ONR Decarbonization Research Consortium

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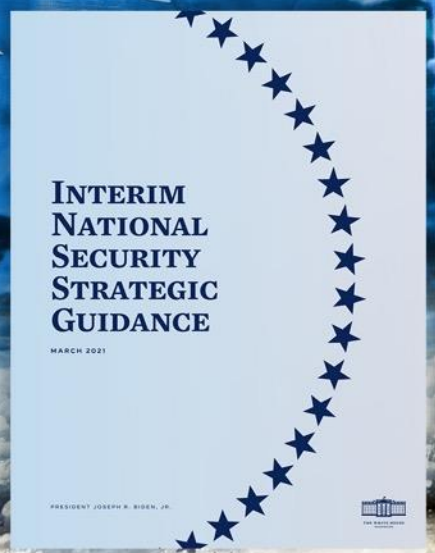
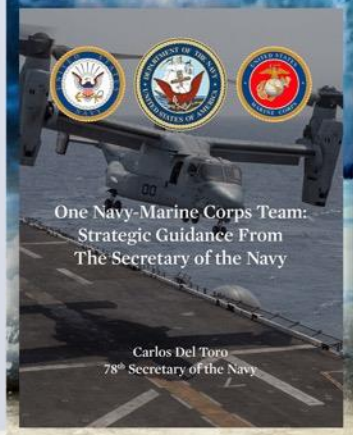
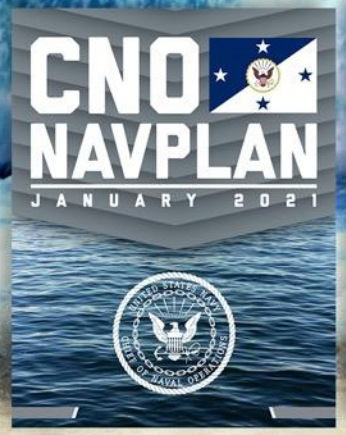
ONR is a mission-oriented agency!

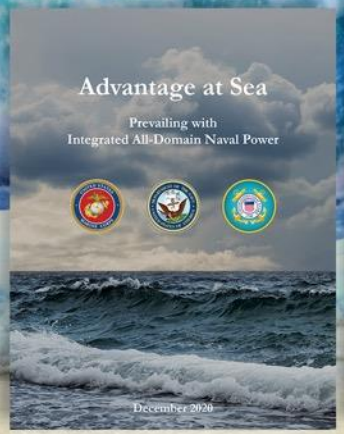
Established by Congress in 1946, The Office of Naval Research's mission is to:

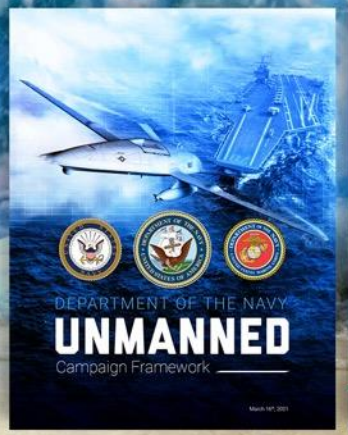
"…plan, foster and encourage scientific research
in recognition of its paramount importance as related to the maintenance of future naval power, and the *preservation of national security*…"

