Federal Update Webinar

ONR Discovery and Invention

Dr. David K. Han
Deputy Director of Research

david.k.han@navy.mil

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Naval S&T Strategic Plan

S&T Plan Focus Areas:
- Assure Access to Maritime Battlespace
- Autonomy & Unmanned Systems
- Expeditionary & Irregular Warfare
- Power Projection/Integrated Defense
- Information Dominance
- Power & Energy
- Platform Design & Survivability
- Total Ownership Cost
- Warfighter Performance

- Cascades from National, DoD and SECNAV/CNO/CMC Guidance
- Vetted by Fleet/Forces Stakeholders
- Approved by DoN S&T Corporate Board

Focus

- Broad
- Narrow

Time Frame

- Near
- 1-2 years
- Quick Reaction & Other S&T ≈ 8%
- QR S&T
- FNCs

- 3-5 years
- Acquisition Enablers (FNCs, etc) ≈ 30%

- 5-10 years
- Leap Ahead Innovations (Innovative Naval Prototypes) ≈ 12%

- 5-20 years
- Discovery & Invention (Basic and Applied Science) ≈ 45%

INPs

D&I
Discovery & Invention (D&I) consists of Basic Research (BA 6.1) and early Applied Research (BA 6.2). It is the essential foundation required for advanced technology:

- Focused on 5-20 years out
- ≈ 45% of ONR’s budget
- New investments selected through competitive process across warfare areas
- D&I budget includes:
  - ONR’s core research programs
  - University Research Initiatives (MURI, DURIP, PECASE)
  - In-House Laboratory Independent Research
  - STEM

- Diverse portfolio
- Fosters innovation
- Long-term
- Investment in people: 64, 62 Nobel laureates

Discovery & Invention (Basic and Applied Science) ≈ 45%
2012 Nobel Prize in Physics “for groundbreaking experimental methods that enable measuring and manipulation of individual quantum systems.”

Quantum logic-enabled aluminum ion clock, accuracy equivalent to 1 second in 32 billion years.

- Dr. Wineland’s research sponsored by ONR since 1978
- First demonstration of quantum logic gates (1995)
- World’s most accurate clock, based on quantum entanglement (2010)
- National Medal of Science (2007)
- Benjamin Franklin Medal (2010)
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).
- ONR funding sustains the Atomic Clock industrial base in U.S.

ONR research support produced:
- Four ONR Nobel Laureates
- Two orders of magnitude improvement in Naval Observatory primary clock

Global Positioning Systems (GPS):
The origin of GPS began in 1960 when the Navy launched the Transit satellite constellation for submarine navigation. Today’s GPS systems are possible because of ONR sponsored research in precision timekeeping. ONR funding currently sustains the atomic clock industrial base in U.S.
ONR research produced “Wide Bandgap Semiconductors”
- Led to compact, high power RF amplifiers for E-2D
- Is enabling development for high frequency, power amplifiers for Nulka and SEWIP

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.

Tropical Cyclone Formation & Intensity Forecasts

35-45 Typhoons per year

In the Western Pacific, improvement of typhoon intensity forecasts is the #1 METOC requirement

Basic Research Efforts —

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.
Graphene - Graphane

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

- 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
FOCUS AREAS:

Assure Access to the Maritime Battlespace

ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology
ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology

FOCUS AREAS:

Autonomy and Unmanned Systems

Human/Unmanned Systems Collaboration

Scalable and Robust Distributed Collaboration
ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology

FOCUS AREAS:

Expeditionary and Irregular Warfare

Irregular Threat Countermeasures

Irregular Warfare Battlespace Awareness

Expeditionary and Distributed Operations
Program Selections

**FOCUS AREAS:**

- **Information Dominance**

- **Computational Environment Architecture**
  - Information Space for Integrated C2, ISR, and Combat Systems Decision Making

- **Computer Network Operations**

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ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology
Program Selections

**FOCUS AREAS:**

**Platform Design and Survivability**

*ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology*
ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology

FOCUS AREAS:

Power and Energy

High Energy and Pulsed Power
ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology

FOCUS AREAS:

Power Projection and Integrated Defense

Integrated Layered Defense

Future Naval Fires
Program Selections

**ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology**

**FOCUS AREAS:**

- Total Ownership Cost
- Lifecycle and Sustainment Cost
- Platform Affordability
Program Selections

ALL 6.1 AND EARLY 6.2 (D&I) Map to Naval Science and Technology

FOCUS AREAS:

Warfighter Performance

Warfighter Health and Survivability

Manpower, Personnel, Training and Education
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.

