Human Systems in Emerging Domains: *Autonomy, Human Augmentation, and Cyber*

Dr. Paul Zablocky
Chief Scientist (Acting)

March 14, 2018

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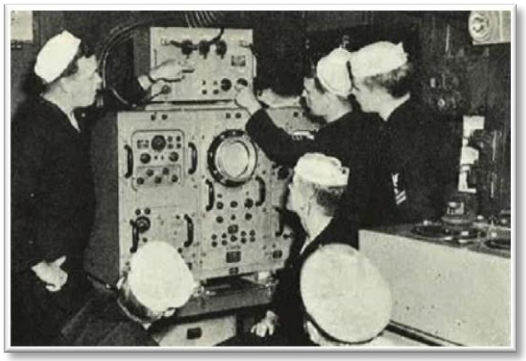
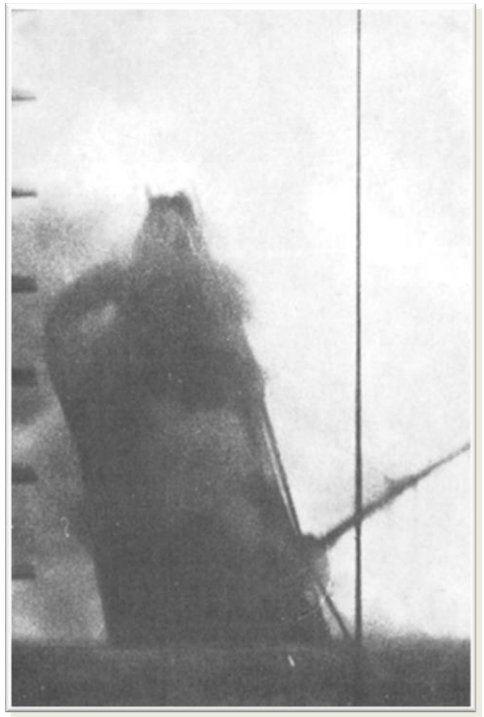
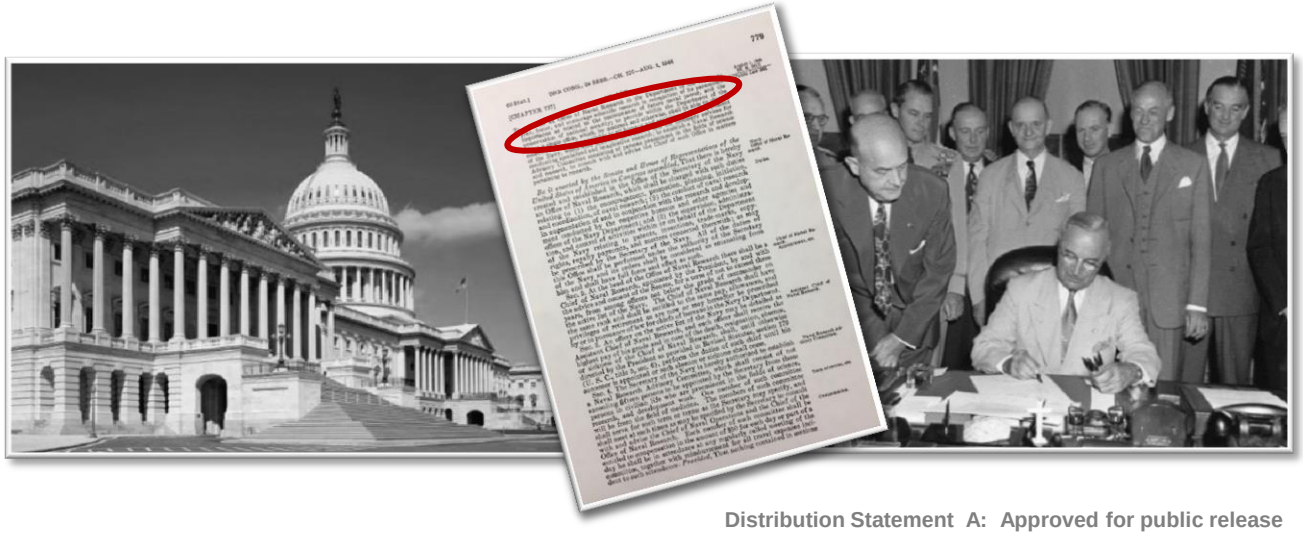
Lessons from History





"…plan, foster and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security…"

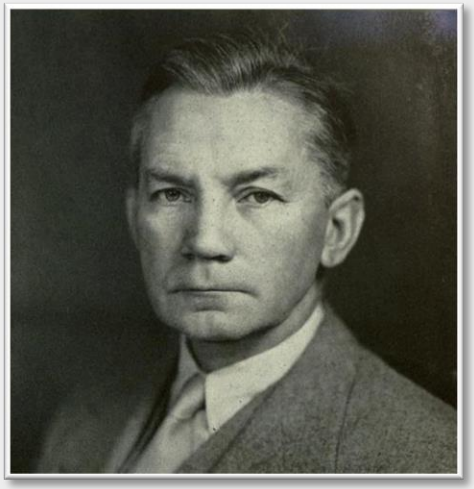


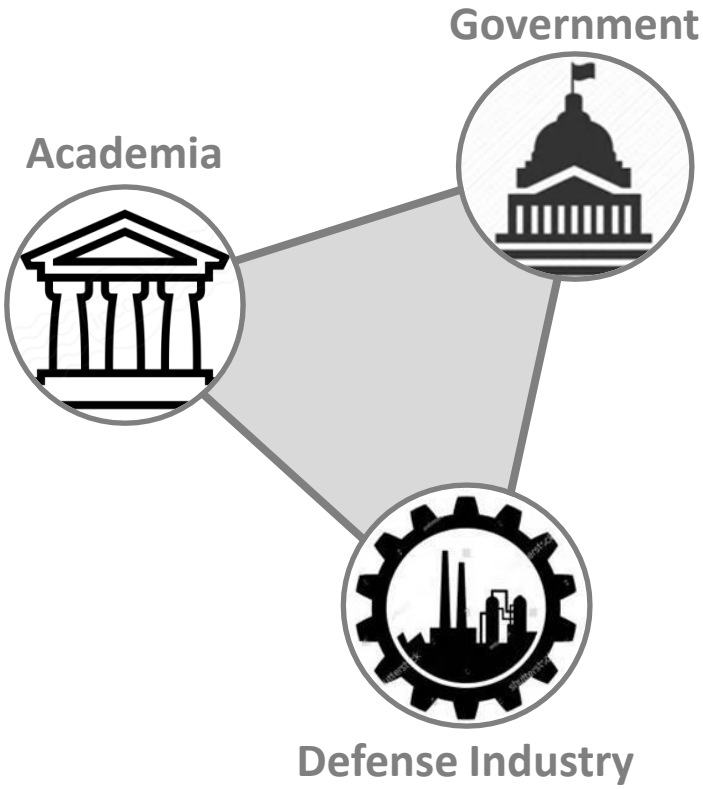
The Naval Research Model c. 1947

U.S. Government Driven

"It is of the utmost importance to our national security that the Navy prosecute a vigorous and well-rounded program of research and development…"