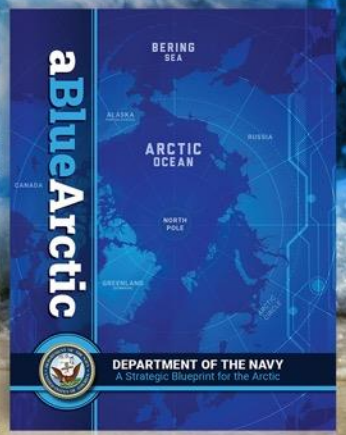












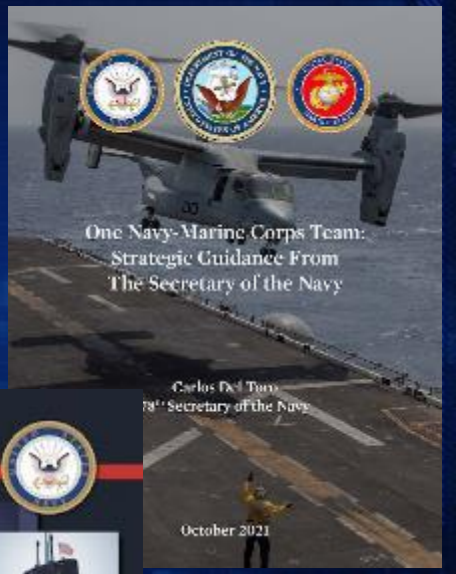
Why Climate Matters to the DON

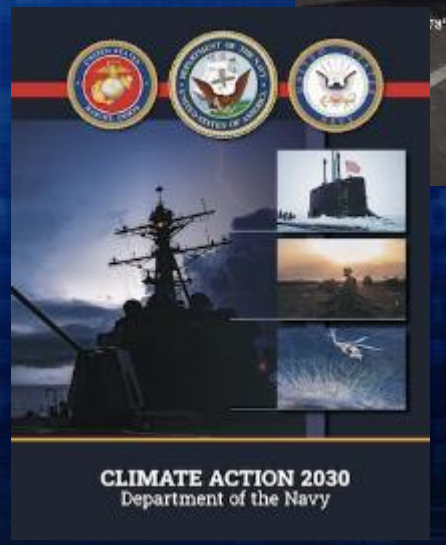
National Defense Strategy: Changes in global climate and other dangerous transboundary threats, including pandemics, are transforming the context in which the Department operates. We will adapt to these challenges, which increasingly place pressure on the Joint Force and the systems that support it.

SECNAV Strategic Guidance: It is a national security and warfighting imperative for the Department of the Navy to address the impact of climate change on our readiness, operations, and ability to fight and win.

DON Climate Action 2030: "Climate change is one of the most destabilizing forces of our time, exacerbating other national security concerns and posing serious readiness challenges,"
Honorable Carlos Del Toro, Secretary of the Navy

- Doing our part to reduce the destabilizing threat of climate change and to ensure our ability to operate in an increasingly unstable future is an integral part of our mission and will make us a more capable, agile, and lethal fighting force
- The DON has made meaningful progress, and now the magnitude and urgency of the climate crisis demand that we accelerate our efforts, work together, and think creatively to arrive at new and expanded solutions.





DoN Greenhouse Gas Emissions

- Department of the Navy emits approximately 16.7M MTCO2$_e$ per year (Scope 1 and 2)
  - 70% of emissions are from operations, 30% from installations
  - >95% of operational emissions are from burning fuel (~26 billion barrels per year)
    - 50% from aircraft (USN and USMC)
    - 48% from ships (USN and MSC)
    - <2% from ground vehicles and generators (USMC)

Consortium Vision

- The Decarbonization Research Consortium is a public-private collaboration that advances interdisciplinary research to help the Navy meet the complex challenges of platform decarbonization, with a focus on ships and aircraft.

- Many other programs in the US and internationally focused on decarbonization.
- Our intent is not to duplicate, but identify promising technologies that can be adapted to naval platforms and accelerate their adoption through an applied research portfolio.
- Partnership of academia, industry, and government.

ESRDC

ELECTRIC SHIP RESEARCH AND DEVELOPMENT CONSORTIUM

Bringing together leading research institutions to advance electric ship concepts.

- The Electric Ship Research and Development Consortium (ESRDC) brings together in a single entity the combined programs and resources of leading electric power research institutions to advance near to mid-term electric ship concepts.
- The ESRDC's efforts contribute to the goal of ensuring the United States' superiority in electric systems well into the future.
- The five major thrusts are:
  - Combat Power and Energy Systems (CPES) Design Methodologies
  - High Power Dense Component Development and Characterization
  - System Management and Control Technologies
  - Developing New Design Functionalities
  - System Level Experimentation

Decarbonization Research Consortium

- Timeline
  - Looking to establish research agenda by June 2023
  - Initial period of 4 years
- Funding
  - 6.2 – Applied research (potential for future 6.1, 6.3, 6.4)
  - Universities funded through individual grants
  - *Participation in these planning meetings does not guarantee future funding, nor preclude others from being funded.*
- Small/large business engagement
  - Not intended to follow NSF IUCRC model
- International partnerships

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.

