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The Office of Naval Research – Science and Technology in Support of the US Navy and Marine Corps

Mark S. Spector, Ph. D.
Advanced Naval Platforms Division
Office for Naval Research

6 May 2022

Office of Naval Research

Established by Congress in 1946, The Office of Naval Research's mission is to:

"…*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*…"

Naval Research Enterprise

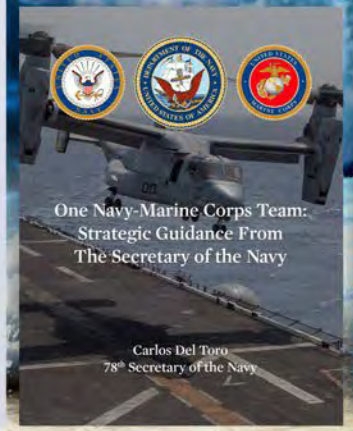
Office of Naval Research
ONR
Science & Technology

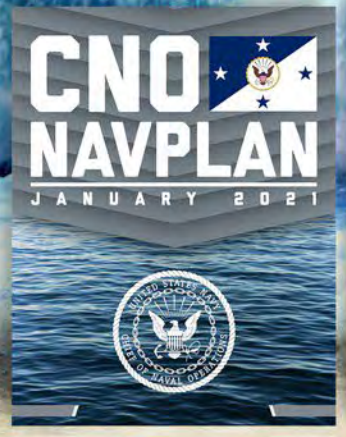
U.S. NAVAL RESEARCH LABORATORY

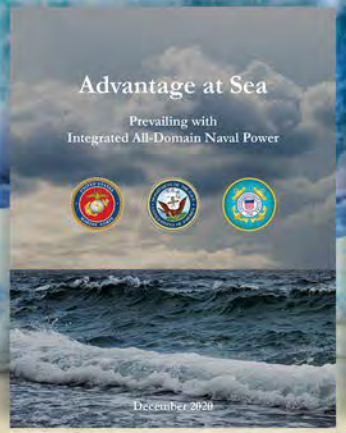
Office of Naval Research
GLOBAL
Science & Technology

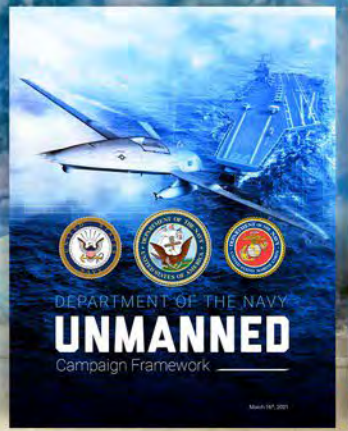
PMR 51

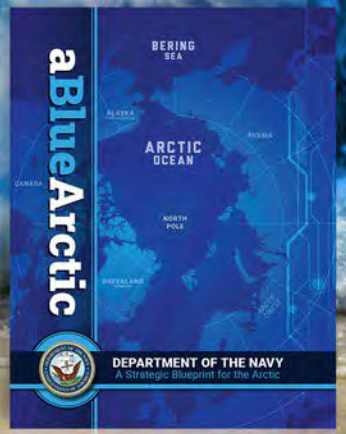
ONR is a mission-oriented agency!





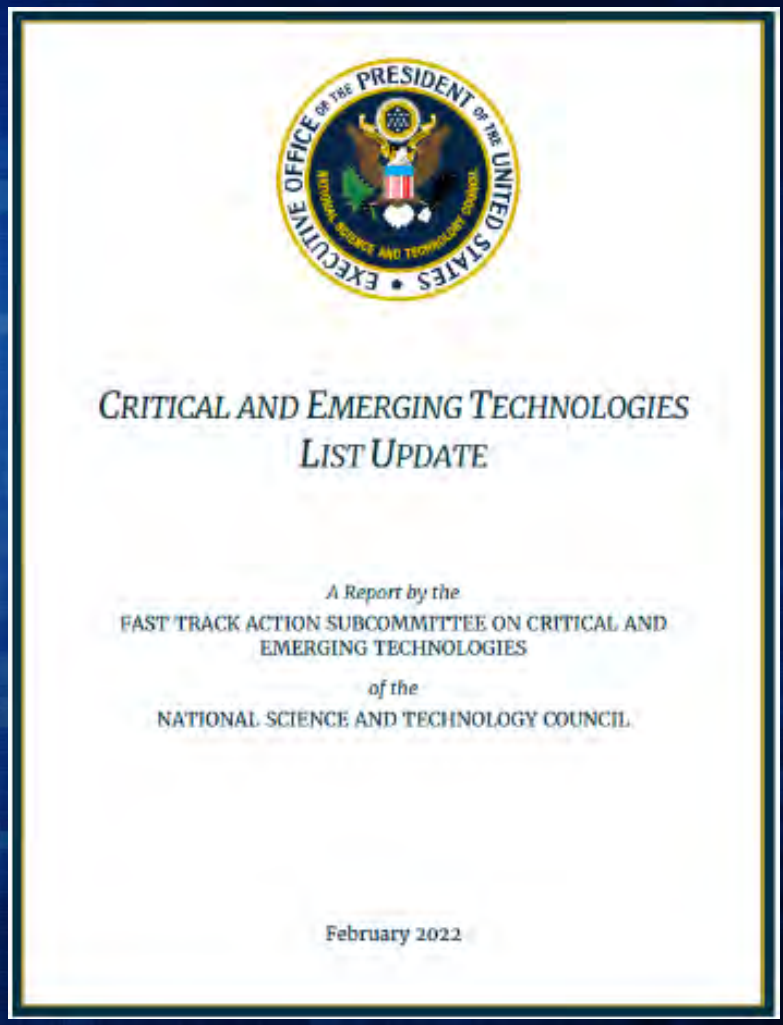






White House Office of Technology and Policy Critical And Emerging Technologies

- Advanced Computing
- Advanced Engineering Materials
- Advanced Gas Turbine Engine Technologies
- Advanced Manufacturing
- Advanced and Networked Sensing and Signature Management
- Advanced Nuclear Energy Technologies
- Artificial Intelligence
- Autonomous Systems and Robotics
- Biotechnologies
- Communication and Networking Technologies
- Directed Energy
- Financial Technologies
- Human-Machine Interfaces
- Hypersonics
- Networked Sensors and Sensing
- Quantum Information Technologies
- Renewable Energy Generation and Storage
- Semiconductors and Microelectronics
- Space Technologies and System



