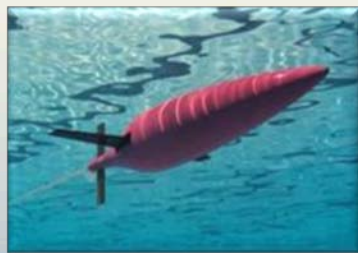
- NWC
- NRL
- ONR CORE



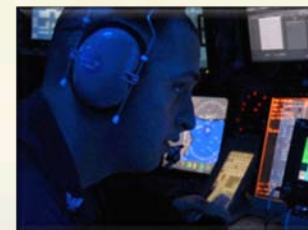
## Applied Research Areas

- Mine and Expeditionary Warfare Applied Research
- Warfighter Sustainment Applied Research
- Power Projection Applied Research
- RF Systems Applied Research
- Undersea Warfare Applied Research
- Ocean Warfighting Environment Applied Research
- Force Protection Applied Research
- Common Picture Applied Research

- Autonomous Sciences
- Bio-Inspired Sciences
- Cognitive, Neural and Training Technologies



- Information Technology Sciences
- Advanced Computing
- Materials
  - Metamaterials
  - Integrated Computational Material Sciences
  - Nano-Manufacturing
- Counter IED Sciences



Assess 6.1 Basic Research portfolio in terms of S&T Quality, Scientific Breakthroughs & Contributions, and Program Risk to determine strengths/weaknesses of the current portfolio.

- Every ONR basic research program will be peer-reviewed during the 2<sup>nd</sup> to 3<sup>rd</sup> year from its inception.
  - ONR Program Officers will schedule an off-site review of their programs
  - ONR Program Officers will convene Peer Review Boards comprised of recognized scientific/technical experts
  - Principal Investigators will present their work
  - O3R will compile Review Panel comments for each program
  - Director of Research, Department Head, and Program Officer will review Panel comments and adjust program as needed

## **Multidisciplinary University Research Initiative (MURI)**

- Teams of researchers investigating high-priority topics that intersect more than one technical discipline.

## **Defense University Research Instrumentation Program (DURIP)**

- Funds (\$.5M to \$1M) will be used for the acquisition of major equipment to augment current or develop new research capabilities in support of DoD-relevant research.

## **Presidential Early Career Award for Scientists and Engineers (PECASE)**

- Honors and supports the extraordinary achievements of young professionals at the outset of their independent research careers in science and technology.





# In-House Laboratory Independent Research (ILIR)

- Provides Navy laboratory directors the ability to invest in basic research of technical interest to meet laboratory mission elements
- ONR funding provided through the Naval S&T for America's Readiness (N-STAR) program office
- Broadens Navy S&T perspective to avert technological surprise
- Provides means for PIs to interact more directly with academia on topics of interest

- Designed to develop and maintain a cadre of subject experts and technologists at the Navy Warfare Centers
- Technical focus is determined by laboratory TD and CO as it relates to mission areas and responsibilities
- All FY09 projects map to the Naval S&T strategic plan

- ILIR provides funding for education & outreach programs
  - Naval workforce development
  - Naval Research Enterprise Internship Program (BS, MS, PhD)

## **ONR Core 6.1 Programs**

- Basic research programs executed by ONR program officers

### **Basic Research Challenge (BRC)**

- Select and fund promising research programs in new areas not addressed by the current basic research program.

### **Young Investigator Program (YIP)**

- Identify and support academic scientists and engineers who are in a tenure-track position.

### **Historically Black Colleges and Universities and Minority Institutions**

- Increase the quantity and quality of minority scientists and engineers.