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

Two areas are being considered for designation as NNRs:

- Precision Time and Timekeeping
- Communications across the ocean-air interface
Research Areas of Emphasis

Autonomous Sciences
Bio Inspired Sciences

In-Water Tests of the Mantabot
Data Analysis: Image Sequence

Speed: 1 BL/s
Fin flapping freq.: 1.1 Hz
Fin flapping amp.: 0.4 BL
Strouhal number: 0.44
Research Areas of Emphasis

Cognitive, Neural, and Training Technology
Research Areas of Emphasis

Information Technology Sciences
Advanced Computing

Molecular Dynamics (MD) trajectory reduced to a continuous-time Markov chain

Electron density of a carbon chain computed using a linear scaling algorithm

Succession of transitions between hyper-surfaces (the milestones) for the evolution of a protein.
A schematic of the flow of information in an integrated suite of computational tools for aluminum cylinder heads that includes a manufacturing process (casting) a material system (Al-Si alloys) and a component (cylinder head) that dictates the set of key properties and the geometry.
Research Areas of Emphasis

Counter IED Sciences
Program Selections

FOCUS AREAS

**New Basic Research Areas of Emphasis**
- Autonomous Sciences
- Bio-Inspired Sciences
- Cognitive, Neural and Training Technologies
- Information Technology Sciences
- Advanced Computing
- Materials
- Counter IED Sciences

**Five Approved NNRs:**
- Ocean Acoustics
- Undersea Weapons
- Naval Engineering
- Undersea Medicine
- Sea-Based Aviation

**Two Proposed NNRs:**
- Precision Time & Timekeeping
- Electromagnetic Communications Across the Ocean-Air Interface
Basic research is defined by the DoD as a systematic study directed toward greater knowledge of understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. It includes knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. REF: Department of Defense Financial Management Regulation, DOD 7000.14-R, Vol. 2B, Chapter 5, July 2008.
ONR FY13 Basic Research (6.1) D&I Spending Authority

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 FY13 Applied Research (6.2) D&I Spending Authority

$313,305

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

ONR + NWC $224,135
NRL $89,170
University Research Initiatives

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.

Multidisciplinary University Research Initiative (MURI)
Teams of researchers investigating high-priority topics that intersect more than one technical discipline.

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.
Defense University Research Instrumentation Program (DURIP)

Supports university research infrastructure essential to high-quality Navy-relevant research

- Proposals may request $50,000 to $1,500,000
- Funds will be used for the acquisition of major equipment to augment current or develop new research capabilities
  - Over 270 proposals were submitted for FY12
  - 96 proposals totaling $32.8M were funded
Multidisciplinary University Research Initiative (MURI)

- Multiple institutions investigating high priority topics
- Stimulate innovations, Accelerate research progress, Expedite research transition into naval applications
- 9 MURI grants were initiated in FY12.

**BIO-BASED OLFACTORY PROCESSING**
MURI: UCSD/Cal. Tech./U. Pittsburgh

**MATERIALS APPROACH to FORCE PROTECTION**
MURI: UVA/Harvard

**Direct Methanol Fuel Cells (DMFC)**
MURI: Univ of Texas at Austin
The PECASE award recognizes and honors outstanding scientists and engineers at the outset of their independent research careers. In FY12, 4 ONR funded researchers and 2 Navy Laboratory researchers received PECASE awards.
Defense Research Sciences

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 (HBCU/MI)
Increase the quantity and quality of minority scientists and engineers.

ONR Core 6.1 Programs
Basic research programs executed by ONR program officers.
Basic Research Challenge (BRC)

- Competitively funds promising Basic Research programs
- New areas not currently addressed by the Basic Research program
- Stimulates new, high-risk Basic Research projects
- Multi-disciplinary and Departmental collaborative efforts

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

Expected outcome: A comprehensive theory of co-prime sensing system design.