CRITICAL AND EMERGING TECHNOLOGIES LIST UPDATE

A Report by the

FAST TRACK ACTION SUBCOMMITTEE ON CRITICAL AND EMERGING TECHNOLOGIES

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

February 2022

DoD Critical Technology Areas

Office of the Under Secretary of Defense for Research and Engineering

- Areas of Emerging Opportunity
  - Biotechnology
  - Quantum Science
  - Future Generation Wireless Technology
  - Advanced Materials
- Effective Adoption Areas
  - Trusted AI & Autonomy
  - Integrated Network System-of -Systems
  - Microelectronics
  - Space Technology
  - Renewable Energy Generation & Storage
  - Advanced Computing & Software
  - Human-Machine Interfaces
- Defense-Specific Areas
  - Directed Energy
  - Hypersonics
  - Integrated Sensing and Cyber

UNDER SECRETARY OF DEFENSE
[redacted] DEFENSE PENTAGON
WASHINGTON, DC [redacted]

February 1, 202[redacted]

SUBJECT: USD(R&E) Technology Vision for an Era of Competition

The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E) will spearhead a National Defense Science and Technology strategy for the Department of Defense (DoD), informed by the 2022 National Defense Strategy (NDS) and structured around three strategic pillars: mission focus, foundation building, and succeeding through teamwork. This technology strategy will chart a course for the United States' military to strengthen its technological superiority amidst a global race for technological advantage.

To maintain the United States military's technological advantage, the Department will champion research, science, technology, engineering, and innovation. From the earliest days of this country the role of technology in shaping military concepts and providing for the defense of the nation has been essential. The demands of the present era call for new operational concepts, increasingly joint operations, and quickly fielding emerging science and technology opportunities.

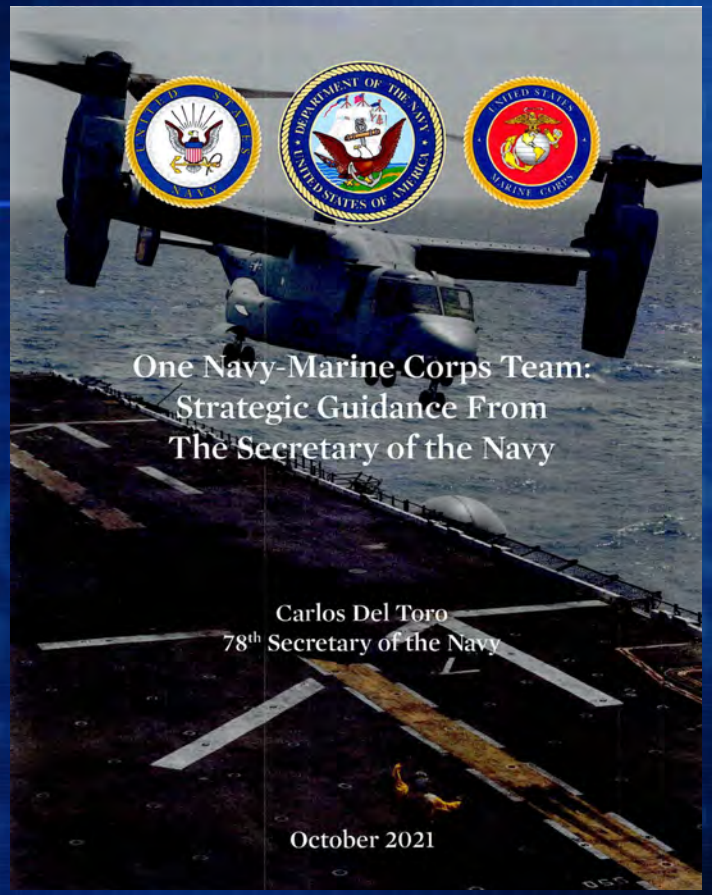
Strategic competitors in the United States have greater access to commercial state-of-the-art technologies than ever before and can wield these technologies to be disruptive to America's interests and its national security. The challenges facing our country are both diverse and complex, ranging from sophisticated cyber-attacks to supply chain risks, and from defending against hypersonic missiles to responding to biological threats. In an ever shifting and fast-moving global environment, technological advantage is not stagnant and the Department cannot rely on today's technology to ensure military technological dominance tomorrow.

It is imperative for the Department to nurture early research and discover new scientific breakthroughs to prevent technological surprise. The Department must harness the incredible innovation ecosystem both domestically and globally in order to stay ahead of our competitors.

A. Innovation in an era of competition

The Department of Defense's Research and Engineering community welcomes cooperation and competition. As Secretary of Defense Austin said in his December 2021 speech at the Reagan National Defense Forum, "America isn't a country that fears competition. And we're going to meet this one with confidence and resolve." Competition has helped to bring about the United States' private sector and technology industry, both of which are the most vibrant in the world. Competition helped advance the space program, the seeds of modern information technology, and a myriad of derivative technologies that every day drive our national security and economic activity.

SECNAV Strategic Guidance



"Since my confirmation as the 78th Secretary of the Navy, I have characterized the most pressing challenges facing the Department of the Navy as the ***"Four Cs": China, Culture, Climate Change, and COVID***. The People's Republic of ***China represents the pacing challenge*** against which we must plan our warfighting strategies and investments. Cultural challenges that we must tackle include confronting sexual assault and harassment, ***promoting diversity, equity, and inclusion,*** preventing suicide, and demanding integrity and accountability across our naval leadership. ***Climate change poses a rapidly intensifying spectrum of risks*** to our operating environment, our allies and partners, and our planet. And ***COVID has posed an unprecedented test of the resilience*** of our people, their families, and our health system. We must tackle these Four Cs with a sustained sense of urgency and a strong bias for action."

