



ONR

Revolutionary Research . . . Relevant Results

Sharpening the Edge

Serving the Next Generation Warfighter ... Now

Powering Future Naval Forces

Presented by

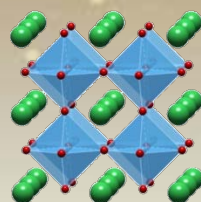
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O F F I C E O F N A V A L R E S E A R C H

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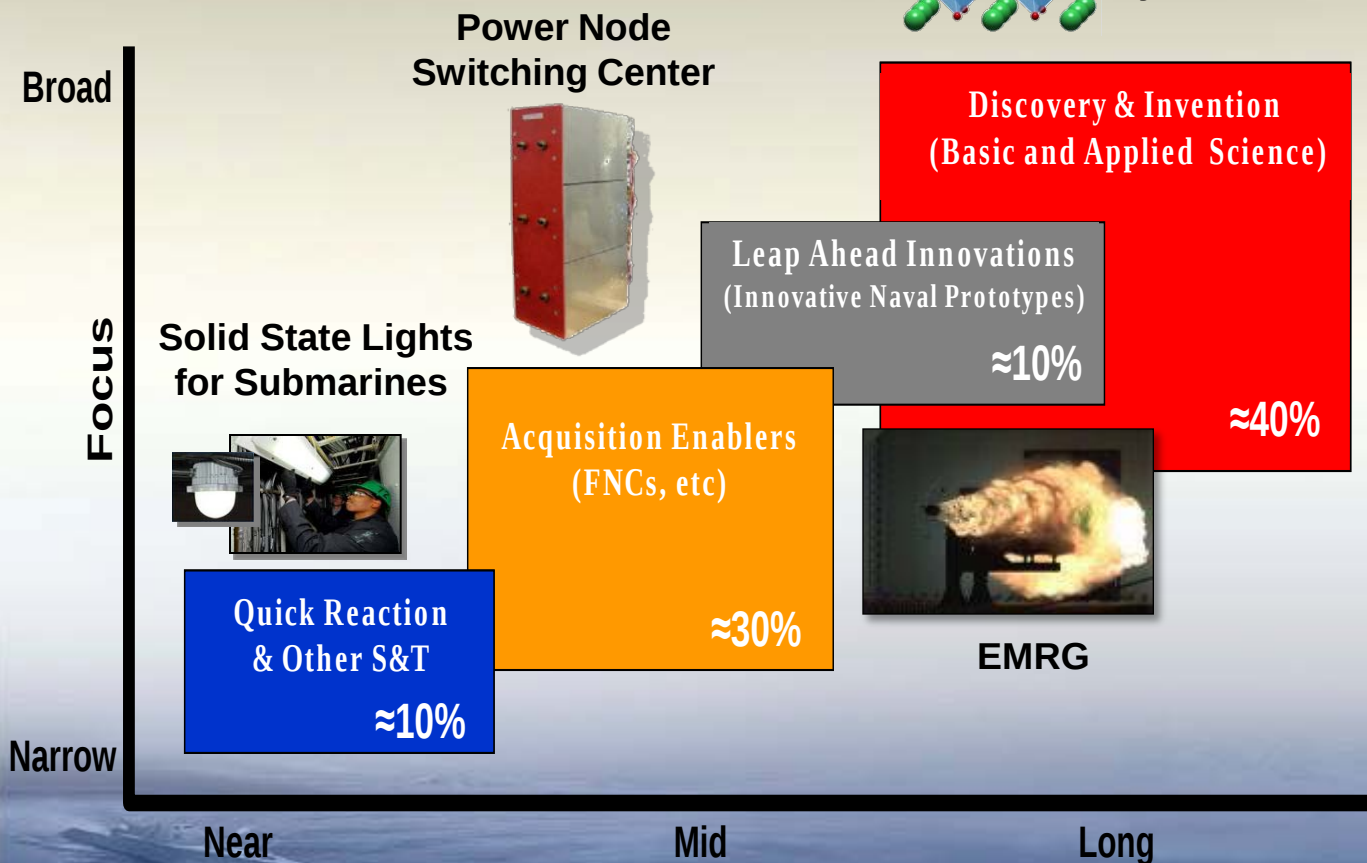
Naval S&T Strategic Plan