**The ONR Basic Research Challenge (BRC) Program:** was established to competitively fund promising research programs in new areas not currently addressed by the current basic research program:

- Stimulates new, high-risk basic research projects in multi-disciplinary and departmental collaborative efforts
- Funds topics that foster leading edge science and attract new PIs and organizations
- 4 to 5 Years, up to \$1.5M per year, Inter-Departmental Collaborations

## FY 2012 Program Status:

- 36 Proposals Submitted
- 5 Selected

### FY 2012 Selections

Decentralized On-Line Optimization

Carbon Molecular Electronics

Co-Prime Sensor Array Signal Processing: A New Framework for Reduced Complexity Sensing

Understanding and Characterizing Intuition for more Effective Small Unit Decision Making Training Technologies

Couplings – Ocean to Space or Ionospheric Drivers from Below

# National Naval Responsibility (NNR)

Established by ONR to ensure areas of Naval importance have steady research investment and a trained S&T workforce for basic research

Enhancing the recruitment, training, and retention of researchers through research awards for graduate, post-docs, and early career faculty

FIVE APPROVED NNRs:

Ocean Acoustics  
Undersea Weapons  
Naval Engineering  
Undersea Medicine  
Sea-Based Aviation

TWO PROPOSED NNRs:

Precision Time & Timekeeping  
Underwater Communications



# National Naval Responsibility (NNR)

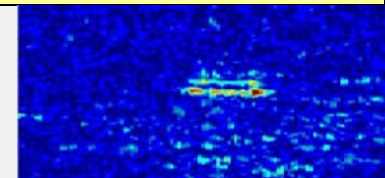
--APPROVED--

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**Ocean Acoustics** Investments in Shallow Water Acoustics; High Frequency Acoustics; and Long Range/Low Frequency Propagation

**Naval Payoffs:** Improved Shallow-water ASW, Wide-Area Surveillance, & SSBN security; Rapid environmental assessment



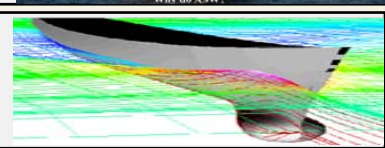
**Undersea Weapons** Focus on Multidisciplinary Systems Design; Guidance & Control; Undersea Warheads; Counterweapons & Countermeasures; and Super-cavitating Weapons

**Naval Payoffs:** Improved Guidance and Control capabilities for littoral environment; improved PK & PCK; increased weapons load-out



**Naval Engineering** Conducts major field experiments that integrate various technologies innovative ship concepts

**Naval Payoffs:** Improved ship design tools, analytics for platform affordability



**Undersea Medicine** Focus Areas include Non-recompressive treatment for decompression sickness (DCS), arterial gas embolism; Accelerated decompression; mechanisms of DCS

**Payoffs:** Extended warfighter reach; Freedom of action (in water column, in thermal extremes & in contaminated water); Optimized submariner & diver performance



**Sea-based Aviation:** Focus on multidisciplinary systems design; autonomous G&C for TO/landing; shipboard-suitable structures and materials; innovative aircraft concepts

**Navy Payoffs:** Matching other technology advancements for integration into revolutionary naval aviation systems. continued Navy/Marine Corps leadership in unique capability / mission areas; Reduced development cost and risk



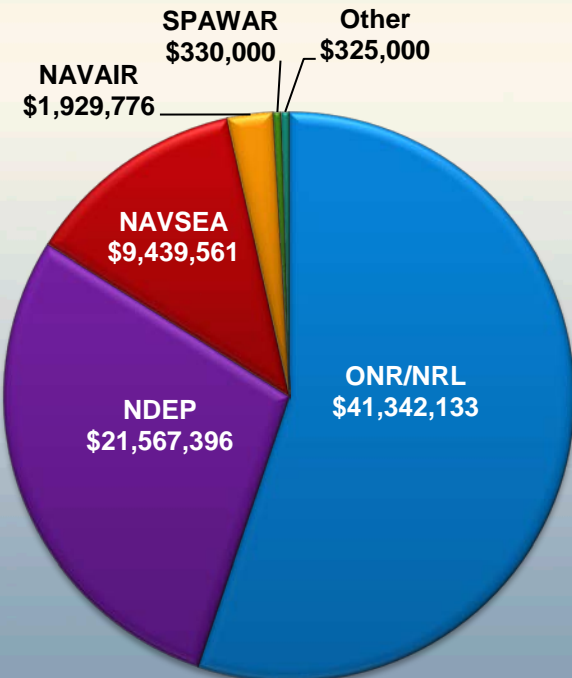
## Education & Outreach for the Naval Enterprise