As President Biden stated in his March 2021 Interim National Security Guidance, "our world is at an inflection point." In the President's words, ***"The United States must renew its enduring advantages so that we can meet today's challenges from a position of strength."***

The Navy-Marine Corps Team is one of America's unmatched enduring advantages, and will be a vital part of realizing the President's vision.

ASN Research, Development, and Acquisition

2022 Operational Mission Focus Areas

- Promote best practices from industry and government in our acquisition processes
- Deliver resilient software capability at the speed of relevancy
- Improve our world-class workforce by enhancing diversity and talent
- Build and sustain relationships and capabilities with international partners and other services
- Accelerate the adoption of new technologies into our fleet through a continuum of operational experimentation and prototyping

2022 Commander's Intent for the Naval Research Enterprise

RADM Lorin C. Selby, Chief of Naval Research

"Our mission is to 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"

"Leadership in the 21st century belongs to whoever harnesses and guides the myriad of continuous technological revolutions including Artificial Intelligence, quantum, biotechnology, autonomy, hypersonics, and space."

- Desired NRE Attributes and Outcomes
  - Promote a vibrant S& T portfolio and performer network
  - Fuel a driven, empowered and diverse workforce, rooted firmly in a culture of collaboration and respect
  - Deploy Innovative Business Practices and Processes to Boost the S&T mission
  - Provide an infrastructure that enables cutting-edge research and work efficiency

Rear Adm. Lorin C. Selby
Chief of Naval Research

Our Mission: **Reimagine Naval Power**

Relentless search for FUNDAMENTAL, HIGH PAY OFF scientific understanding

PARTNER with the **RIGHT SCIENTISTS** to ensure the Navy and Marine Corps are always linked to **SCIENTIFIC DISCOVERY**

Partnering with the S&T Community

Government

Academia

1000 Universities/Colleges
Domestic/International

Industry

Small/Medium/Large
Companies

Portfolio Investment

6.1 Basic Research

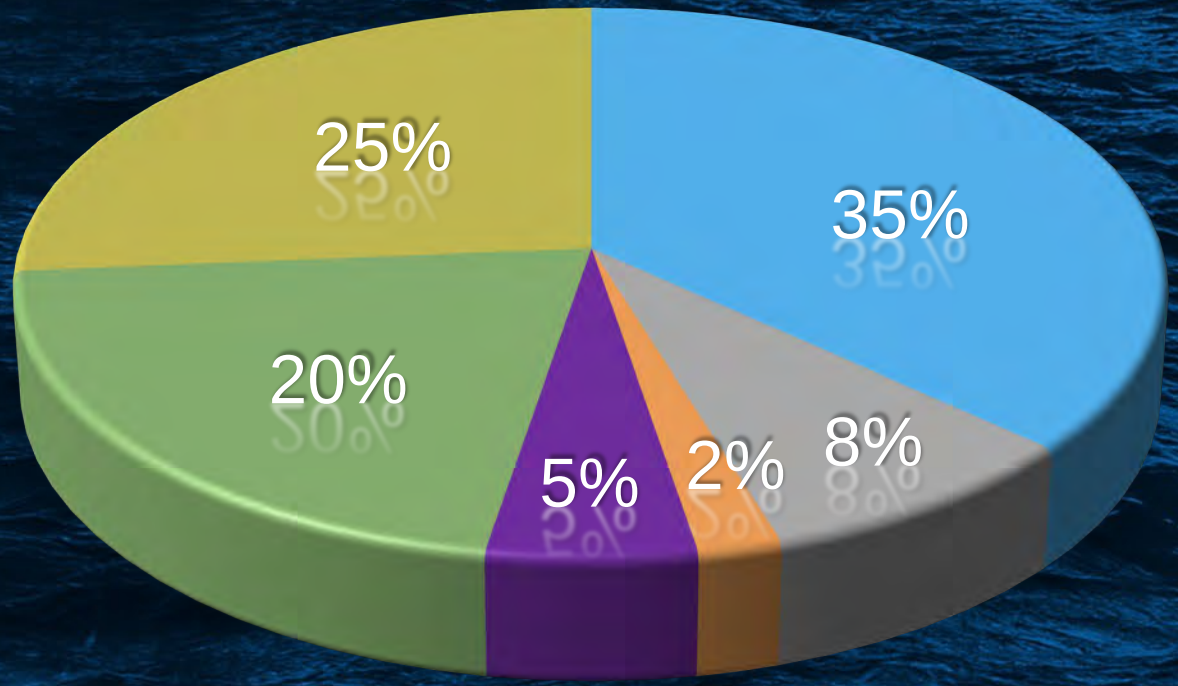
6.2 Applied Research

6.3 Advanced Technology Development

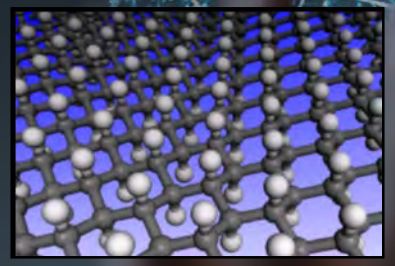
6.4 Advanced Component Development and Prototypes

6.6 Management Support

6.7 Operational System Development



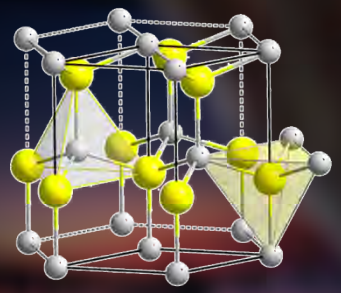
Basic Research:
From Test Tubes to Launch Tubes



Graphene

Crack & Failure Prediction

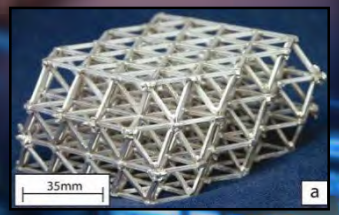
3D Printing of Veins



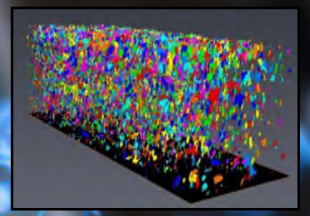
Gallium Nitride

Microbial Fuel Cells

-Advanced Materials
-Algorithmic Phenomenology
-Synthetic Biology



Blast/Energy Absorbing Structures



Mesoscale Characterization

Systematic studies directed toward greater understanding of the fundamental aspects of phenomena and of observable facts without specific applications in mind.