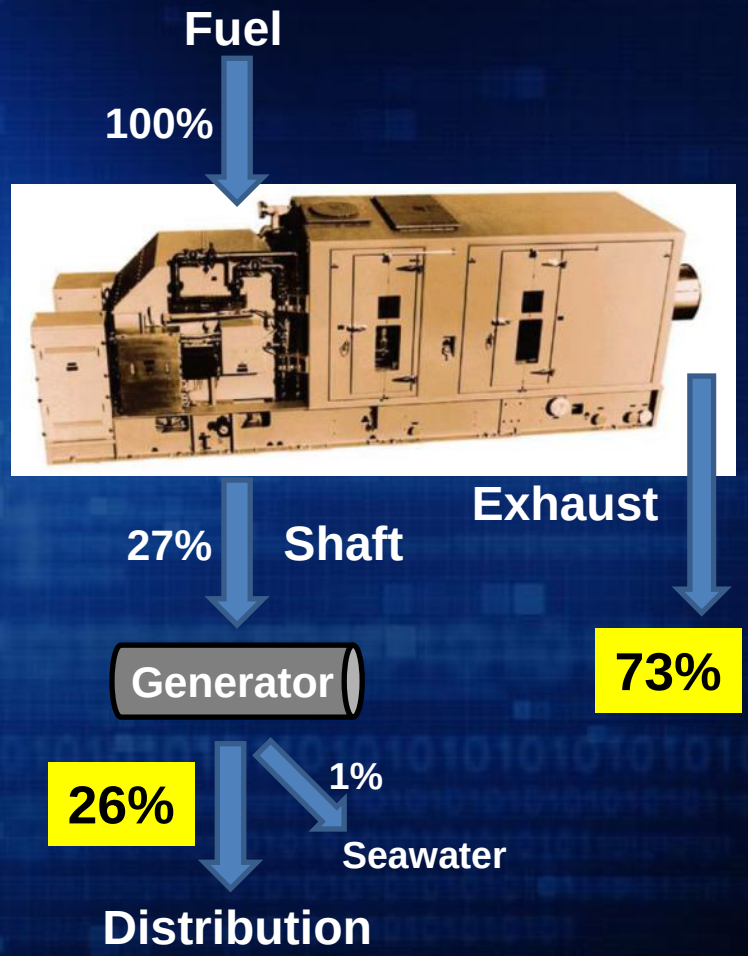
Ongoing/Potential Decarbonization S&T

- Energy Efficiency
  - Engine Efficiency
  - Energy Recovery
  - Hybrid Systems
- Low Carbon Technologies
  - Alternative Fuels
  - Renewable Power Generation
  - Carbon Capture
- Low GWP Refrigerants

Are there opportunities missing?

Gas Turbine Efficiency

- Two-thirds of the energy from DoN's fuel is exhausted.
  - By far the largest carbon emission
- Not all 'waste' heat
  - Thermodynamics dictates maximum engine efficiency
- Pathways to improve efficiency
  - Higher temperature operation
  - Combined cycles to increase efficiency
  - Commonly used in commercial power plants to achieve efficiencies up to 65%
  - *Come with serious size, weight and integration challenges.*



Sea Warfare & Weapons

Direct Air Capture & Blue Carbon Removal Technology

ONGOING INITIATIVES

1. ***Development of lightweight, compact, efficient, cost-effective, deployable technologies for direct ocean (DOC) and direct air capture (DAC) of environmental carbon.***
2. ***Scalable thermochemical, biological, and electrochemical reaction pathways to liquid fuels, lubricants, and materials.***
3. ***Modeling and simulation of reaction pathways, technology scaling, and environmental and mission impacts.***

– *Leverage government, academia, and industry collaborations, partnerships, and accomplishments to date to support research, development, demonstration, and transition of technologies to commercial and military partners*

WHY THIS IS IMPORTANT

1. ***Enhancing DOC and DAC capabilities to fieldable technologies is becoming increasingly important for future operational implementation.***
2. ***Next-generation carbon conversion technologies are important for operational endurance and sustainability.***
3. ***DAC and DOC Technology program supports Navy Climate Action 2030, "net zero" carbon emissions goals.***