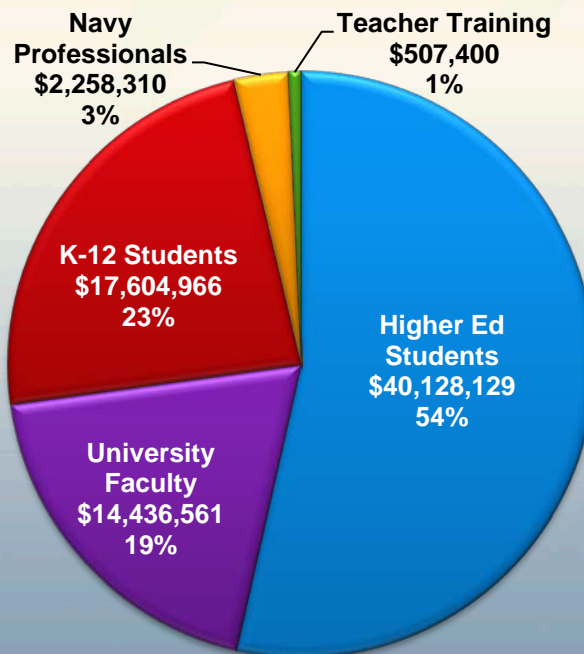
## Fast Facts

- **\$74.9M investment** in STEM (\$54M direct Naval), plus \$108M for ONR supported domestic and graduate students
- 182 Programs (224 engagements)
- 31 Commands
- 69,000 Students (+200,000 via festivals/fairs)
- All 50 States

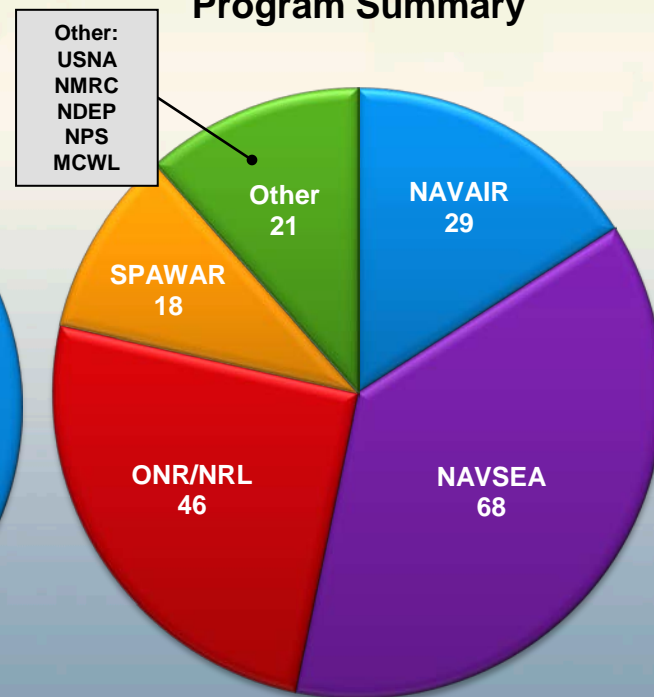
### Investment Summary



### Target Audience



### Program Summary



# Strategic Themes

## Diversity

Engage more under-represented populations

## Collaboration

Partner with nationally recognized, best practice organizations, universities, and industry

## Local is Good

Support the valuable implementation role of SYSCOMS and local organizations

## Naval Relevance

Ensure programs are relevant to the Naval services; especially efforts supported with non-Navy funds

## Metrics

Ensure the appropriate and consistent metrics are in place across the Naval STEM Portfolio, which assess both progress and impact

## Go Viral

Invest in programs and social networking tools that have the potential for rapid growth and geographic expansion