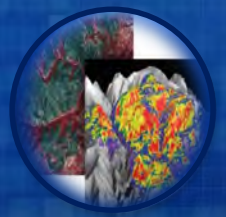
ONR Research Portfolios

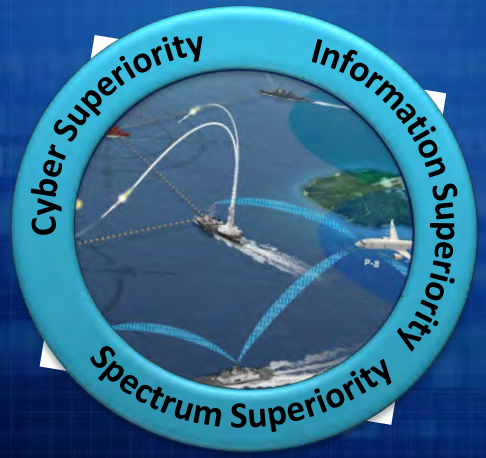
Information, Cyber & Spectrum Superiority Department (Code 31)

Electromagnetic Warfare

Full-Spectrum Cyber

Surveillance, Sensors and Phenomenology





Communications and Networking

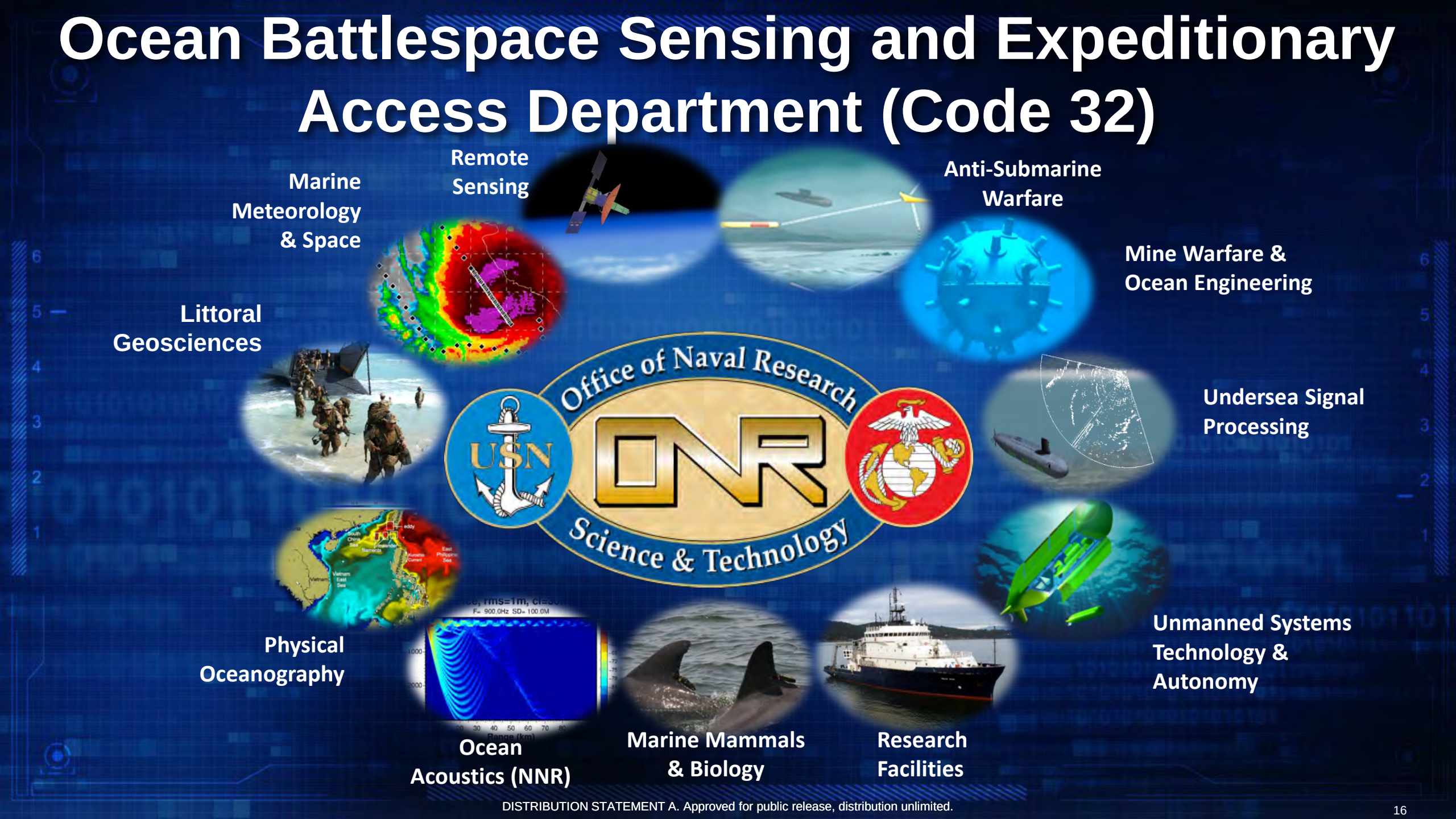
Quantum, Positioning, Navigation and Timing