Perovskite-based
Pyroelectrics

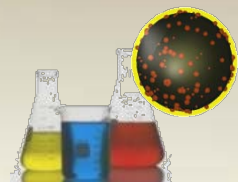
Focus Areas

- *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



Power & Energy Technologies

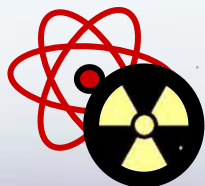
Fuel



Fuels Chemistry



Alternative Fuels



Nuclear

Power Generation



"Ion Tiger"
UAV Fuel Cell



Fuel Cells



Aircraft Engines

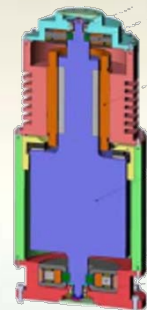


Gas Turbine Generators

Energy Storage



Batteries

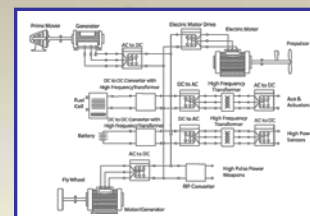


Flywheels

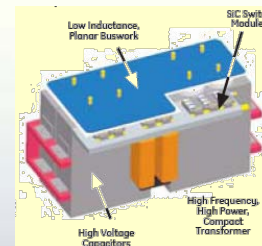


Capacitors

Distribution & Control

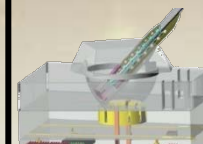


Electrical Architectures
& Pulse Forming
Networks



High Voltage Silicon
Carbide (SiC)
Switches

Power Loads



Electric
Weapons



Powering & Resistance



UV Sensor Loads

Reconfigurable Blades /
Blade Loading



S&T Energy Investments

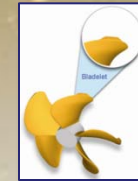
Power Loads



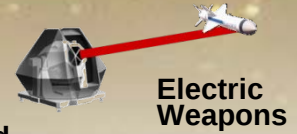
Advanced Sensors
Solid State Lighting



Coatings & Cleaning



Advanced Propellers



Electric Weapons

Distribution and Control



SiC Devices

Bi Directional Power Converters
Power Management Controllers

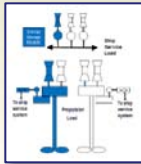


Medium Voltage Direct Current Architecture

HTS Power Transmission Cables



Energy Storage

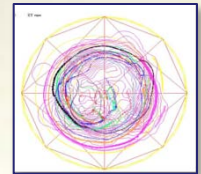


Hybrid Electric Drive



High Density Energy Storage Advanced Batteries

Antimatter/ Particle Storage



Power Generation



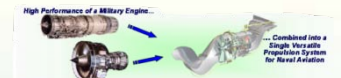
UAV Fuel Cells



Mobile Power Fuel Cells

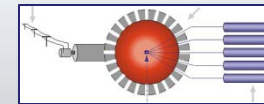


UUV Power



Variable Cycle Advanced Technology (VCAT)

Fuel



Laser Fusion

Near

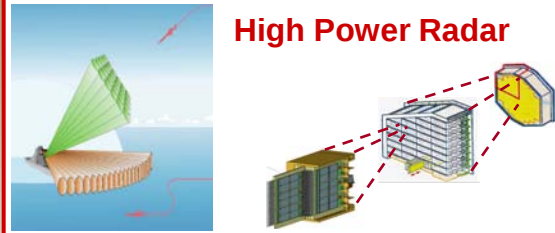
Far

Advanced Electric Warship Next Generation Integrated Power System (NGIPS)