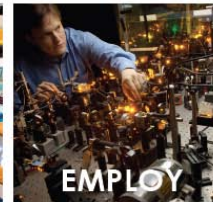
## SECURING OUR FUTURE:

### The Naval Science, Technology, Engineering, and Mathematics (STEM) Workforce



A Strategic Approach

June 2011



## MESSAGE FROM THE SECRETARY OF THE NAVY

The Department of the Navy currently enjoys a high level of technological superiority across the full spectrum of its missions. To maintain this technological superiority, we must nurture a world-class Science, Technology, Engineering and Mathematics (STEM) workforce able to contribute to, and support, a culture of innovation. I am committed to the Department's aggressive leadership role in STEM education, to improve the quality and the quantity of the future STEM workforce, from which we will draw future Sailors, Marines, Engineers and Scientists.

The need is clear -- large numbers of Naval STEM professionals will be retiring over the next few years, and fewer American students are graduating with the preparation and interest needed to pursue STEM careers.



In FY 2010, the Navy portfolio included over \$54 million in direct investments as well as an additional \$20 million from the Department of Defense spread across 180 STEM programs nation-wide. An additional \$108 million was invested annually to support domestic graduate students and research assistants under research grants to academic institutions. These investments are significant but not sufficient. As a result, I have committed to doubling the Department of the Navy's direct investment in STEM over five years, to more than \$100 million dollars.



This Strategic Roadmap presents a path forward for the Navy and Marine Corps -- a way to increase our impact on STEM education. This plan provides strategies to address gaps and weaknesses in the current Naval STEM portfolio, and includes exciting new programs that will help increase participation by students and teachers. As the Naval STEM Executive, the Chief of Naval Research will continue to align service-wide STEM education and outreach efforts using this Roadmap as a guide.

I challenge each of you to enter the discussion and consider how you can take bold steps to partner with us to expand, enhance and increase the effectiveness of the nation's investments in STEM education. More importantly, I challenge you to remember what first excited you about STEM subjects and to consider how the experiences and technologies of tomorrow can inspire the same excitement in our future scientists and engineers.



The Honorable Ray Mabus  
Secretary of the Navy

- The Office of Naval Research (ONR) coordinates, executes, and promotes the science and technology programs of the United States Navy and Marine Corps through schools, universities, government laboratories, and nonprofit and for-profit organizations.
- The Business Opportunities web site at: <http://www.onr.navy.mil/Business.asp> provides a step-by-step guide to business opportunities with ONR for the Public Sector, Commercial Contractors, Non-Profit Organizations, Universities and Colleges.
- Opportunities include the [Long Range Broad Agency Announcement \(BAA 12-001\)](#) for Navy and Marine Corps Science & Technology and [Requests for Proposals \(RFPs\)](#) from the Acquisition Department.
- STEM: Funding Opportunity Announcement (FOA 12-002)
- Navy STEM web site: [www.STEM2stern.org](http://www.STEM2stern.org)
- Guidance for submitting a proposal may be found at [http://www.onr.navy.mil/02/how\\_to.asp](http://www.onr.navy.mil/02/how_to.asp) including instructions for Electronic Application and Submission Information via [www.Grants.gov](http://www.Grants.gov)

# BACK-UP SLIDES

## Graphane, a chemical derivative of Graphene

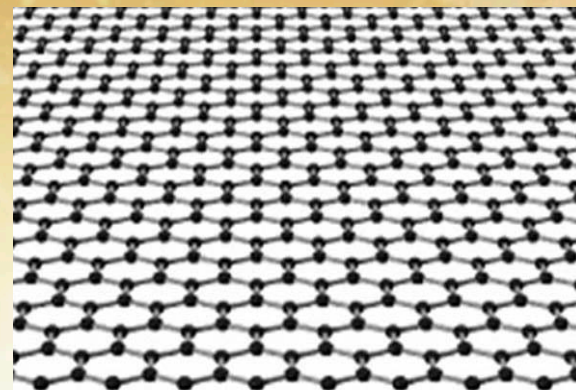
- Formed by attaching a hydrogen atom to each of the carbon atoms in the original graphene sheet
- Hydrogen alternates between above and below the sheet

