Brief to S&T Partnership Conference

Dr. Michael Kassner
Director of Research
Office of Naval Research
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**Develop Naval-relevant fundamental knowledge**
- Expand the boundaries in traditional Naval interest research areas
- Examine new research directions for future Naval needs
- Encourage risk-taking to seek scientific breakthroughs

**Provide the basis for future Navy and Marine Corps systems**
- Ensure research relevancy to Naval S&T strategy
- Transition promising Basic Research to applications
- Use knowledge (even failures) to reduce risk in acquisition

**Maintain the health of the Defense Scientist and Engineer workforce**
- Develop and nurture future generation of DoD researchers and engineers
- Ensure continued U.S. advantage in intellectual capital
- Maintain unique/essential research infrastructure

**Knowledge Transitions**

**People**

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**Office of Naval Research**

**Discovery & Invention**
Focus Areas:
- Power and Energy
- Operational Environments
- Maritime Domain Awareness
- Asymmetric & Irregular Warfare
- Information Superiority and Communication
- Power Projection
- Assure Access and Hold at Risk
- Distributed Operations
- Naval Warfighter Performance
- Survivability and Self-Defense
- Platform Mobility
- Fleet/Force Sustainment
- Total Ownership Cost
Research Areas of Emphasis

- 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
- Mechanics: Solid & Fluid
– 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.
NSF and ONR Basic Research Budget Histories 1951 – 2010

ONR/NSF 6.1 Constant FY10 $

NSF Funds 1951 - 2008

ONR Funds 1962 - 2010
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.
Multidisciplinary University Research Initiative (MURI)

- Multiple institutions investigating high priority topics
- Stimulate innovations
- Accelerate research progress
- Expedite transition of results into naval applications
- Eight MURI grants were initiated in FY2009.
- For FY2010, proposals will be solicited in research areas determined by DDR&E Director of Basic Research

**University Research Initiatives**

**Multidisciplinary University Research Initiative (MURI)**

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

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

- **RADIATION BELT DYNAMICS**
  - MURI: UCLA/U. Maryland

**Gas detection**

- Acquisition
- Pre-processing
- Data processing
- Identification
- Pattern Recognition
- Olfactory bulb
- Brain
- Smell
- Pollutant gases
- Sensors
- Generation signal
Defense University Research Instrumentation Program (DURIP) supports university research infrastructure essential to high-quality Navy-relevant research

- Proposals may request $50,000 to $1,000,000
- Funds will be used for the acquisition of major equipment to augment current or develop new research capabilities
  - Over 270 proposals were submitted for FY2011
  - Approximately 60 proposals totaling $15.5M will be funded
  - Awards will be in place by June 2011
Presidential Early Career Award for Scientists and Engineers (PECASE)

- The PECASE award recognizes and honors outstanding scientists and engineers at the outset of their independent research careers.
- In FY2011, 5 ONR researchers have been nominated for their work in the following areas:
  - Mathematics
  - Health Sciences
  - Electronics
  - Optics
  - Ocean Circulation
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 have received Ph.D. or equivalent degrees within the last five years

Historically Black Colleges and Universities and Minority Institutions
• 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

- 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

FY11 BRC Program Selections

- Biologically-Inspired Flow Field Computation for Sensing and Control of Ground Vehicles
- Serial Section of a Zr-Cu electrical connector
- Development of analytical and computational techniques for multi-physics based models
Young Investigator Program
25th Anniversary Celebration

October 15, 2010
ONR Core 6.1 Programs

- Six Science and Technology Departments coordinate and execute the basic research investment strategy

- Code 30: Expeditionary Maneuver Warfare & Combating Terrorism
- Code 31: C4ISR
- Code 32: Ocean Battlespace Sensing
- Code 33: Sea Warfare and Weapons
- Code 34: Warfighter Performance
- Code 35: Naval Air Warfare and Weapons
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\textsuperscript{nd} to 3\textsuperscript{rd} 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
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

FOUR APPROVED NNRs:
- Ocean Acoustics
- Undersea Weapons
- Naval Engineering
- Undersea Medicine

THREE PROPOSED NNRs:
- Precision Time & Timekeeping
- Underwater Communications
- Sea-Based Aviation
Early basic work:
Bio-inspired auditory/visual/motor abilities:
• Auditory – sniper localization
• Visual – object detection & identification
• Motor – hydrodynamics & neural controller
• Led to: Autonomous / underwater robotic systems and Smart Fence