Intelligence, Decision-Making Superiority, C2 and Combat Systems

Microelectronics

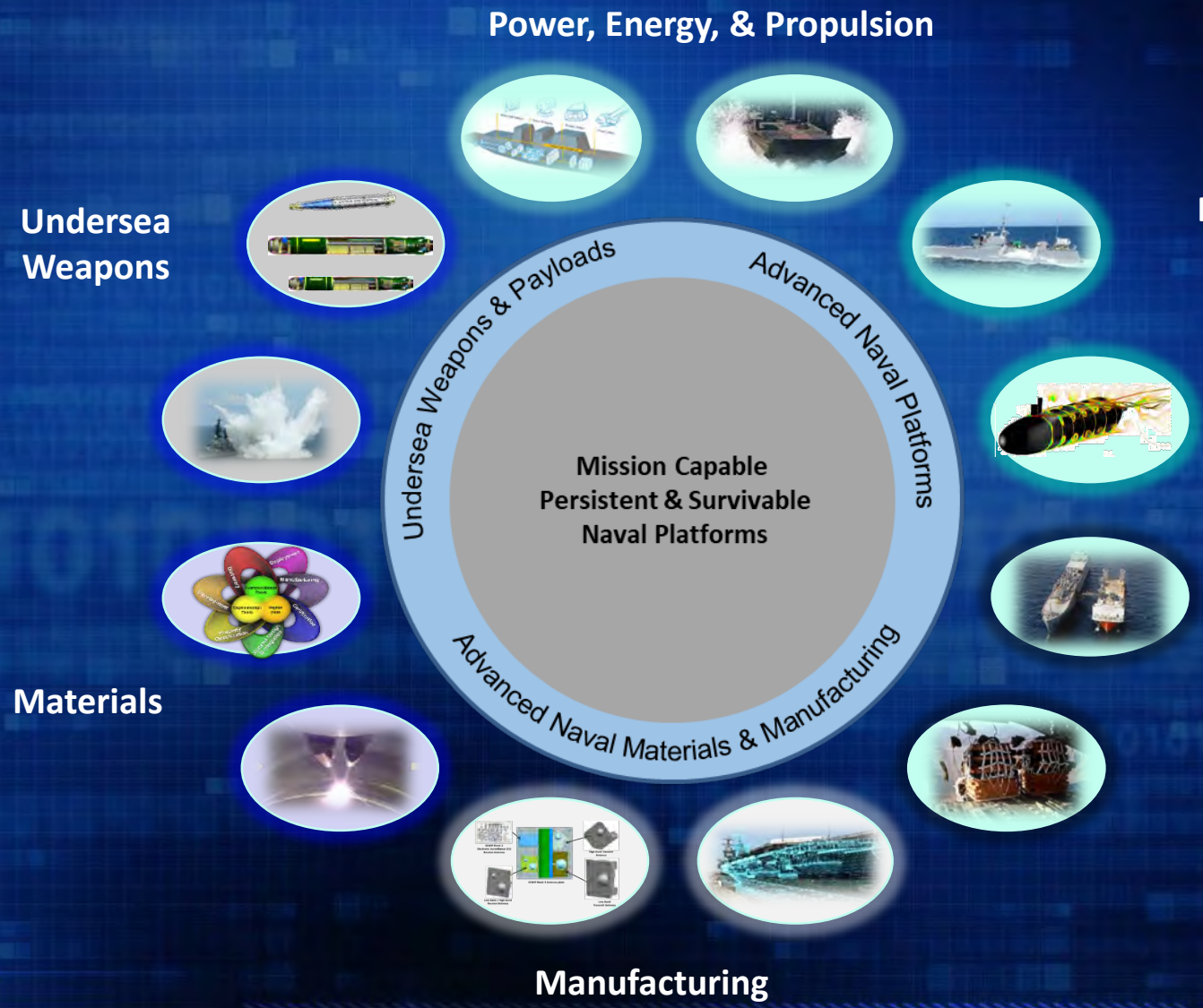
Mathematical Foundations for Analytics and Predictive Science

Ocean Battlespace Sensing and Expeditionary Access Department (Code 32)



Naval Platforms (Code 33)

Mission Capable, Persistent, and Survivable



Warfighter Performance Department (Code 34)

Decision Sciences

Human Performance

Information Warfare & Future Conflict

Medical

Manpower Personnel Training & Education

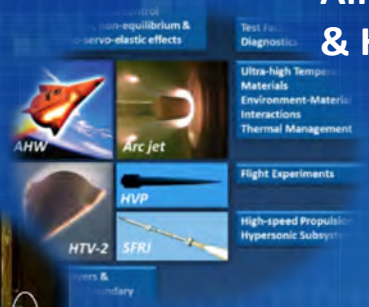
Biocentric Technologies

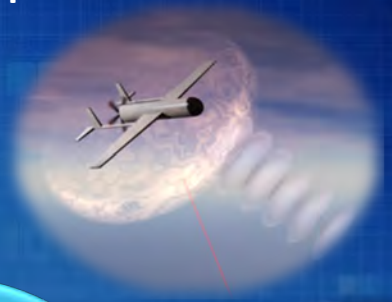
Intelligent & Autonomous Systems

Aviation, Force Projection and Integrated Defense (Code 35)

Kinetic Weapons

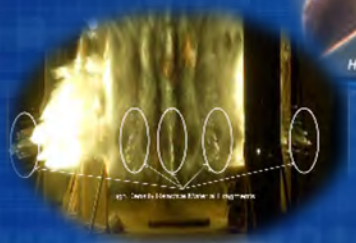
Air Weapons & Hypersonics





Directed Energy

Advanced Energetic Materials



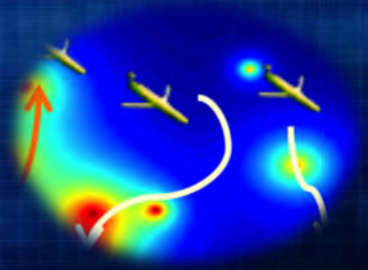
Railgun

Aviation, Force Projection & Integrated Defense

High Power Microwave

Laser Weapons

Autonomy



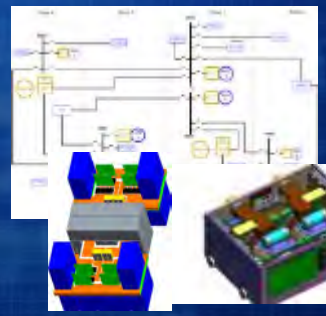
Naval Air Platforms

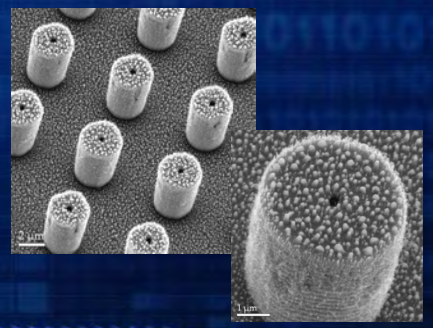
Aerodynamics / Flight Dynamics & Control
Structures & Materials
Power, Propulsion, & Thermal Management