## Graphene and Graphane have drastically different electronic properties

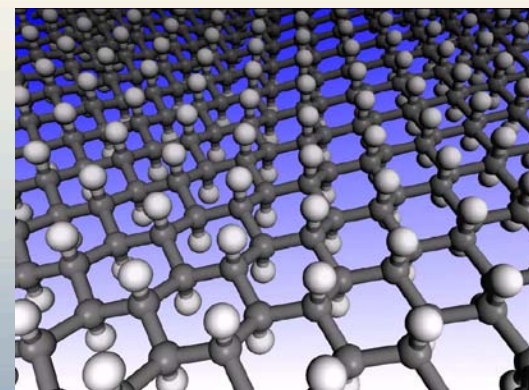
- Graphene is the best conductor known to man (at room temperature)
- Graphane is an electrical insulator

## Graphene-Graphane reaction is entirely reversible

*ONR Researchers, Geim & Novoselov, Awarded 2010 Nobel Prize in Physics*



GRAPHENE (Single-layer 2D Carbon)



GRAPHANE (Single-layer 2D Hydro-Carbon)

- ONR first in US to fund basic research; initial work general in nature, e.g. entire circuit perspective
- ONR & AFOSR work closely via the MURI process
- DARPA exploring RF applications

New ways of constructing 2D electron devices and circuits

## ONR research support produced:

- Three Nobel Prizes (1997, 2001, & 2005)
- Four ONR Nobel Laureates
- Two orders of magnitude improvement in Naval Observatory primary clock