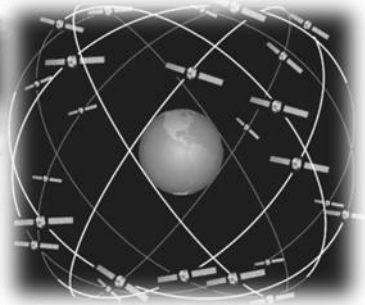
– Secretary of the Navy James V. Forrestal, January 1947



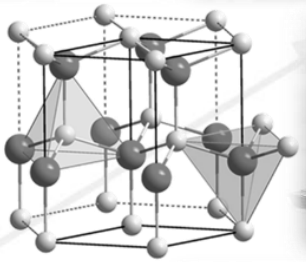


Cold War Success Stories

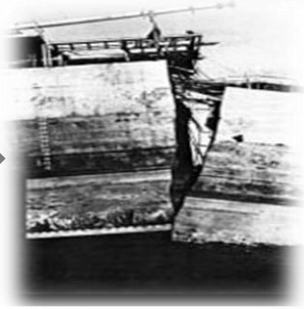
Satellites

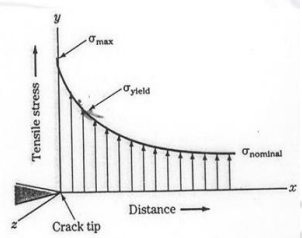


Gallium Nitride

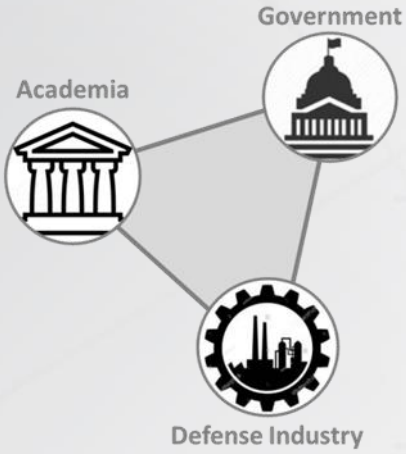


Fracture Mechanics





Ballistic Missile Submarine



Today's Challenge

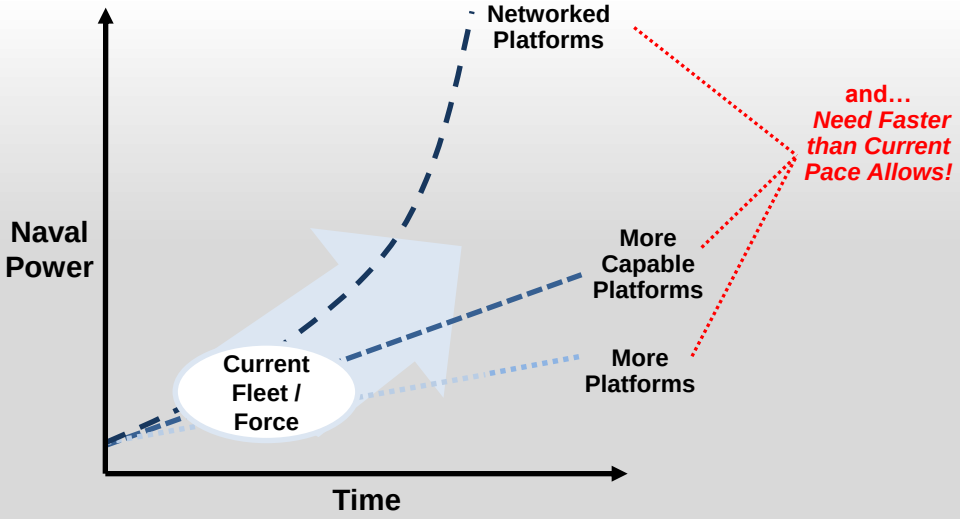
Accelerating Pace of Technological Change

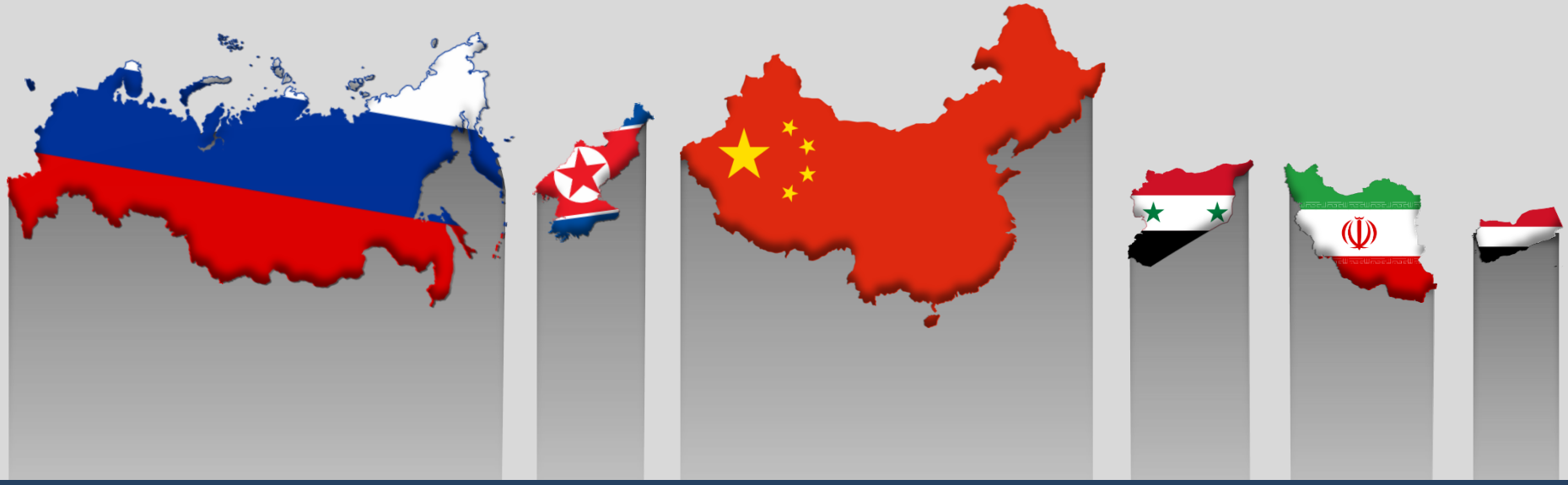
Commoditization and Proliferation of Information