Naval Power Systems S&T

- Increase the effective use, conversion, storage, distribution, and control of energy to enable integration of future weapons and sensors onto platforms and extend operational reach.
- Major Programs:
  - Power Electronics and Electromagnetics
  - Electrochemical Materials
  - Functional Polymeric and Organic Materials
  - Electric Power Components and Control
  - Power Generation and Energy Storage
  - Thermal Science and Engineering
  - Energy Resiliency
  - Efficient Electromechanical Machinery
  - Materials for Carbon Neutral Energy and Resources
  - Expeditionary Power & Energy
  - Advanced Power Systems for Undersea Applications





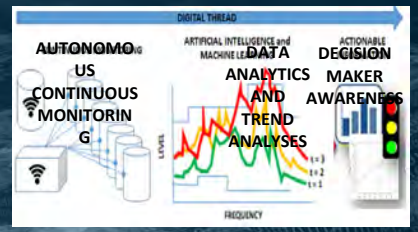



Digital Twin Science and Technology

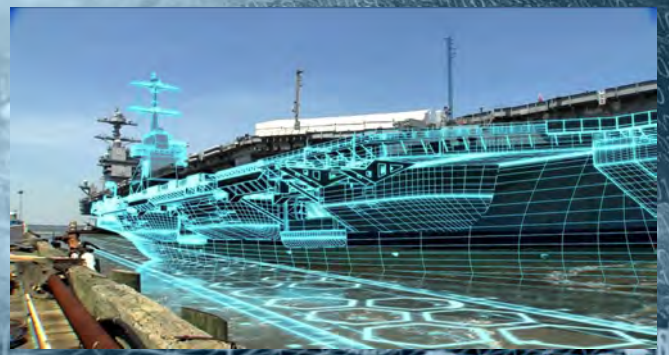
ONGOING INITIATIVES

- Developing technology to turn Navy's large data sets into useable knowledge to enable and expand the warfighting advantage.
- Continuous analytical fusion of data, physics-based models, and machine learning (ML) to prescribe multiple, future representations of the platform and its environment.
- Develop methods for autonomous command and control of a naval platform's power distribution system.

Data and Model Based Component
and Subsystem Measurement and Analysis



Real-Time Data Compared to Historical and Model Data
To Provide Actionable Information for Decision Makers



Subsystem Information is Aggregated to
Provide Increased Platform-Level Awareness

WHY THIS IS IMPORTANT

- Having a tool to help identify the critical issues in a timely fashion to increase mission readiness and operational availability.
- Apply AI/ML techniques to recognize deviations from expected operational conditions to prevent failures.
- Improving the ability to provide protection against large power fluctuations and increase platform survivability.

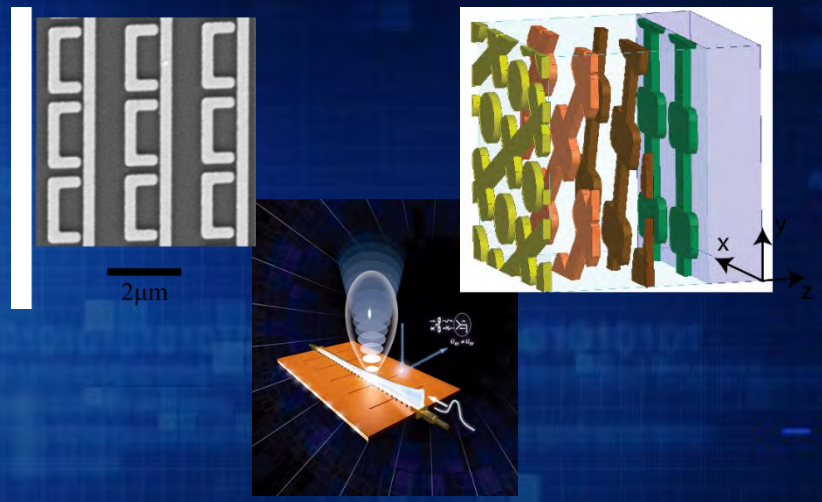
TRANSITION OPPORTUNITIES

- Digital twin technology supports various power and energy programs, both manned and unmanned
- Identify and mature digital twin technologies and capabilities that they can be operationalized for use on existing and future platforms

Photonic Metamaterials

- Discover novel artificial composites engineered to control light propagation and overcome challenges associated with loss, bandwidth, and scalability.