TRANSITION OPPORTUNITIES

1. ***DOC and DAC science and technology developments align with NPES-TDR.***
2. ***Fuels, lubricants, and materials from environmental carbon align with DoN Installation Energy Resilience Strategy, Naval R&D Framework, NPES-TDR***
3. ***Carbon-neutral fuel that meets MIL-DTL-5624W.***

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Sea Warfare & Weapons

Direct Air Capture & Blue Carbon Removal Technology Program Roadmap & Technology Pathways

Technologies

DAC and DOC RDT&E

- Process and electrical efficiencies
- Material development (catalyst, membranes, and absorbents)
- Water efficiencies
- CO_2 production efficiencies
- Size, weight, footprint
- Designs and scale-up
- Test and evaluation

Fuel and Material Synthesis RDT&E

- Process and electrical efficiencies
- Catalyst development for CO_2 conversion and selectivity to fuel
- Designs and scale-up
- Test and evaluation
- Down select catalyst for demonstrations
- Biological conversion of CO_2 to fuels and lubricants
- Solid Oxide Fuel Cells (SOFC) for hydrogen and syngas production
- Synthesis of CO_2 to JP10 and new materials

Scaling, Integrating, Evaluating Demonstrating, and Transitioning

- Larger-scale testing of integrated systems as processes for "Proof of Concept,"
- Measure feasibility, efficiencies, scaling, deployability, and identify technology gaps

FY23 Plans

- DOC stack design to reduce size, weight, materials, and cost
- Test and evaluate DOC multicell design
- Scaling and integrating HDAC systems
- Materials testing and advancing energy recovery

- Catalyst modeling
- NRL fixed-bed reactor skid tested and evaluated
- Down select catalyst materials to produce less methane
- Army electrochemical reactor design to reduce CO_2 to methanol /ethylene
- Biological reactor design for CO_2 to lubricants
- CO2 to aromatics
- Syngas and hydrogen production by SOFC

- Time line and dollar value to construct and build 100 gal/day BC/FS process
- CNA operational and logistical benefits analysis of technology in South Pacific
- Evaluate integrated DAC and FS processes
- CNA Environmental impacts and carbon cycle modeling

FY24 Plans

- Precommercial DOC module for test and evaluation
- New catalyst materials for DOC
- Test and evaluate IWVC and Southern States Energy Board DAC systems

- Army construct, test, and evaluate electrochemical reduction of CO_2 from different feedstocks.
- Biological reactor evaluation and demonstration of lubricants
- Evaluate new processes to produce cement and materials from CO_2
- Test, evaluate, integrate, scale SOFC

- EDMs for integrated 100 gal/day DOC and FS technologies
- Begin process to construct and build 100 gal/day DOC/FS process
- EDMs for integrated DAC and FS technologies to produce syngas and liquid fuel
- Identify technology gaps that require more RDT&E

FY25 Plans

- RDT&E plans for DAC and DOC technologies updated from the results and progress obtained in FY23 and FY24

NRL CBD Test Site

- RDT&E plans for FS, materials, and biological processes updated from the results and progress obtained in FY23 and FY24

- Demonstrations of integrated DAC/FS processes
- Construction of 100 gal/day DOC/FS process
- Plans to build 1,000 to 10,000 gal/day DAC/FS and DOC/FS (FNC, INP, etc)