State and Non-State Complexity

Shifting Economic Power

U.S. Naval Superiority is NOT Guaranteed



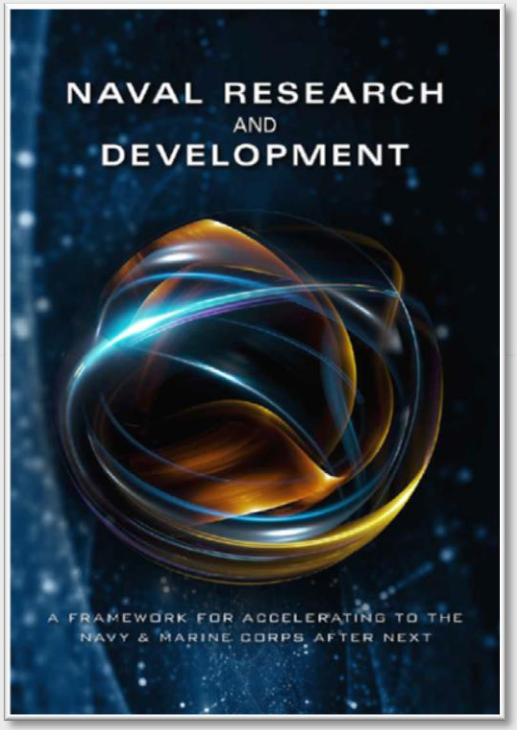


Renewed Urgency in R&D is Needed to Win

The Naval Research Ecosystem c. 2018

Global Commercial Market Driven

Naval Research Response



FRAMEWORK PRIORITIES

Augmented Warfighter

Integrated & Distributed Forces

Operational Endurance

Scalable Lethality

Sensing & Sense-Making

"…the tempo of modern war has reached the point where this Nation will probably never again have an opportunity to arm itself successfully after the start of hostilities…." *– Forrestal*

Research & Development Priorities

Five Framework Priorities that are Strategic and Warfighter-Focused…

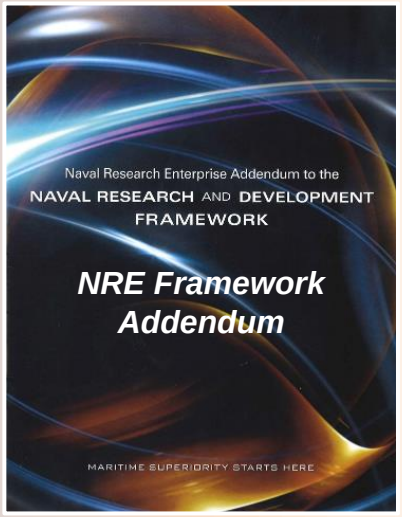
Augmented Warfighter

Integrated & Distributed Forces

Operational Endurance

Scalable Lethality

Sensing & Sense-Making



…Translates to Six Technology-Focused Integrated Research Portfolios

Amphibious Expeditionary Maneuver

Information, Cyber & Spectrum Superiority

Undersea Battlespace & Maritime Domain Access

Mission Capable, Persistent & Survivable Sea Platforms

Warfighter Supremacy

Aviation, Force Projection & Integrated Defense

55 Enduring Research Responsibilities

- EXPEDITIONARY FIRES AND LETHALITY
- EXPEDITIONARY C4ISR
- HYBRID THREAT DEFEAT
- HUMAN PERFORMANCE AND PROTECTION
- AMPHIBIOUS MOBILITY
- LOGISTICS, SUSTAINMENT AND MAINTENANCE
- EXPEDITIONARY POWER AND ENERGY
- LIGHTENING THE LOAD
- ACCELERATED LEARNING/DECISION-MAKING
- INFORMATION ENVIRONMENT OPERATIONS
- DIRECTED ENERGY (DE) & COUNTER DE
- AERODYNAMICS
- FLIGHT DYNAMICS & CONTROL
- PROPULSION
- STRUCTURES AND MATERIALS
- ENERGETIC MATERIALS
- HYPERSONICS
- AUTONOMY

- ADVANCED RF ELECTRONICS & MATERIALS
- COMMUNICATIONS AND NETWORKING
- COMPUTATIONAL METHODS FOR DECISION MAKING
- DATA SCIENCE AND ANALYTICS
- ELECTRONIC WARFARE
- SENSORS AND SENSOR PROCESSING
- MACHINE LEARNING, REASONING AND INTELLIGENCE
- RESOURCE OPTIMIZATION
- PRECISION NAVIGATION & TIMEKEEPING
- UNDERSEA MEDICINE
- BIOLOGICAL SCIENCES
- BIOROBOTICS
- CAPABLE MANPOWER
- COMMAND DECISION MAKING
- FORCE HEALTH PROTECTION
- HUMAN-ROBOT INTERACTION
- NOISE-INDUCED HEARING LOSS
- TRAINING AND SIMULATION

- ARCTIC AND GLOBAL PREDICTION
- LITTORAL GEOSCIENCES AND OPTICS
- MARINE MAMMALS AND BIOLOGY
- MARINE METEOROLOGY
- MARITIME SENSING
- OCEAN ACOUSTICS
- OCEAN ENGINEERING & MARINE SYSTEMS
- PHYSICAL OCEANOGRAPHY
- RESEARCH FACILITIES
- SPACE ENVIRONMENT
- UNDERSEA SIGNAL PROCESSING
- NAVAL ENGINEERING
- ADVANCED NAVAL POWER SYSTEMS
- ADVANCED SURVIVABLE SEA PLATFORMS
- UNMANNED SEA PLATFORMS, AUTONOMY AND POWER
- ADVANCED NAVAL MATERIALS
- UNDERSEA WEAPONS, COUNTER-WEAPONS AND ENERGETICS
- SEA PLATFORM ENVIRONMENTAL QUALITY
- CORROSION CONTROL

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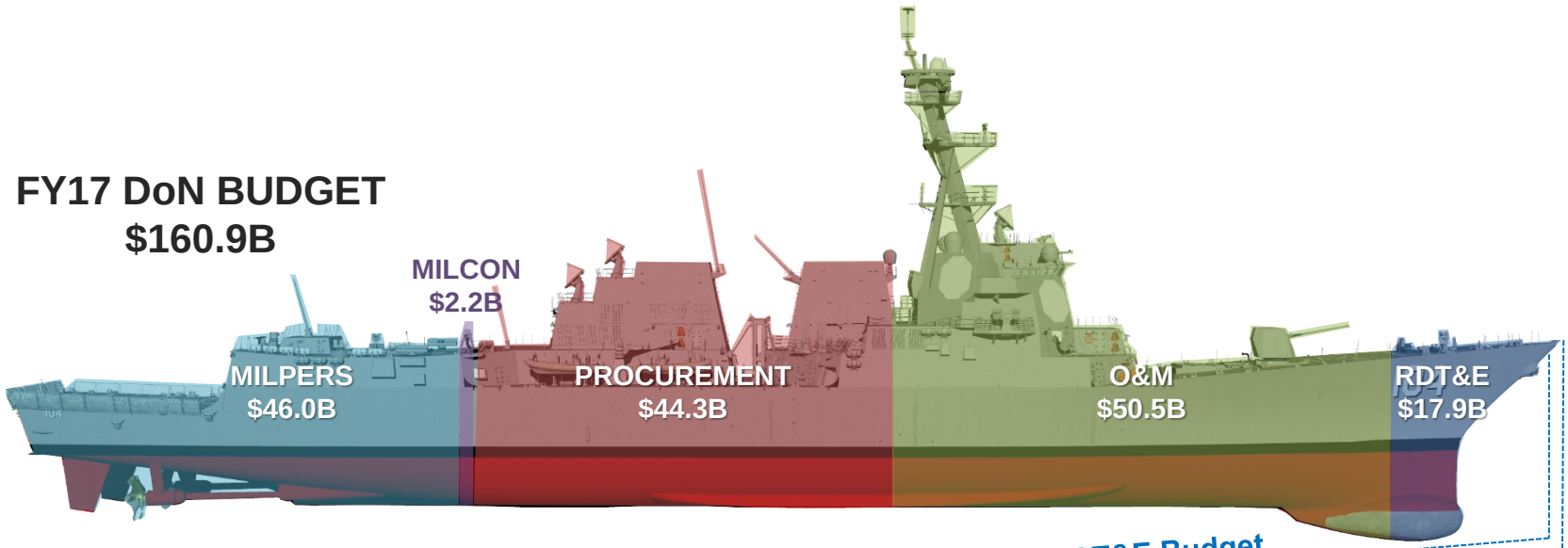
Getting to Capability