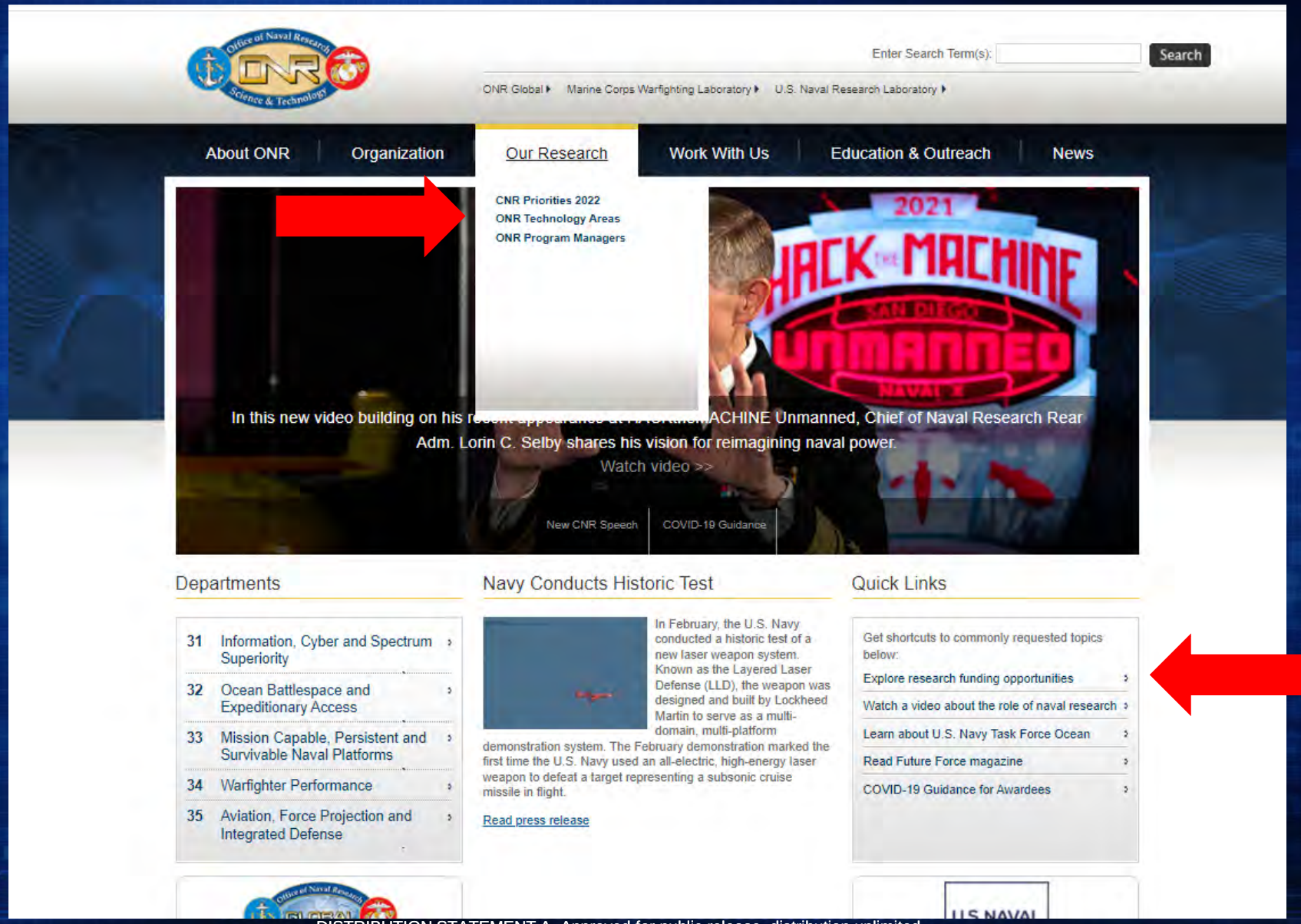
- Technical Approach:
  - Explore the physics and optics of strong light-matter interactions supported by topological polaritonic metasurfaces.
  - Develop reconfigurable three-dimensional metamaterials for manipulating polarization, amplitude and phase.
  - Three-dimensional all-dielectric metamaterials with tailored bianisotropic response and low loss.
  - Novel three-dimensional fabrication methods to produce large area samples.
  - Nonlinear materials with tunable electromagnetic properties.



WHY THIS IS IMPORTANT

- Thermal signature reduction/management
- High resolution lenses
- Highly absorptive coatings
- Smaller, higher performing antennas
- Light concentration

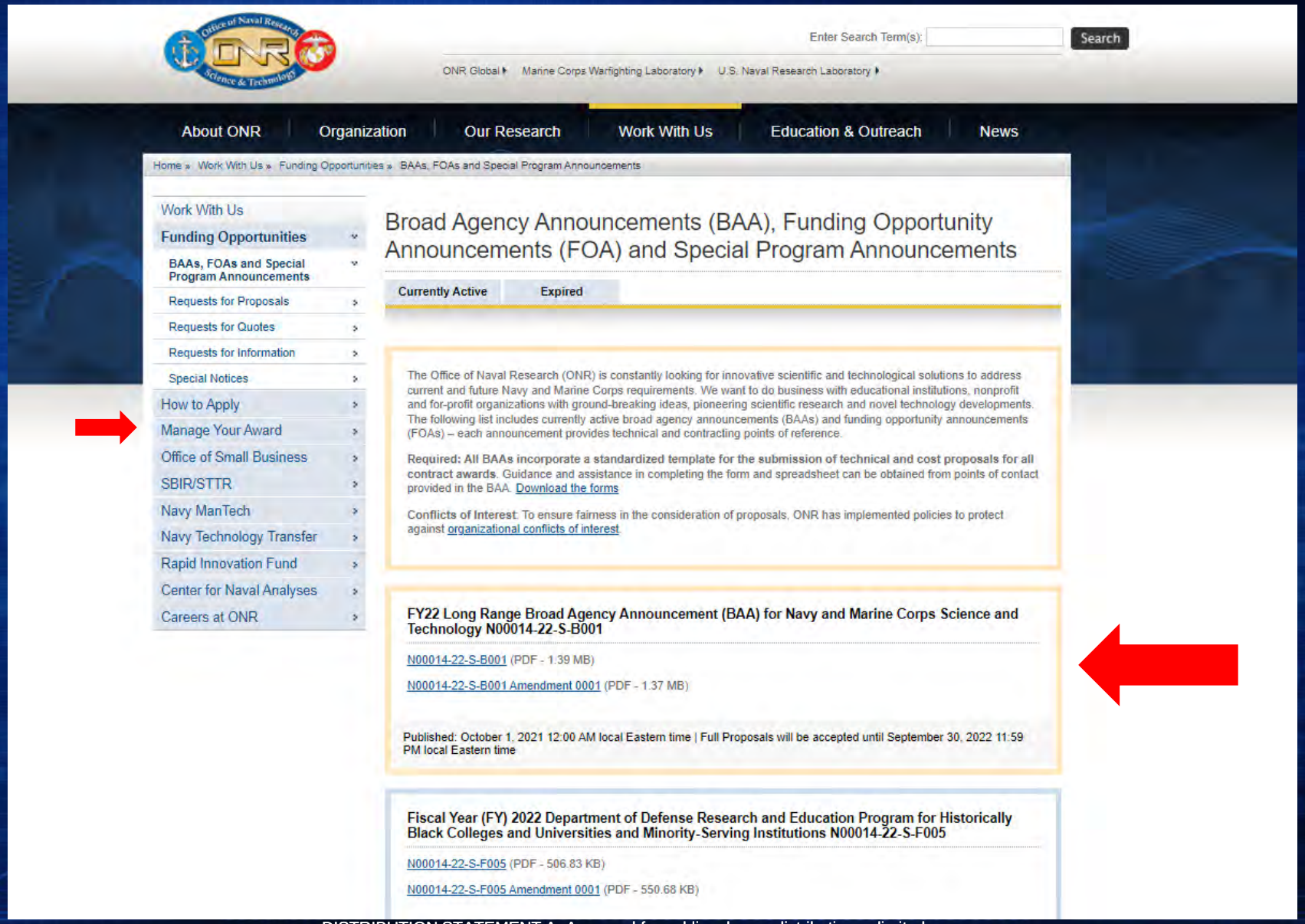
Engaging with ONR: https://www.onr.navy.mil/