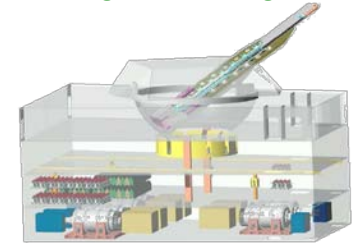
**Laser
Self-Defense
System**



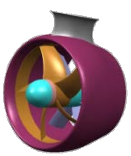
High Power Radar



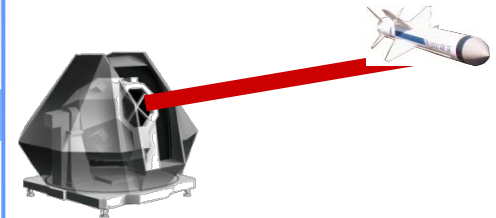
Electromagnetic Railgun



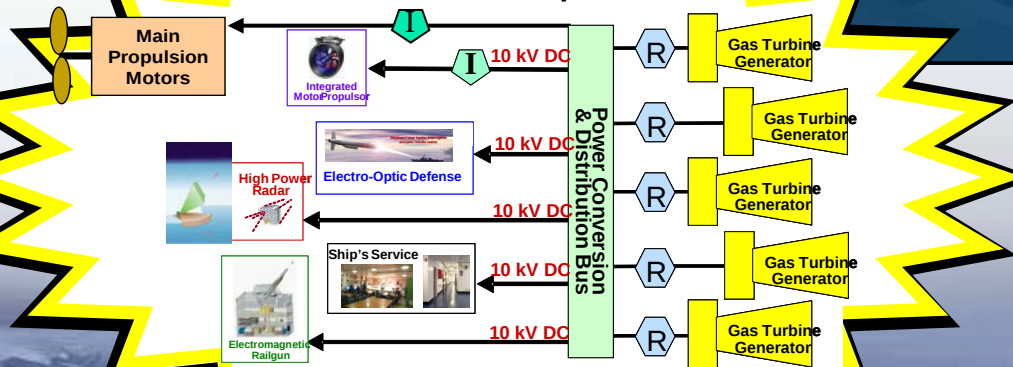
**Integrated
Motor
Propulsor**



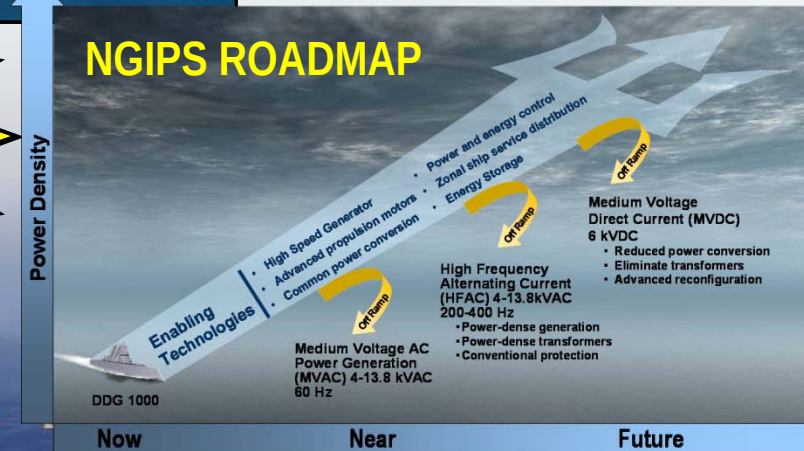
Free Electron Laser System



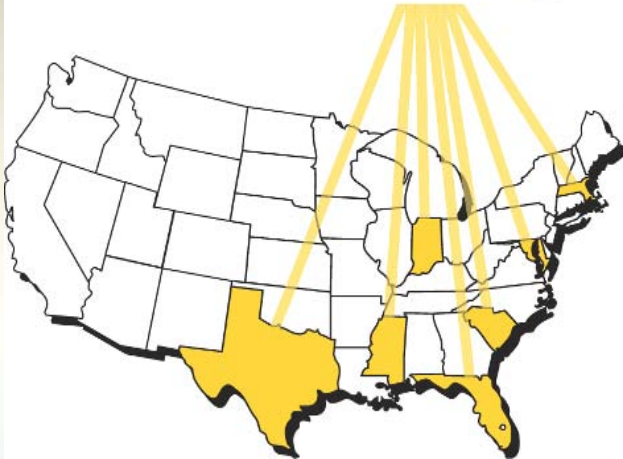
Electric Warship



NGIPS ROADMAP

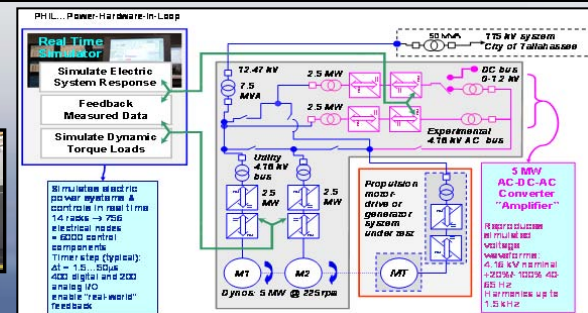


ELECTRIC SHIP RESEARCH
ESRDC
AND DEVELOPMENT CONSORTIUM



U.S. Naval Academy

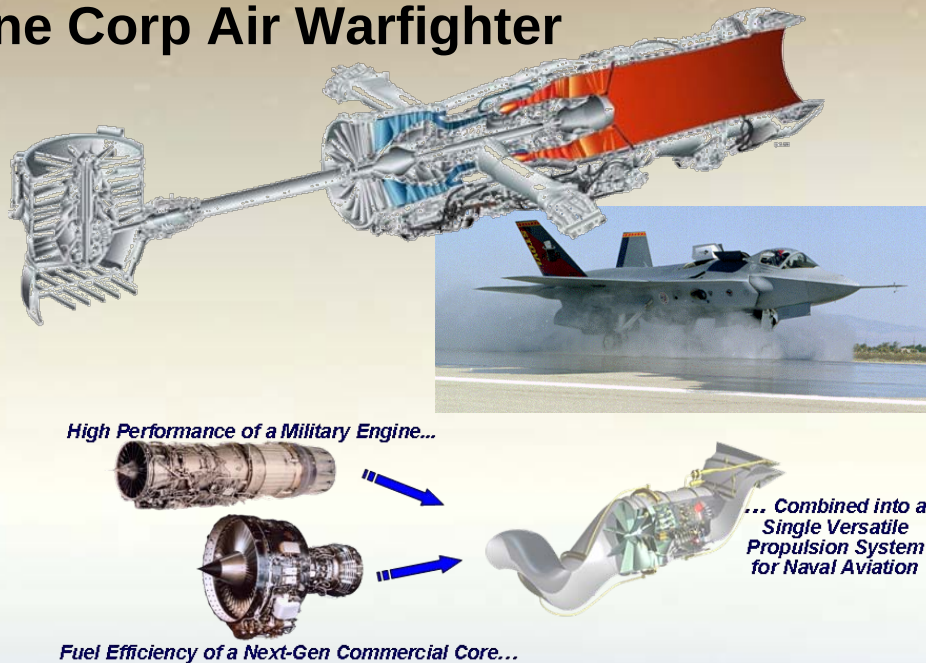
- **Hardware in the loop coupled with physics based models for system design, testing, and validation**
- **Computational tools for early-stage ship systems design**
- **Total ship system solution to thermal management**
- **Load management**
- **Next Generation Integrated Power System (NGIPS)**



Advanced Aerospace Propulsion Science and Technology

Develop and transition advanced airbreathing propulsion technology to the Navy and Marine Corp Air Warfighter

- Engine materials, coatings and processing techniques
- Critical propulsion system component technologies
- Modeling and Simulation
- Propulsion Health Management



Payoffs:

Reduced fuel consumption

Lower life cycle costs

Higher performance and increased durability

Improved environmental compliance

Expeditionary Portable Power

Solid Oxide Fuel Cell for Tactical Vehicle APU and Towable Generator

Efficient, low emission, and low signature



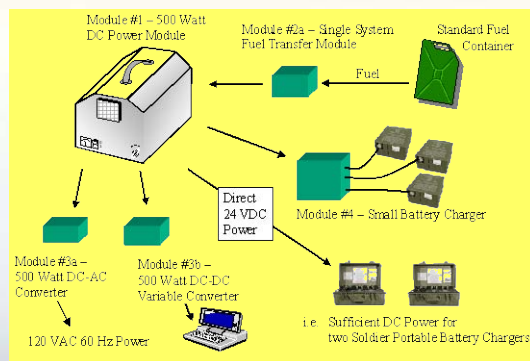
Solid Oxide Fuel Cell



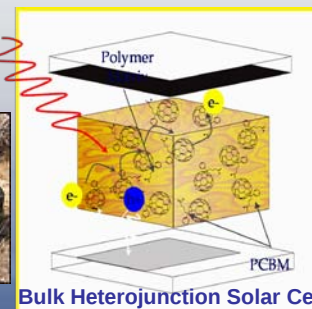
Vehicle Based



Towable Power



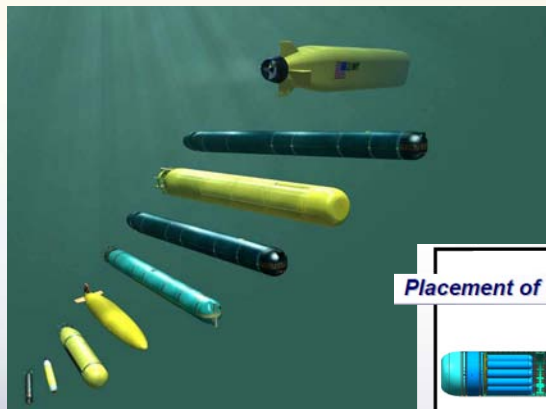
GREENS – Ground Renewable Expeditionary Energy System



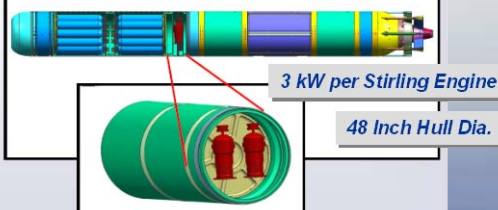
Unmanned Systems Power

Unmanned Air Vehicle Power

- Long endurance fuel cell power (26hr flight Nov 2009)
- Low noise & heat signature
- Affordable



Placement of Stirling Engines in Sea Lion Section



Unmanned Undersea Vehicle Power

- Lithium-ion battery safety
- Long endurance , air independent power systems

Synergy: Energy Efficiency & Affordability

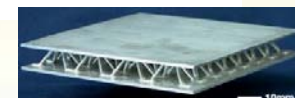
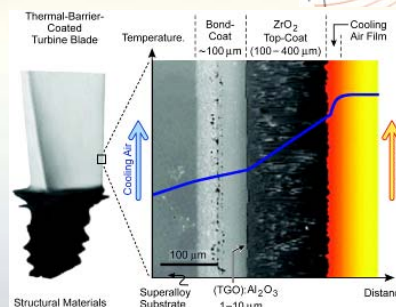
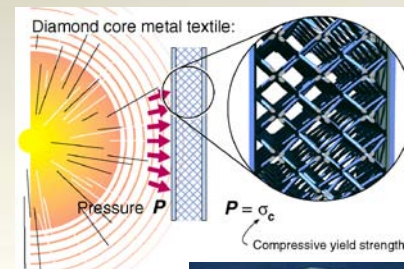
- **Anti-Biofouling Coatings & Hull Husbandry**
- **Lightweight Structural Materials**
- **HTS Degaussing Cable**
- **Turbine Engine Materials Systems**
- **Corrosion Prevention and Mitigation**
- **Advanced Shipboard Water Desalination**
- **Nano-Ceramic Coatings for Life-of-System Wear Surfaces**



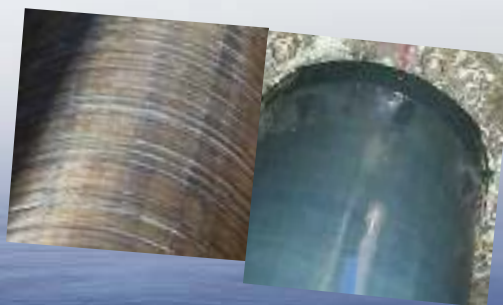
Hull Bug



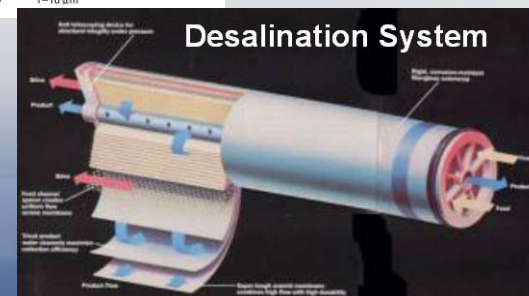
HTS Degaussing Cable



Al-alloy formed pyramidal core



No wear after 4 yrs in in-service



Summary

- **Broad portfolio of research in power, energy and thermal with applications across sea, land, and air systems**
- **Partnerships with industry academia and government with strong international engagement**
- **Holistic approach to efficiency (demand reduction plus improved systems)**
- **Key areas of technical interest: distribution and control, energy storage, hybrid systems**
- **Focus on: optimized platform efficiency, extending unmanned missions, providing adaptive networks, and enabling integration of high power sensors and electric weapons**