The ONR Portfolio is Broad Yet Singularly Focused on Delivering Continued Naval Superiority

$37M	**Demonstration and Validation**	Efforts that have moved into the development and integration of hardware for field experiments and tests.
$879M	**Advanced Technology Development**	Evaluation of integrated technologies in as realistic an operating environment as possible to assess the performance or cost reduction potential.
$956M	**Applied Research**	Research to determine the means by which a recognized and specific need may be met.
$547M	**Basic Research**	Research without specific applications toward processes or products in mind.

FY17 Funding

The Portfolio Investment Relative to FY17 Navy Budget

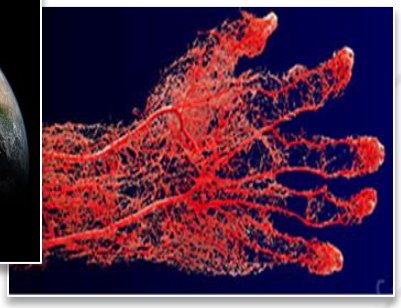


Naval Research Enterprise Allotted $2.42B of FY17 RDT&E Budget

Basic Research $547M	Applied Research $956M	Advanced Technology Development $879M

Demonstration and Validation $37M

The Naval Research Enterprise







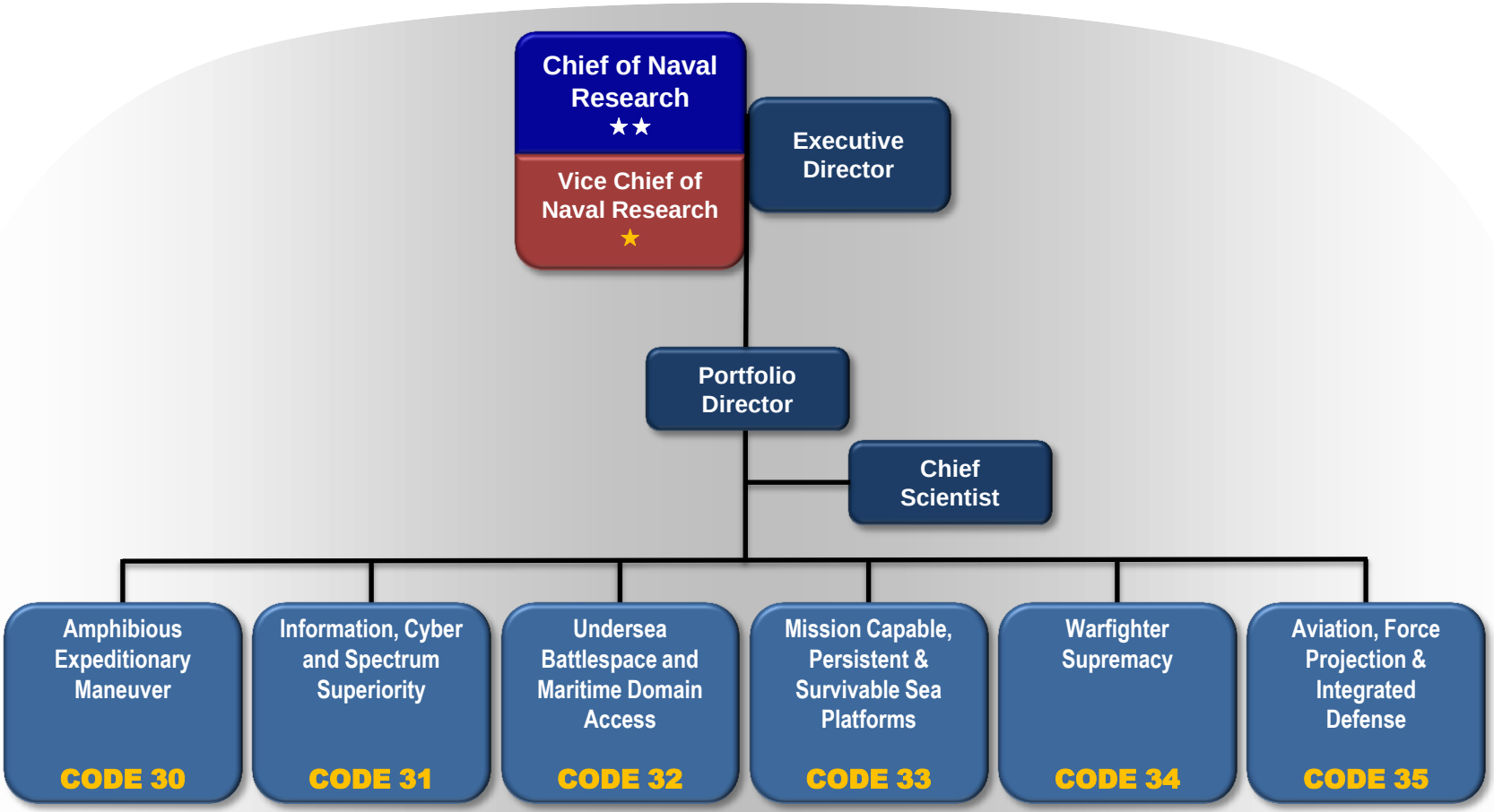

ONR HQ

U.S. NAVAL RESEARCH LABORATORY
NRL

ONR Global

4,000+ People
23 Locations
$2.1B / year
>1,000 Partners

ONR Headquarters



Managing the Portfolio

Naval Research Laboratory

- *The Navy's Corporate Laboratory*
- *World Class Research Team*
- *Basic and Applied Research and Advanced Technology Development for Anticipated Navy and Marine Corps Needs*