ONR Insider Hints

- ONR is a mission-oriented agency. We work S&T issues that matter to the Navy and US Marine Corps.
- We want to fund the *best people*, not just projects.
- We want to grow the next generation of scientists and engineers.
- ONR program officers are the decision makers!
  - Talk to them and understand their priorities.
  - Priorities change: subject areas are initiated, grow, evolve and go away.
- Become familiar with Navy terminology and where your technology fits by reviewing the ONR website, attending national conferences, asking questions.
  - Read BAA and DoD/ONR grant terms and conditions!
- White papers typically precede formal proposals. Always submit a white paper first!
- We like peer-reviewed publications and a robust exchange of ideas.
- Although ONR does classified research; basic research is almost never classified.
  - However, be aware of security sensitivities in some research areas.

Research Funding Opportunities



Tri-Service University Research Programs

University Research Programs fund promising new research, stimulate innovation, and attract outstanding researchers to naval-relevant research projects; proposals accepted from academic institutions only.

The **Multidisciplinary University Research Initiative (MURI)** involves teams of researchers investigating high priority topics and opportunities that intersect more than one traditional technical discipline. *FY22 FOA published in Feb; white papers due 16 May 2022; proposals due 9 Sep 2022.*

The **Defense University Research Instrumentation Program (DURIP)** supports university research equipment/infrastructure essential to high-quality naval-relevant research. *FY22 FOA published in Feb; proposals due 13 May 2022.*

The **Vannevar Bush Science & Engineering Faculty Fellowship (VBFF)** (managed by Office of the Under Secretary of Defense, Basic Research Office) provides extensive, long-term financial support to distinguished university faculty and staff scientists and engineers to conduct unclassified, basic research/"blue sky" on topics of interest to DoD. *Goal: publish FOA in Jun; proposals due in Dec. or Jan.*

ONR Young Investigator Program (YIP)

Support the best and brightest early-career academic researchers whose scientific pursuits show outstanding promise for supporting the Department of the Navy, while also promoting their professional development. *Goal: publish FOA in Jun; proposals due in Aug.*

Successful Candidates

- Research the Program's / Program Officer's research interests and portfolio.
- Contact ONR Program Officer before submitting proposal.
  - PO comment: *"if only the researcher would have contacted me first – this would have been a great proposal!!"*
- Show a record of publishing in peer-reviewed journals.
- Include a strong letter of support from University and/or Department
- Include a complete curriculum vitae with white paper and/or proposal package.

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Diversity and Inclusion

The Key to Success

"Strong Naval STEM efforts are critical to America's future, and are a matter of national security."

- Rear Adm. Lorin Selby, Chief of Naval Research

New Naval STEM Initiatives

Spurred by ongoing global and national events

1. ***Virtual STEM Initiatives*** targeted education and outreach to 5,000+ students (K-12, community college, undergraduate, and graduate) via virtual career seminars, virtual field trips, virtual internships, and online challenges/competitions.
2. ***Naval Horizons*** is an online essay contest designed to increase student awareness of STEM careers and naval science and technology challenges via video interviews with DON scientists and engineers *(21,000+ views on YouTube) .*
3. ***NREIP Fall Engagement*** is a short-term (40 hour) virtual internship opportunity to broaden student participation. 177 college students completed the 2020 internship which was highly successful from both the student and naval scientist and engineer mentor perspective. Internships occurred: OCT-DEC 2021.
4. ***STEM Diversity Initiatives*** broaden opportunities to increase diverse participation in STEM in a meaningful and scalable way. For example, new HBCU/MI summer internship programs at NAVSEA, NMRC, and NAVFAC expanding on existing HBCU/MI internships at NRL, NAVWAR, and NAVAIR.

Naval STEM Re-Design
Diversity-focused, Virtual, Scalable, Sustainable

Other Pathways to Partnership

Backup Slides

Budget Activities

- **6.1 Basic Research:** Basic research is defined as systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts *without specific applications* towards processes or products in mind.
- **6.2 Applied Research:** Applied research is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. It is a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.
- **6.3 Advanced Technology Development:** Includes all efforts that have moved into the development and integration of hardware for field experiments and tests. The results of this type of effort are proof of technological feasibility and assessment of operability and producibility rather than the development of hardware for service use.
- **6.4 Advanced Component Development:** Demonstration efforts to validate integrated technologies in as realistic an operating environment.
- **6.5 Engineering and Manufacturing Development:** Engineering and manufacturing development needed to reach full-rate production.
- **6.6 RDT&E Management Support:** Research and development efforts directed toward support of installations or operations required for general research and development use.
- **6.7 Operational System Development:** Development projects in support of development acquisition programs or upgrades still in engineering and manufacturing development.

Future Naval Capabilities

More Technologies / Shared Resources / Shared Destiny

Innovative Naval Prototypes

Fewer Technologies / High Risk / High Reward

Today's Challenge

DON SBIR/STTR Innovation Delivers Solutions to Our Warfighters*

Naval Research Enterprise Needs
National Defense Strategy, Acquisition, Sustainment, Modernization

Innovative Proposals
Start-ups and Small Businesses

Feasibility Study (Phase I)
Scientific or technical merit of an idea

Technology Development (Phase II)
Build and test prototypes

Commercialization (Phase III)
Sales to defense and private sector markets

DON topics derive from Warfighter-driven needs and identify a transition end state

*FY21 Data