1997

Phillips



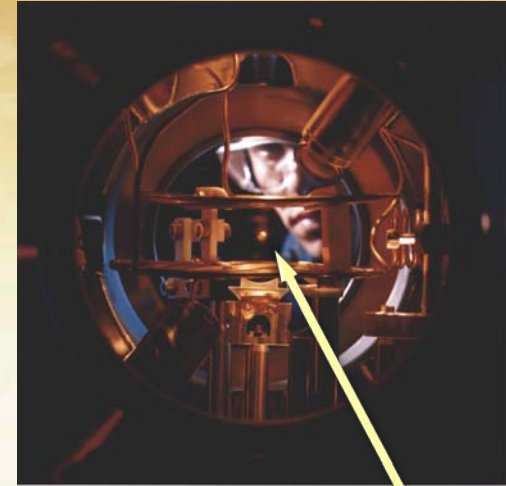
2001

Kettlerly  
Wieman



2005

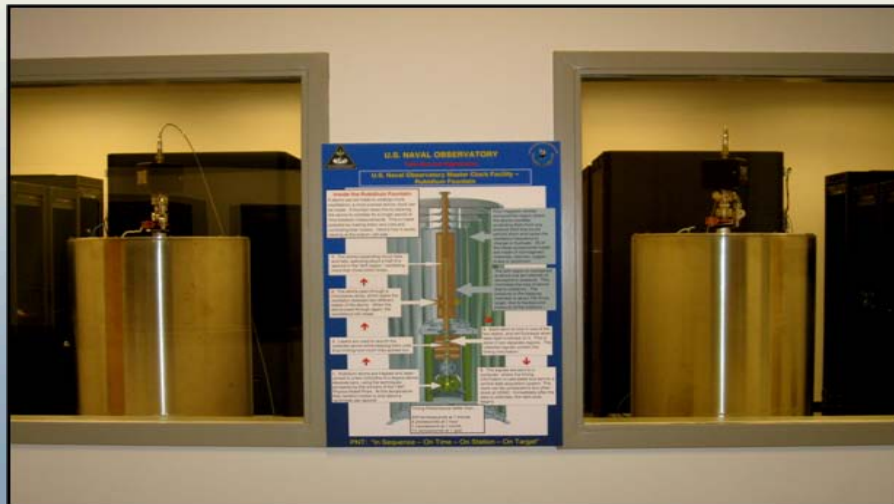
Hall



Ball of Laser-Cooled Atoms

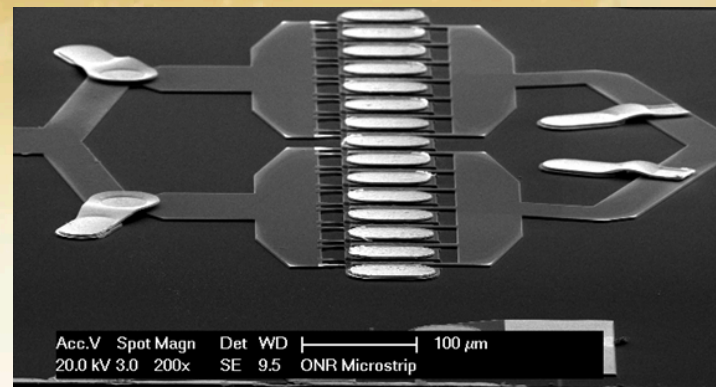
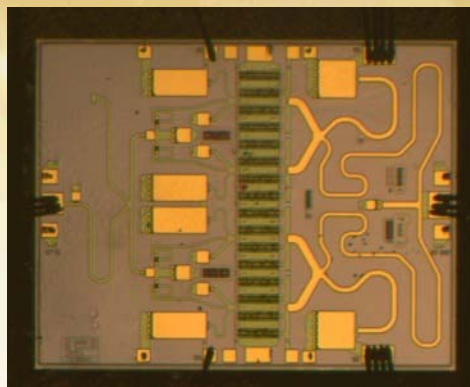
## Precision Time and Timekeeping (PTT):

- ONR funding for basic research in atomic clocks has led to significant advances in PTT.
- The US Naval Observatory (USNO) maintains the DoD Master Clock with 60 Cs (Cesium-133) atomic clocks, 20 Hydrogen maser clocks, and two Cesium Fountain atomic clocks.
- The DoD Master Clock is a Critical National Defense Technology (MCTL Section 16).



## GaN & SiC Components—

- ONR funded basic research on Si & GaN components led to the development of the wide bandgap semiconductors.
- Breakthrough technology necessary to meet performance parameters within the space and weight constraints of the E-2D surveillance system design specification.



## ONR research produced wide bandgap semiconductors which:

- Led to compact, high power RF amplifiers for E-2D
- Is enabling development for high frequency, power amplifiers for Nulka and SEWIP

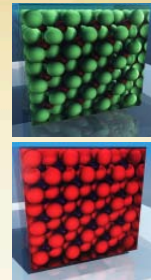
## Basic Research Objective:

- Design engineered elasto-acoustic materials exhibiting anisotropic density and stiffness
- Develop phononic crystal and resonator systems with tunable bandgaps exhibiting negative refractive properties

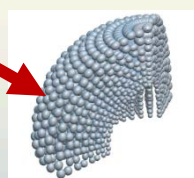
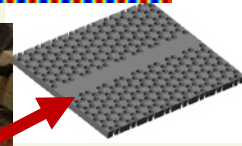
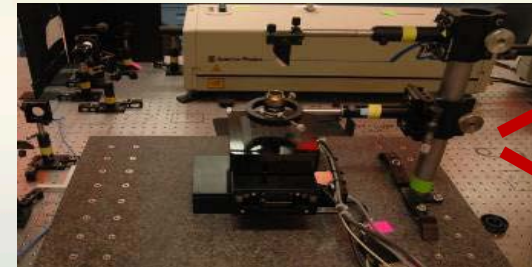
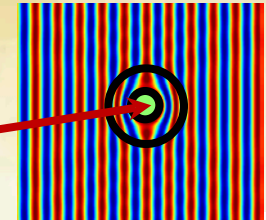
## Technical Approach:

- Hybrid materials with effective negative density and bulk modulus
- Composites of pentamode and orthotropic bimodal materials
- Physics of multiple scattering induced anisotropy in the homogenization limit ( $\lambda > 4a$ )
- Three-dimensional lithographic, modeling, & simulation tools