SPAWAR

$$$

PEO SHIPS

DARPA

U.S.ARMY

NAVSEA NAVAL SEA SYSTEMS COMMAND

Directly Funded Work

U.S. NAVAL RESEARCH LABORATORY

Research Focus Areas

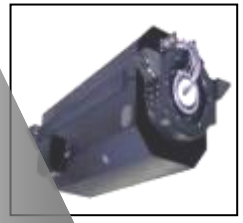
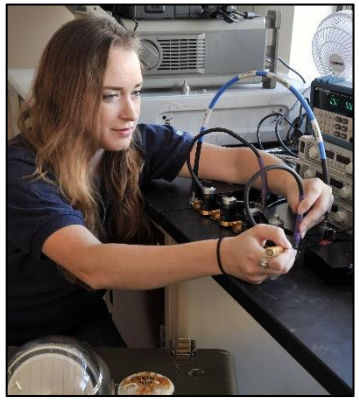
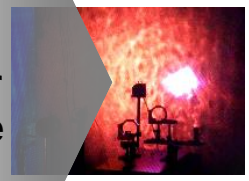
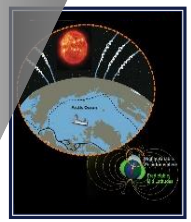
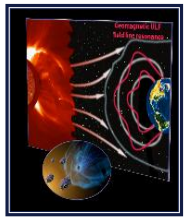
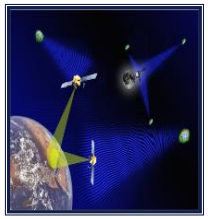
NRL Basic & Applied Research

$

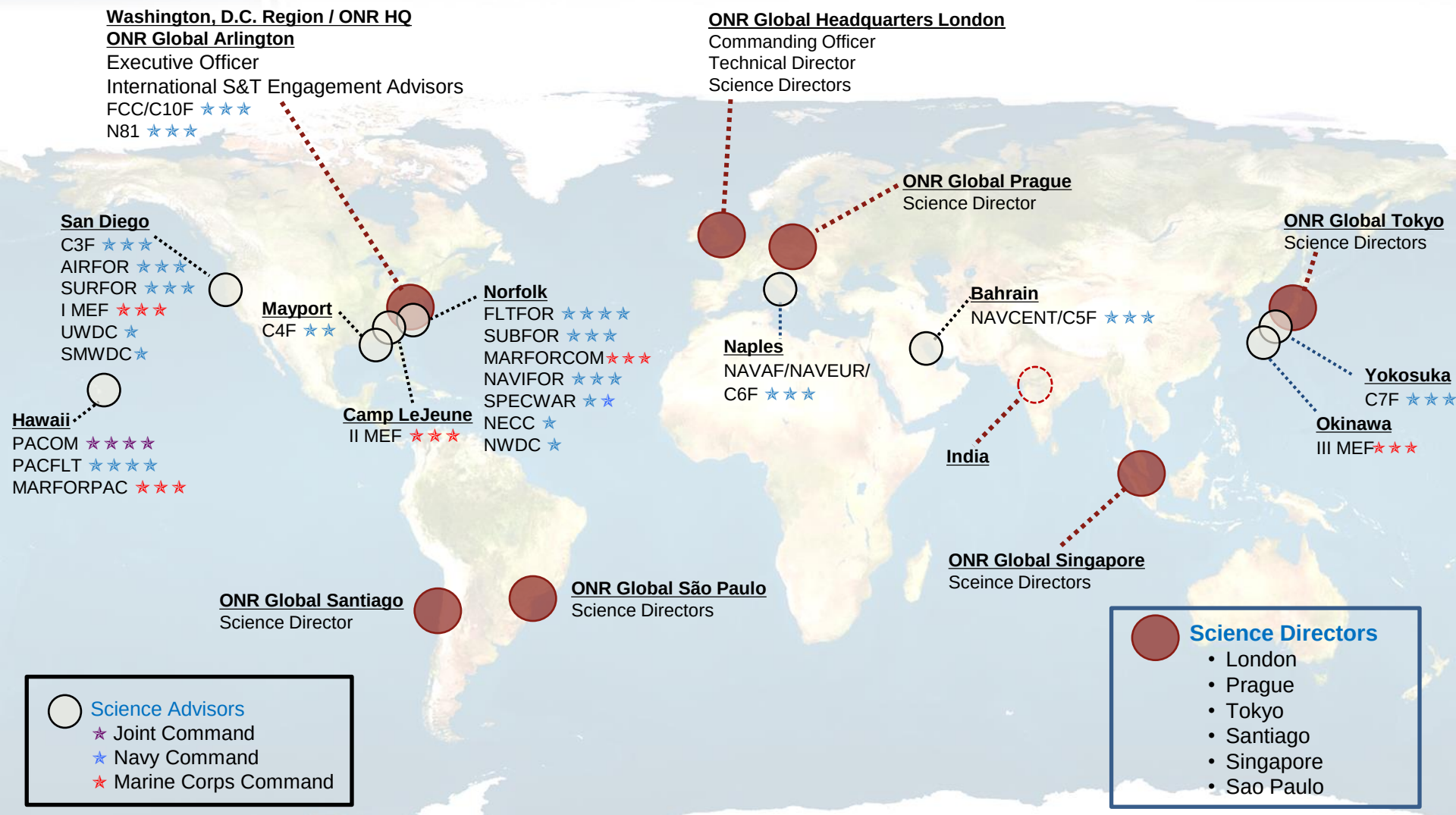
Integrated Research Portfolio

Delivering Warfighter Advantage

NRL Products & Prototypes

ONR Global



ONR's Global Offices are the Bridge to International Partnership; Naval R&D Diplomacy in More than 60 Countries

Complex Operating Environment

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Contested Urban Environment

Area Description

Complex terrains:

- Crowded and cluttered physical, human, communication, and informational environment
- Physical compartmentalization and additional dimensions
- Proliferation of observation and fires technologies
- Threat obscuration

Technical Approach

- Urban fires and weapons
- Urban mobility
- Urban communication
- Threat sensing, detection, and prevention
- Urban survivability

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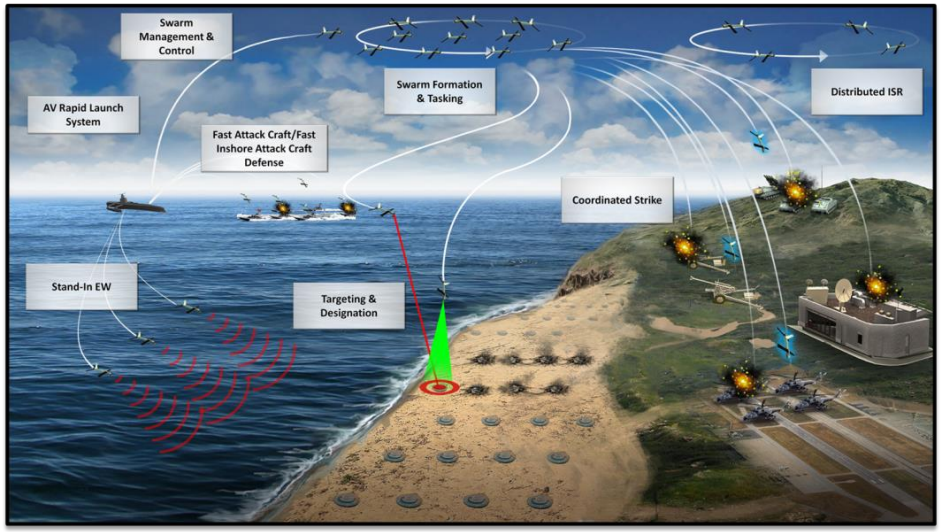
Cooperative Autonomy