Ghost swimmer
ONR Research has

- Identified a strain of bacteria that yields 8X the power of the original strain
- Showed that bacterial ‘nanowire’ structures conduct electricity in biofilms
- Developed MFC design that allows sustained operation in air, even with bacteria that can’t tolerate air
- Developed strategies for evaluating which bacterial genes are important for electricity production
- Gained understanding of electron transfer reactions at the cathode which will allow optimization of MFC

**MFC now operable in air for extended periods**

- Fundamental knowledge of microbial physiology enables improved power and efficiency
- MFC is non-hazardous (no H₂ gas, no explosive reactants)
- Time Magazine named MFC one of the Top 50 Inventions of 2009

Geobacter bacteria produce protein-based ‘nanowires’ which conduct electricity

MFCs generate small amounts of electricity and are useful for powering undersea sensors and other small devices.
Early basic work:
- Acoustic sensor
- Controller & auto-pilot
- Hydrodynamics & body design

Led to: Undersea Gliders for Littoral Battlespace Sensing
Acoustic Metamaterials

Proposed Multicomponent Cylindrical Composite

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

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
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*

**New ways of constructing 2D electron devices and circuits**
Precision Time & Timekeeping

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

1997
Phillips

2001
Kettle
Wieman

2005
Hall

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

CBLAST (2003-2004) Field Program
- 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

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

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

35-45 Typhoons per year
ONR research produced wide bandgap semiconductors which:
- Lead to compact, high power RF amplifiers for E2-D
- Is enabling development for high frequency, power amplifiers for Nulka and SEWIP

GaAs, GaN, & SiC Components
Semiconductor Spintronics

Goal: develop science & technology to use *spin angular momentum* as an alternate state variable in semiconductors *(International Technology Roadmap for Semiconductors - 2009)*

Next Breakthrough for Electronics

- No RF Heating
- Net Spin Current
- Spin Injection
- FM metal
- Interface
- Semiconductor

Warfighter and Fleet Missions effected
- Surveillance / Reconnaissance
- Marine ground forces
- Electronic Warfare
- Target Acquisition / Identification

Many benefits for electronic packages carried by
- Ground-based warfighter
- Air platforms (satellite / ultra-light / UAV)
- Sea platforms (unmanned)

- Reconfigurable logic
- Non-volatile storage
- Instant-on electronics
- Lower power
- Less heat
STEM2Stern

Education & Outreach for the Naval Enterprise
The Problem

Degrees Awarded to US Citizens & Permanent Residents

First university degrees in natural sciences and engineering, selected countries

- China
- US
- Japan
- S Korea
- UK

First-time Freshmen
- Total: 2,367,740

First-time Freshmen Interested in S&E
- Total: 946,383

S&E Bachelor’s Awarded
- Total: 473,828

- BS Natural Science & Engineering
  - Total: 232,645

- MS Natural Science & Engineering
  - Total: 48,306

- PhD Natural Science & Engineering
  - Total: 12,636

NOTE: Natural sciences include physical, biological, earth, atmospheric, ocean, agricultural, and computer sciences and mathematics.

Sources: National Science Foundation, Science & Engineering Indicators, 2010, National Center for Education Statistics

High School Graduates
- Total: 3,304,014

Doctoral degrees in natural sciences and engineering, selected countries

- US Total
- US Citizens
- US Foreign
- India

Scale: 1/35,000

Minority = Black/African American, Hispanic, and Native American; White Does Not Include Hispanic; Asian Includes Pacific Islander
• **Diversity**
  Engage more under-represented populations

• **Collaboration**
  Partner with nationally recognized, best practice organizations, universities, and industry

• **Coordination / Local is Good**
  Support the valuable role of SYSCOMS and local organizations

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

• **Go Viral**
  Invest in programs and social networking tools that have the potential for rapid growth and geographic expansion
Way Ahead

• Double Naval STEM support in five years
• Develop and implement Strategic Plan
• Define ROI . . . then maximize

Near-Term:

• Increase focus on middle school students and teachers
• Launch programs in Urban Areas: DC, LA, NY City, St. Louis, Oakland
• Expand successful “high touch” program models to reach more students
• Create effective bridging mechanisms to move students vertically
• Address needs of teachers more comprehensively
• Embed diversity within all programs
• Explore partnerships with nationally recognized K-12 STEM programs and Industry
• Devise common metrics
• Explore social networking options (iPhone app, Facebook, etc.)
## Other 03R Principals You Should Meet

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