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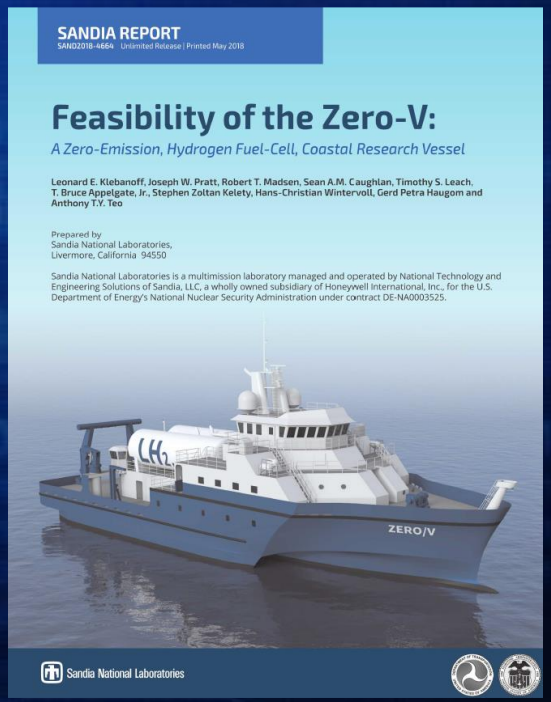
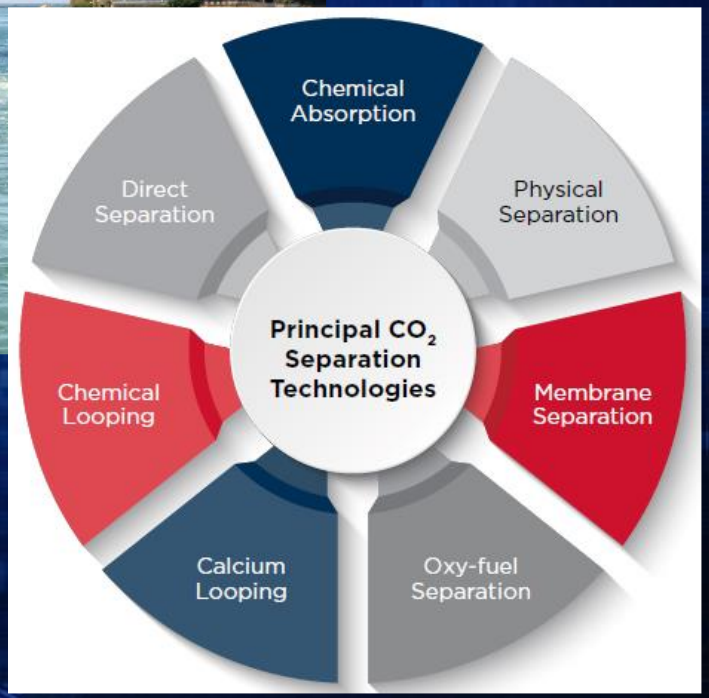
Alternative Fuel: Hydrogen

- Green hydrogen, produced from renewable energy, produces no greenhouse gases when burned
  - DOE Hydrogen Shot program seeks to reduce cost of green hydrogen to $1/kg
  - Infrastructure bill contains $9.5B for DOE hydrogen initiatives
- Scripps Institute of Oceanography plans to build a hybrid hydrogen powered research vessel
  - ONR plans to leverage vessel for engineering studies
- GM developing portable electric vehicle recharge stations using H2 fuel cells
  - Potential use on USN installations for vehicle recharge and energy resiliency



Carbon Capture

- Post-combustion carbon captures technologies have been employed in terrestrial power plants, with chemical adsorption being the most mature.
- Can these be adapted to capture carbon dioxide emissions from ship's exhaust *and* store it onboard until it can be offloaded?