Area Description

- Extend reach, increase mass and quantity, and augment the capability of expeditionary forces
- Allow penetration of environments too dangerous for manned systems
- Retain capability despite combat losses with automatic and flexible unmanned adjustment
- Disperse capabilities associated with traditional capital assets

Technical Approach

- Low cost ground, air, and amphibious autonomous systems
- Distributed, collaborative, coordinated and cognitive autonomy
- Autonomous sensing, obstacle detection and path planning
- Unmanned C4 and control theory
- Manned-unmanned teaming



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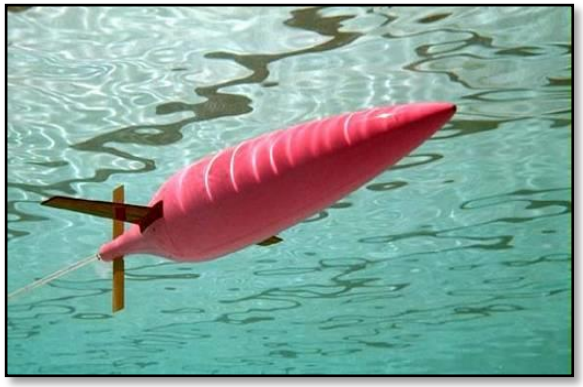
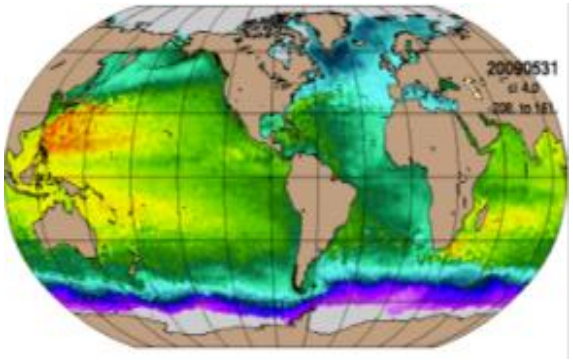
Undersea Autonomous Systems





Goals

- Mobile autonomous environmental sensing
- Predictive capabilities
- Adapt systems to environmental variability

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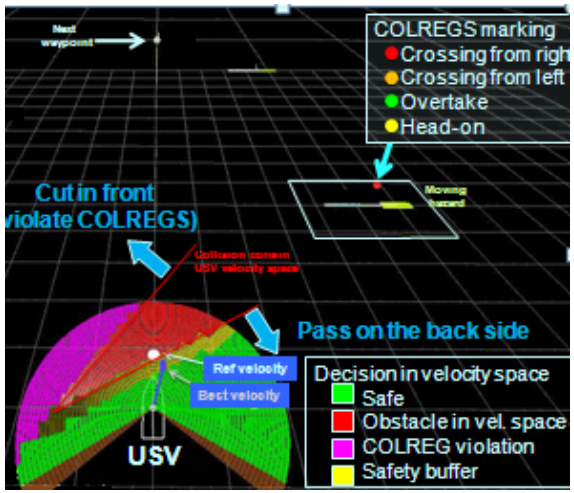
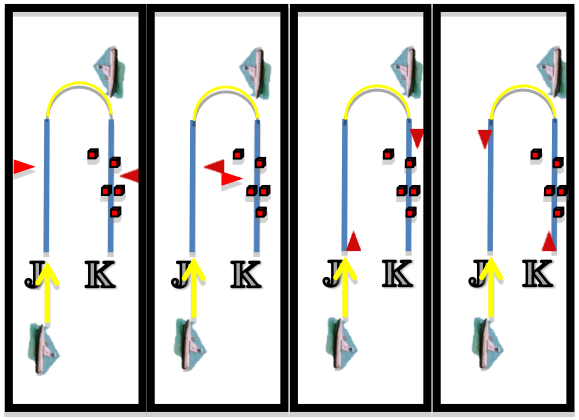
Autonomous Surface Vehicles





Goals

- Perform complex tasks in a complex environment, without human intervention
- Respond effectively to dynamic situations
- Perceive environment, internal and external

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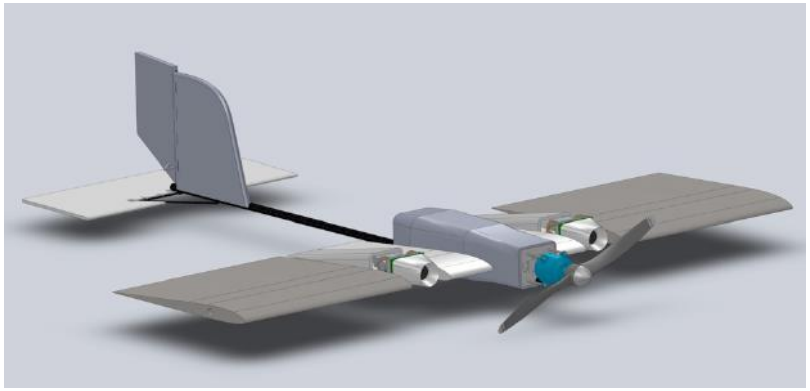
Aerial Autonomous Systems



Goals

- Safe operation in the maritime/shipboard environment
- Effective collaboration with humans
- Increased role with greatly reduced need for human intervention

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Expeditionary Autonomy

Goals

- Affordable platform agnostic modular Autonomy kits for current and future fleet vehicles
- Seamless & natural visual and verbal human-robot interaction
- Multi-platform collaboration

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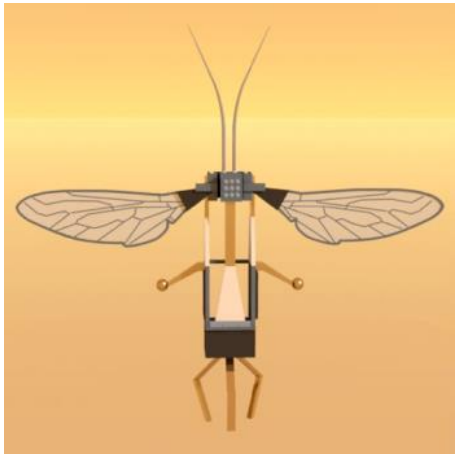
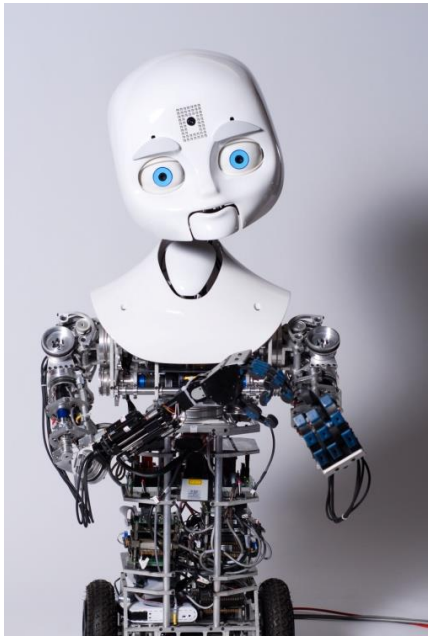
Novel Systems