Proposed Multicomponent Cylindrical Composite



Acoustic Simulation of Composite



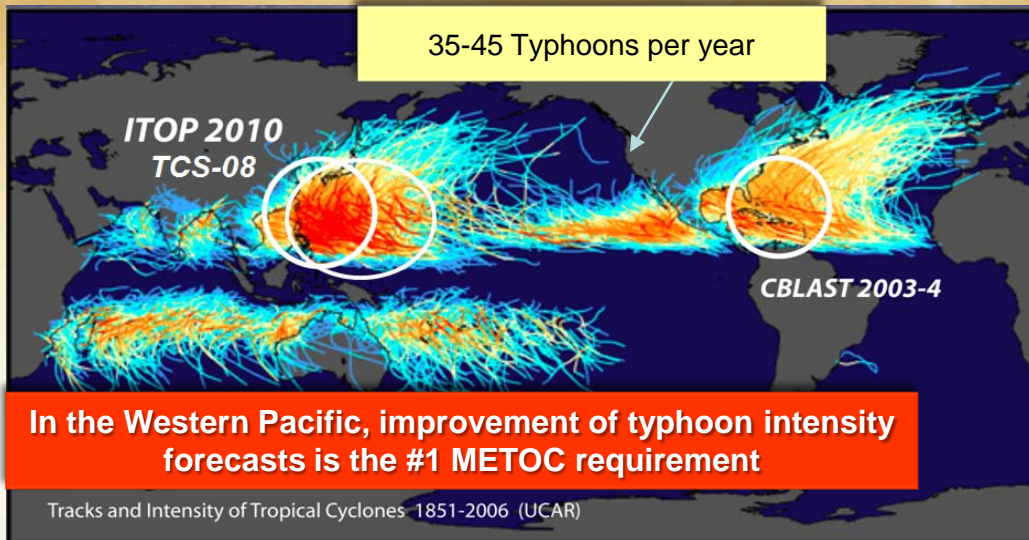
High-speed, high precision 3D fabrication system for phononic crystal (top) and pentamode materials (bottom)

- ONR is uniquely supporting work on acoustic metamaterials for underwater environments
- AFRL has an applied research program focused on identifying near-term applications of metamaterials

## S&T Products (Warfighter Payoff):

- Large-scale rapid 3D fabrication tools
- Acoustic hyperlens for underwater detection
- Next-generation acoustic vector sensors
- Advanced noise/vibration reduction
- Active and passive acoustic stealth coatings

# Tropical Cyclone Formation & Intensity Forecasts



## Basic Research Efforts

### 2003-2004:

- Confirmed coefficient of drag drop at high winds
- Demonstrated need to include waves in coupling physics
- Developed new class of air deployable sensors to observe upper ocean in high wind conditions

### TCS-08 Field Program (2008):

- Observed storm formation in WestPac
- Characterized storm interaction with ocean eddy field
- New technology to observe development of convection

### ITOP 2010 Field Program will:

- Examine cold wake evolution and decay for ASW
- Investigate interaction of storm, wake, and eddy fields
- Field new sensors for tropical cyclone conditions

2004-2012

**6.2 Transition:** Enhance the Coupled Atmosphere-Wave-Ocean Model for Operational Evaluation

2009-2012

**Joint 6.2/6.4 Rapid Transition Program:** Collaborate with operational centers to transition research model to full operational status in 3 years for all typhoon, cyclone, and hurricane forecasts for global Fleet support