Our Mission: **Reimagine Naval Power**

Relentless search for FUNDAMENTAL, HIGH PAY OFF scientific understanding

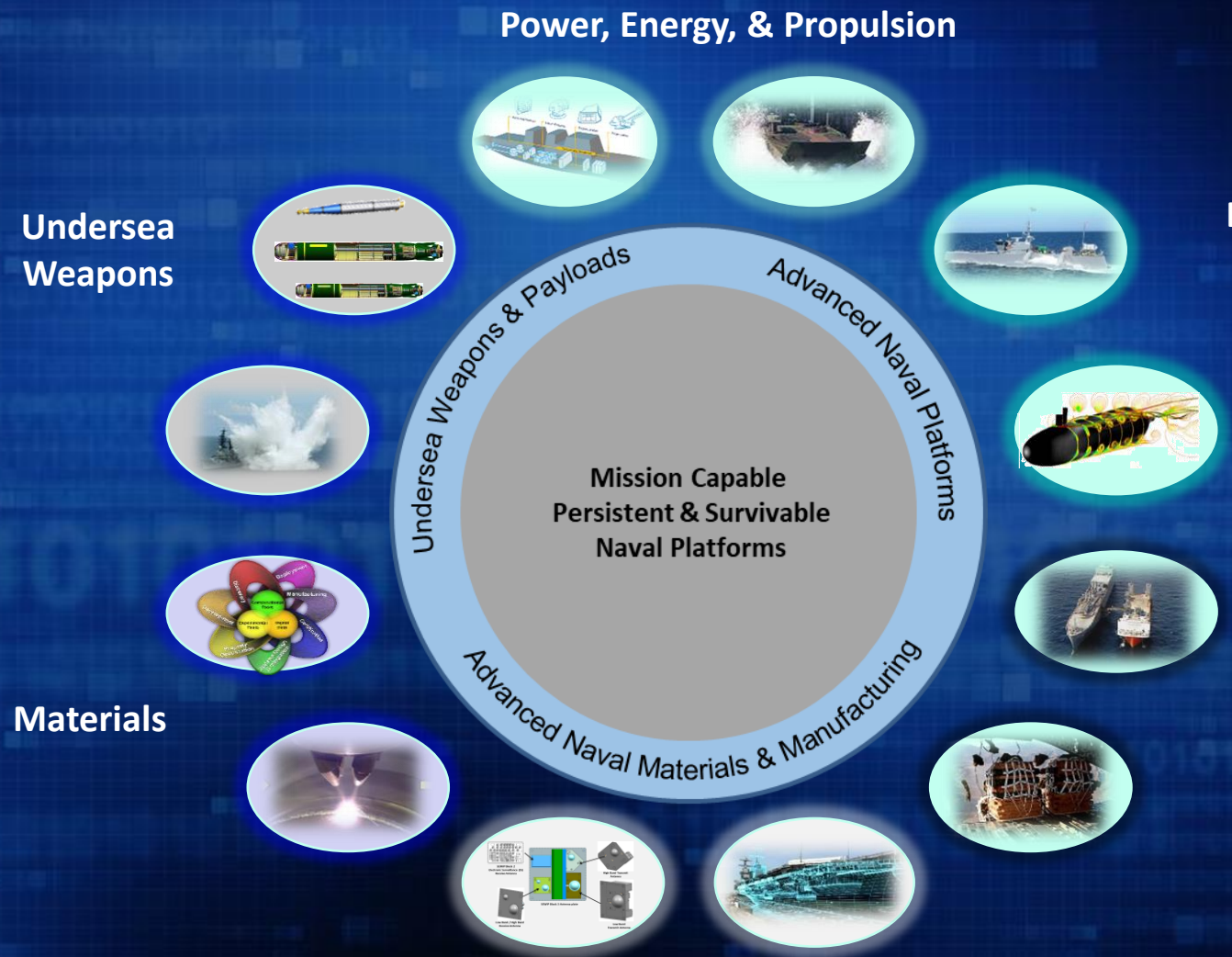
PARTNER with the **RIGHT SCIENTISTS** to ensure the Navy and Marine Corps are always linked to **SCIENTIFIC DISCOVERY**

Backup Slides

ONR Research Portfolios

Naval Platforms (Code 33)

Sea Warfare and Weapons



Naval Platforms (Code 33)

Sea Warfare and Weapons

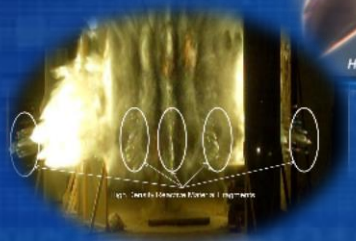
Aviation, Force Projection and Integrated Defense (Code 35)

Kinetic Weapons

Air Weapons & Hypersonics

Directed Energy

Advanced Energetic Materials



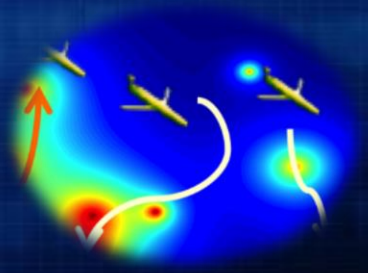
Railgun

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