Goals

- Multi domain platforms
- Fundamental understanding of the hydrodynamics of high efficiency bio-inspired underwater propulsion
- Compact, low-power perception and mapping for nano-UAVs
- Muscle-like actuators and multifunction material control surfaces (undersea and air)

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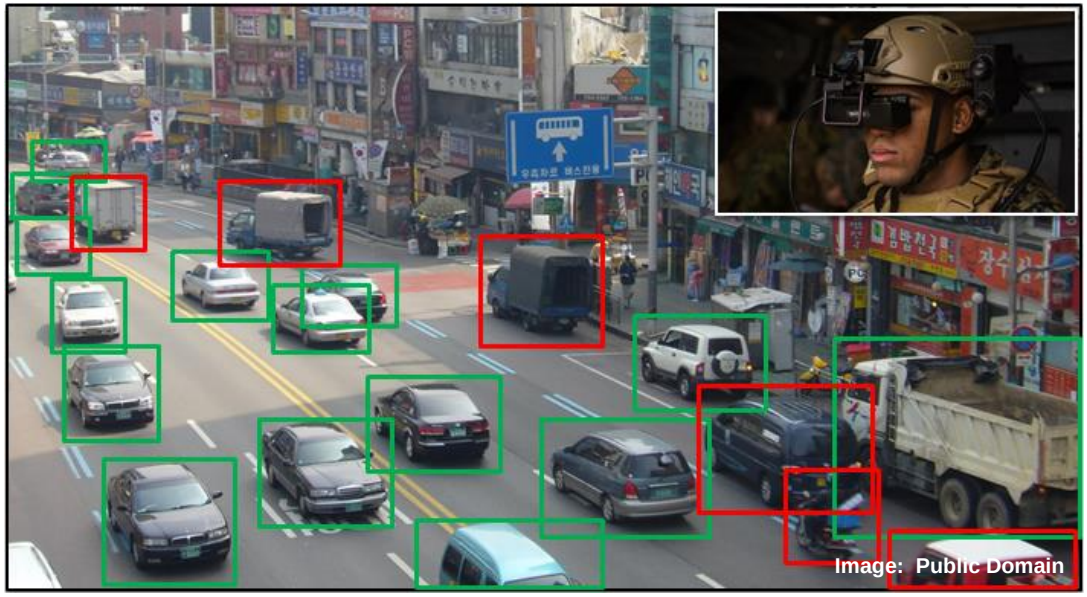
Cognitive Advantage and Artificial Intelligence

Area Description

- Meld machine intelligence and human decision making Ground warrior advanced decision support
- Enhance warfighter sensing, cognitive speed, and decision superiority
- True, rapid, all-source data fusion
- Knowledge products delivered to the warfighter with real world context

Technical Approach

- Data science and analytics
- Image classification
- On-board processing
- Augmented Reality
- Visual attention models



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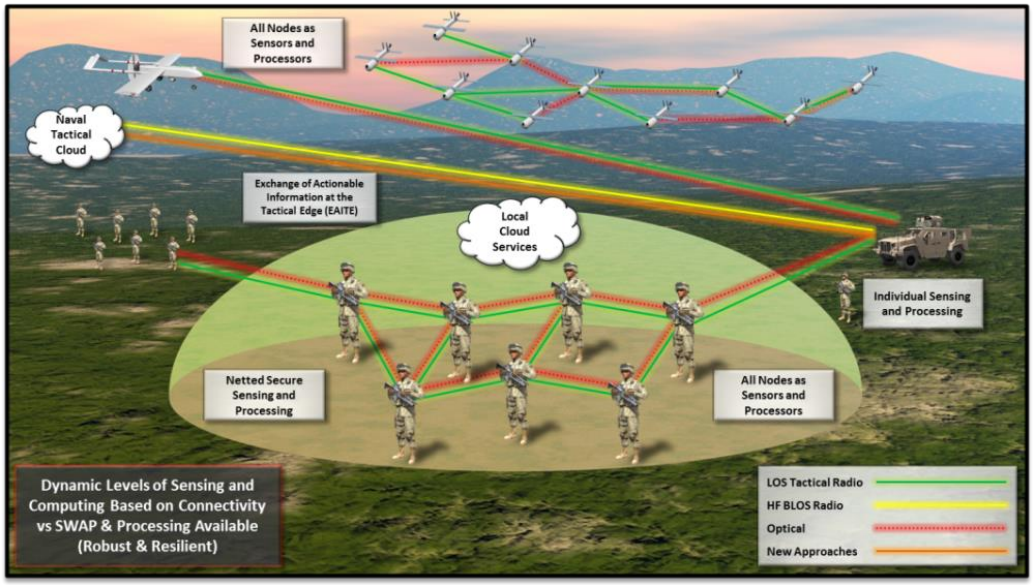
Expeditionary Communications and Cyber

Area Description

- Resilient, robust, and secure communications
- Cyber and information warfare capability
- Electromagnetic signature control and influence
- Rapidly changing network conditions amidst battle of signatures and physical movement
- Exploits close physical proximity while mitigating connectivity shortfalls

Technical Approach

- Networked and local computational availability
- Non-GPS precision, navigation, timing
- Antennas and propagation
- Communications and information theory
- Communications signal processing



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Signature Visualization

2/6 S-2 in Bn COC at FEX II (Dec 2016)

USC ICT Aerial Terrain Line of sight Analysis System

https://www.youtube.com/watch?v=-spEV8dkuOY

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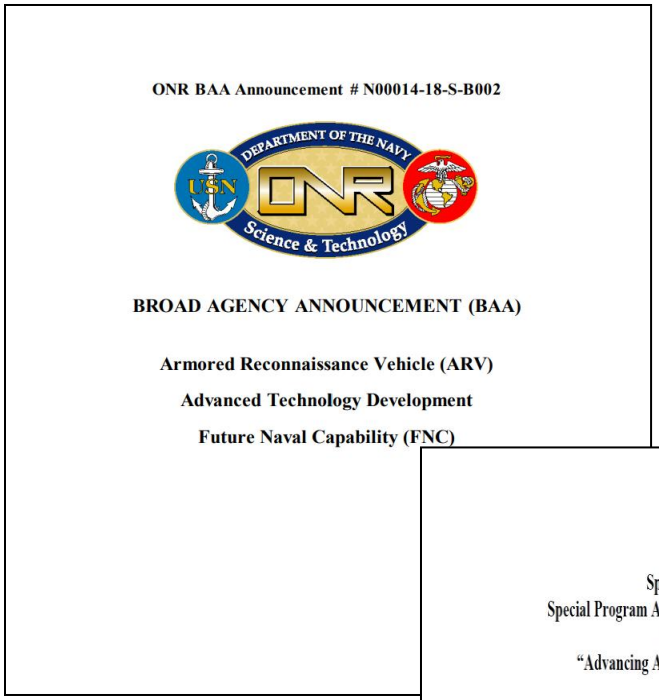
Opportunities