What is Intuition?

How can we enhance it?

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

Decentralized Online Optimization Surveillance Scenario: New Potential Targets Pop Up

Objects: 5 ships Activity: Abnormal Convoys toward shore

Couplings – Ocean to Space or Ionospheric Drivers from Below
Young Investigators Program (YIP)

- Attracts outstanding new faculty researchers to naval-relevant research
- Encourages their teaching and research careers
- 26 awards in FY12
- The FY13 Young Investigator Program (YIP)
  - Broad Agency Announcement will be posted at Grants.gov
  - Proposals accepted December 2012
  - Anticipating 16 awards in FY13
  - FY13 grants to begin May 2013
  - Funding available: $8.3M over three years

Elizabeth Boon, Stony Brook University
Nitric Oxide Signaling in Bacterial Biofilms
ONR Young Investigators Award (2008)

Adrienne Stiff-Roberts, Duke University
Hybrid Nano Material for Infrared Photodetectors
ONR Young Investigators Award (2007)

John Dabiri, California Institute of Technology
Biological Propulsion
ONR Young Investigators Award (2008)
Computational Modeling of Blast-Induced Traumatic Brain Injury (bTBI)
- Investigate effects of blast overpressure on the brain
- Anatomically correct computational model
- Uses real tissue properties
- Identifies extent material property differences
- Enhance / create stress localizations or cavitation
  (NSWC Indian Head)

Stern Flaps for Surface Ship Energy Savings
The Stern Flap has been installed on over 170 Navy and Coast Guard vessels with an estimated fuel savings of over $795M as of 28 Feb 2012.
- ILIR Research in the 1980s developed the computational hydrodynamic tools that enabled development of the Stern Flap.
- Tools allowed modeling that improved the understanding and fidelity for an efficient full-scale design.
  (NSWC Carderock)

Sensors and Sonar Systems

Acoustically Transparent Structurally Strong Windows (NUWC Newport)

Flextensional Transducers (NSWC Panama City)

High Frequency Array Window

Sonar & Torpedo Countermeasures Installed on USS VIRGINIA
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 2nd to 3rd 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
  – 03R 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
• Peer Review of basic research programs began with Code 32 Environmental Optics program in Feb 2010
Why Naval STEM?

- >50% of DoN’s current S&T workforce will be retirement eligible by 2020
- Reductions in the STEM talent base will negatively impact DoN’s technological superiority
- DoN must rely on U.S. citizens for classified technical work

First university degrees in natural sciences and engineering, selected countries

We must grow our future STEM leaders
The Navy’s Vision

“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...” – SECNAV 2011

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 opened access 186 STEM programs nationwide. An additional $158 million was invested annually to support domestic graduate students and research assistants under research grants to academic institutions. These investments are significant but insufficient. As a result, I have committed to doubling the Department of the Navy’s direct investment in STEM over the next 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 national 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

Page 1: Securing Our Future: The Naval STEM Workforce
Consequences of Success...

At a national level

0.5σ increase in math / science scores may increase GDP growth rates by up to 0.87%
Naval STEM
Priorities and Themes

• Diversity -- Engage more with under-represented populations

• Best Practices -- Partner with nationally recognized, best practice organizations

• Collaboration -- Support the valuable implementation role of SYSCOMS and local organizations; leverage resources for maximum impact

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

• Metrics -- Establish & implement metrics to assess progress & impact across the Naval STEM Portfolio

• Go Viral -- Invest in tools with potential for rapid growth & geographic expansion
### STEM Landscape

#### Programs

<table>
<thead>
<tr>
<th>Elementary</th>
<th>Middle</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underrepresented Family Science</td>
<td>Internships</td>
<td>Science Fairs</td>
</tr>
<tr>
<td>Science Fairs</td>
<td>Digital Tutors</td>
<td>Robotics</td>
</tr>
<tr>
<td>iApps</td>
<td>Internships</td>
<td>Camps</td>
</tr>
</tbody>
</table>