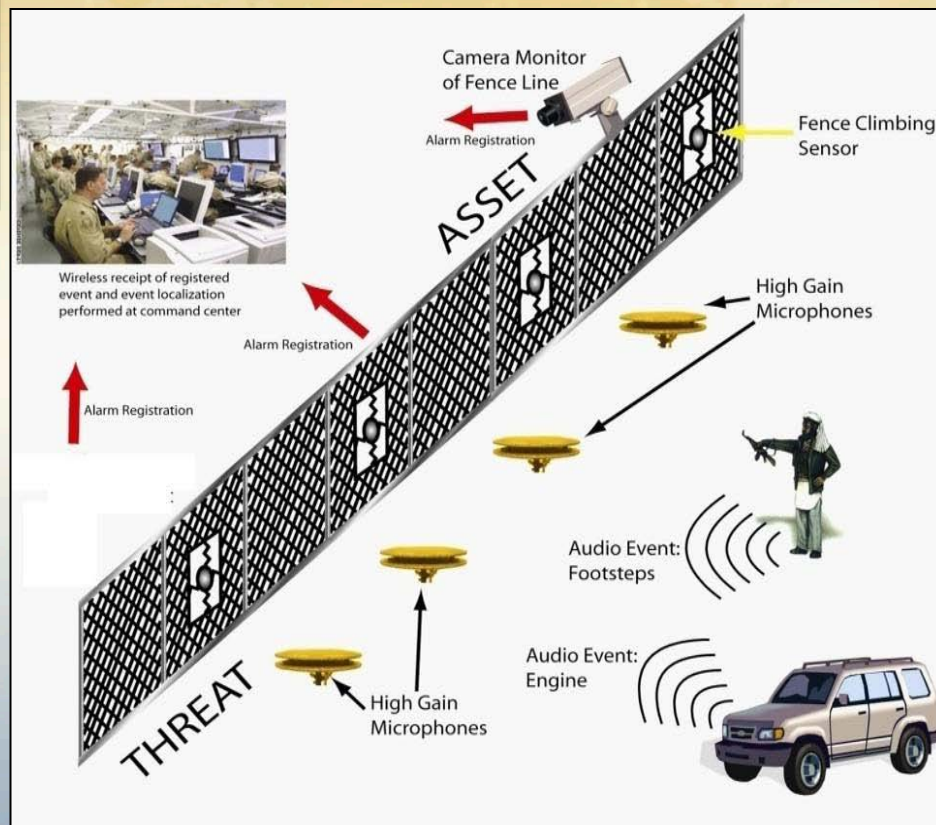
## Early basic work:

### Bio-inspired auditory/visual/motor abilities:

- Auditory – sniper localization
- Visual – object detection & identification
- Motor – hydrodynamics & neural controller

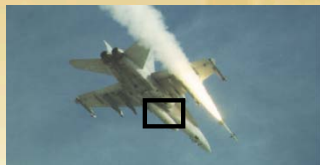


Ghost swimmer



Led to Autonomous/underwater robotic systems and Smart Fence

Beyond 6.3 & Civilian  
6.3  
6.2  
6.1



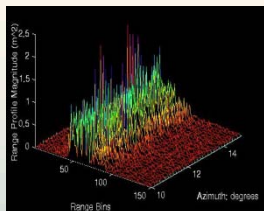
**Surgical Strike Datalink Project (6.3 Demo)**  
Use video compression, Eliminate the 682 lb AN/AWW13 video datalink pod  
NAWCWD, Rockwell, Boeing



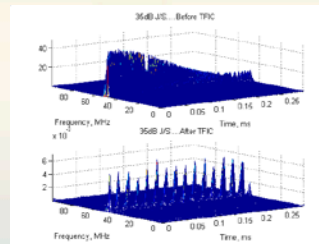
**FBI Fingerprint Compression Standard**



**JPEG2000 compression for Special Operations Forces**



**Wavelet Radar Analysis for HRR and SAR**



**Comms through IED Jammers**



**Query Example Image Library Search Result**

**Image Database Browsing With Complex Wavelets**

University Research on wavelet theory, multi-resolution analysis, mathematical and computational tools

1<sup>st</sup>. Federal grant on wavelet research  
**1986**

Broadened research efforts at academia, DoD labs/centers, and industry  
**~1988**

Emergence of DoD and Civilian Applications  
**~1997**

Industry compression standard JPEG 2000  
**2001**

Numerous DoD & Civilian Applications  
**2000 +**