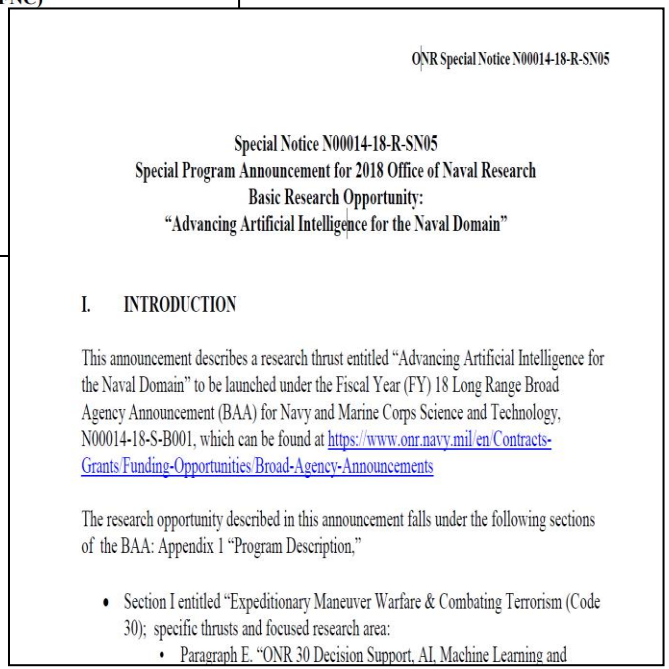
ONR BAA Announcement # N00014-18-S-B002

BROAD AGENCY ANNOUNCEMENT (BAA)

Armored Reconnaissance Vehicle (ARV)

Advanced Technology Development

Future Naval Capability (FNC)



ONR Special Notice N00014-18-R-SN05

Special Notice N00014-18-R-SN05
Special Program Announcement for 2018 Office of Naval Research
Basic Research Opportunity:
"Advancing Artificial Intelligence for the Naval Domain"

I. INTRODUCTION

This announcement describes a research thrust entitled "Advancing Artificial Intelligence for the Naval Domain" to be launched under the Fiscal Year (FY) 18 Long Range Broad Agency Announcement (BAA) for Navy and Marine Corps Science and Technology, N00014-18-S-B001, which can be found at https://www.onr.navy.mil/en/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements

The research opportunity described in this announcement falls under the following sections of the BAA: Appendix 1 "Program Description,"

- Section I entitled "Expeditionary Maneuver Warfare & Combating Terrorism (Code 30); specific thrusts and focused research area:
  - Paragraph E. "ONR 30 Decision Support, AI, Machine Learning and

Advancing Artificial Intelligence for the Naval Domain –

22 March

Armored Reconnaissance Vehicle. Full Proposals-

April 2

Long Range BAA

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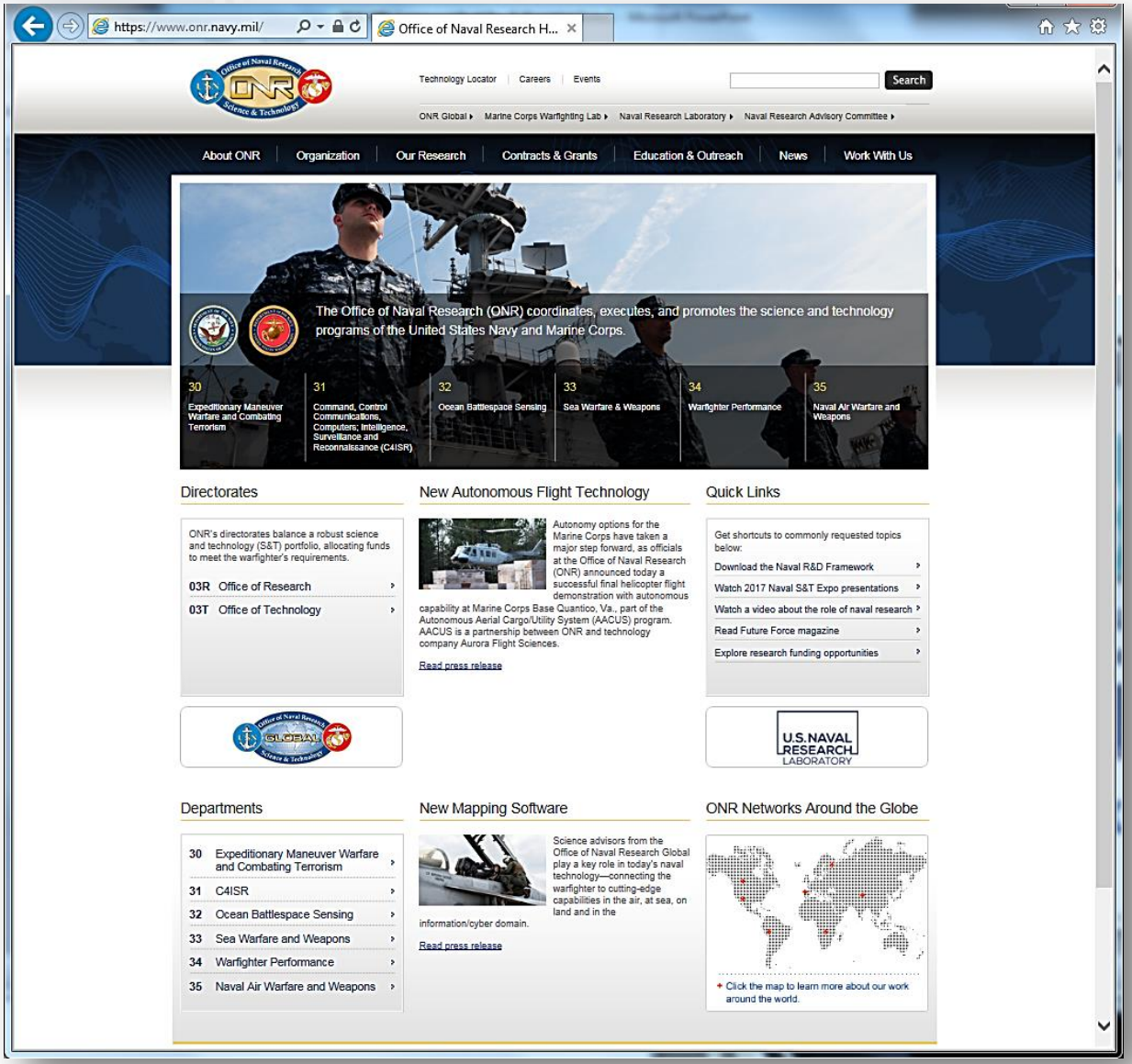
Staying In Touch



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