#### Undergraduate

- Internships
- Scholarships
- Competitions
- Cohorts

#### Masters

- Internships
- Scholarships
- Fellowships

#### PhD

- Scholarships
- Fellowships

#### Faculty Research, Teacher Training & Professional Development

- Young Investigator
- Summer faculty

#### Levers

- Fun
- Interesting
- Hands-on
- Real-world
- Family Involvement
- Use of Near-Peers

#### Metrics

- Inspire
- Engage
- Educate

- Exciting / Relevant
- Competition
- Mentoring
- Social Networking
- Funding / Support
- Real-world Experience

- Employment/Stability
- Prestige
- Relevance
- Compelling Research
- Opportunity to Publish

#### Office of Naval Research
## Selected Efforts

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
<th>Students / Teachers</th>
<th>Minority Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K-12</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• SeaPerch</td>
<td>Middle School robotics competition -- Nationwide</td>
<td>35,000 / 4,000</td>
<td>45%</td>
</tr>
<tr>
<td>• Technovation</td>
<td>High School Girls App Development competition</td>
<td>730</td>
<td>40%</td>
</tr>
<tr>
<td>• Iridescent Family Science</td>
<td>Elementary and Middle School hands-on after school program</td>
<td>7,270</td>
<td>95%</td>
</tr>
<tr>
<td>• National Math and Science Initiative</td>
<td>High School AP courses for Military Dependents</td>
<td>800</td>
<td>26%</td>
</tr>
<tr>
<td>• SEAP</td>
<td>High School internship program</td>
<td>215</td>
<td>21%</td>
</tr>
<tr>
<td>• Sally Ride Science and ASM Teacher Training</td>
<td>Middle and High School Teacher Training Programs</td>
<td>200</td>
<td>From Rural AL, MS and LA</td>
</tr>
<tr>
<td>• Summer Camps (CSI, NSBE)</td>
<td>Middle School hands-on camps</td>
<td>300</td>
<td>80%</td>
</tr>
</tbody>
</table>
# ONR STEM

## Selected Efforts

<table>
<thead>
<tr>
<th>Program</th>
<th>Target</th>
<th>Students / Teachers</th>
<th>Minority Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher Ed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• NREIP</td>
<td>College Internship program at the Labs and Centers</td>
<td>155</td>
<td>15%</td>
</tr>
<tr>
<td>• NRL STEM Academy</td>
<td>Minority focused College Internship at NRL</td>
<td>45</td>
<td>100%</td>
</tr>
<tr>
<td>• Florida International University</td>
<td>Reinventing Curriculum for basic STEM Courses</td>
<td>Development beginning in Fall</td>
<td>83%</td>
</tr>
<tr>
<td>• UT Pan American</td>
<td>Developing 10-15 Navy Relevant STEM Courses</td>
<td>1700</td>
<td>97%</td>
</tr>
<tr>
<td><strong>Tools</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• BHEF Higher Ed STEM Model</td>
<td>Developed Model of best practices for Higher Ed Retention Programs</td>
<td>To be used to select future Naval Programs</td>
<td>Launch Fall 2012</td>
</tr>
<tr>
<td>• Digital Tutor Grand Challenge</td>
<td>Development of Middle School and new recruit STEM Tutor</td>
<td>4 Awards</td>
<td>Oct. 1 Start Date</td>
</tr>
<tr>
<td>• Gooru</td>
<td>Online Student and Teacher Resource</td>
<td>4500 / 200</td>
<td>60%</td>
</tr>
</tbody>
</table>
FOA (Funding Opportunity Announcement) requests innovative ideas to extend and enhance ONR’s current STEM portfolio to:

- **Inspire** the next generation of scientists and engineers, including women and persons from populations under-represented in STEM.
- **Engage** students in STEM-related hands-on learning activities using Naval-relevant content.
- **Educate** students to be well prepared for employment in STEM disciplines in the Navy or in supporting organizations.

**Successful proposals will:**

- Provide “game changing” solutions
- Include active participation by DoN personnel, and/or collaborations with DoN Activities, Commands, or Labs
- Contain a strategy for self – sufficiency