



# ONR

Revolutionary Research . . . Relevant Results

## Sharpening the Edge

Serving the Next Generation Warfighter . . . Now



# Powering The Future Naval Force

*Presented by*

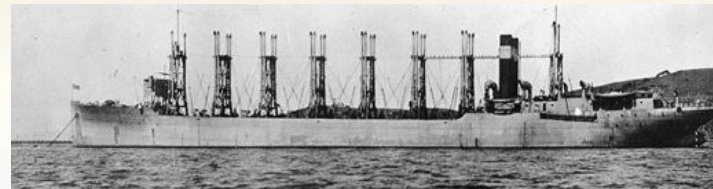
**Dr. John Pazik, Director  
Ship System & Engineering Research Division  
Office of Naval Research**

# History of U.S. Navy Electric Ships



**USS Trenton - 1877**  
1<sup>st</sup> Installation of Electric Lights  
**238 Light Sockets**

**USS Jupiter - 1913**  
US Navy's first  
Electrically-Propelled Ship  
**Installed power: 4,800 kW**



**USS New Mexico – 1918**  
US Navy's first  
Turboelectric Capital Ship  
**Installed power: 22,800 kW**





# Today's U.S. Navy Electric Ships



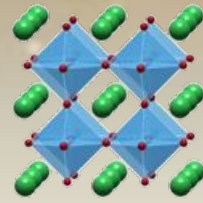
**LHD 8**  
Hybrid Electric Drive  
(\$2.0M Fuel Savings Compared  
with Steam Driven LHD)

**T-AKE 1**  
Commercial Integrated  
Power System  
(Reduced Acquisition and  
Life Cycle Costs)



**DDG 1000**  
Military Integrated Power System  
(78MW Installed Power)

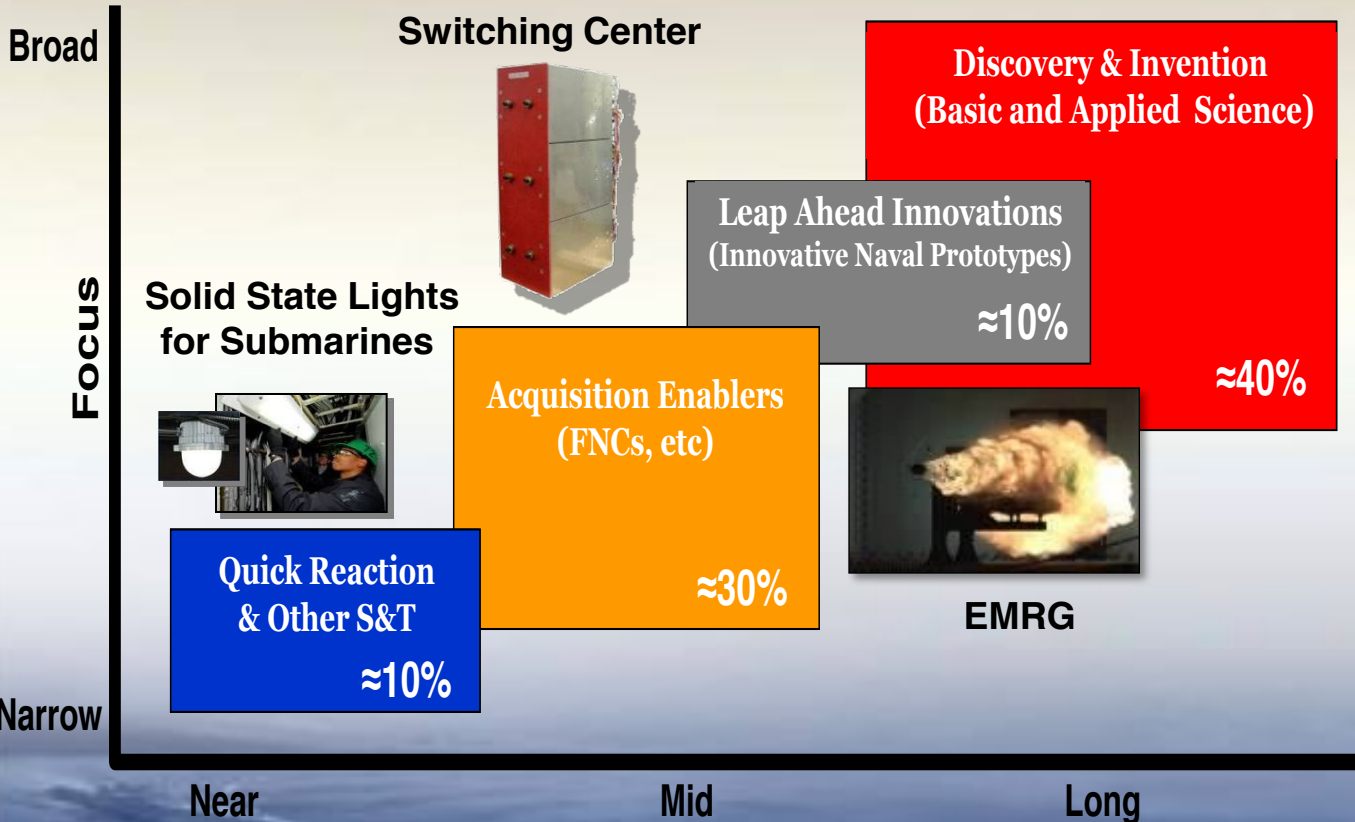
# Naval S&T Strategic Plan



Perovskite-based Pyroelectrics

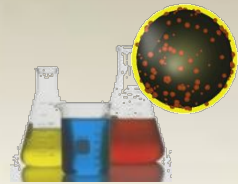
## Focus Areas

- *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

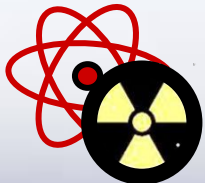
## Fuel



Fuels Chemistry



Alternative Fuels



Nuclear

## Power Generation



"Ion Tiger"  
UAV Fuel Cell



Fuel Cells



Aircraft Engines

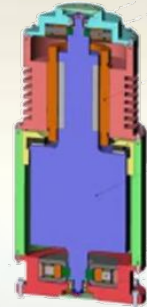


Gas Turbine Generators

## Energy Storage



Batteries

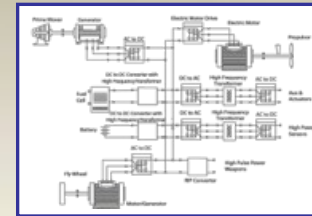


Flywheels

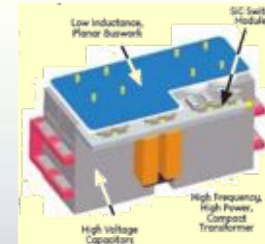


Capacitors

## Distribution & Control

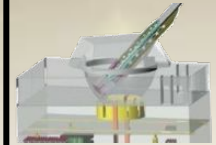


Electrical Architectures  
& Pulse Forming  
Networks



High Voltage Silicon  
Carbide (SiC)  
Switches

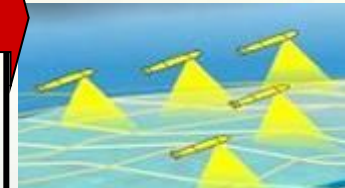
## Power Loads



Electric  
Weapons



Powering & Resistance

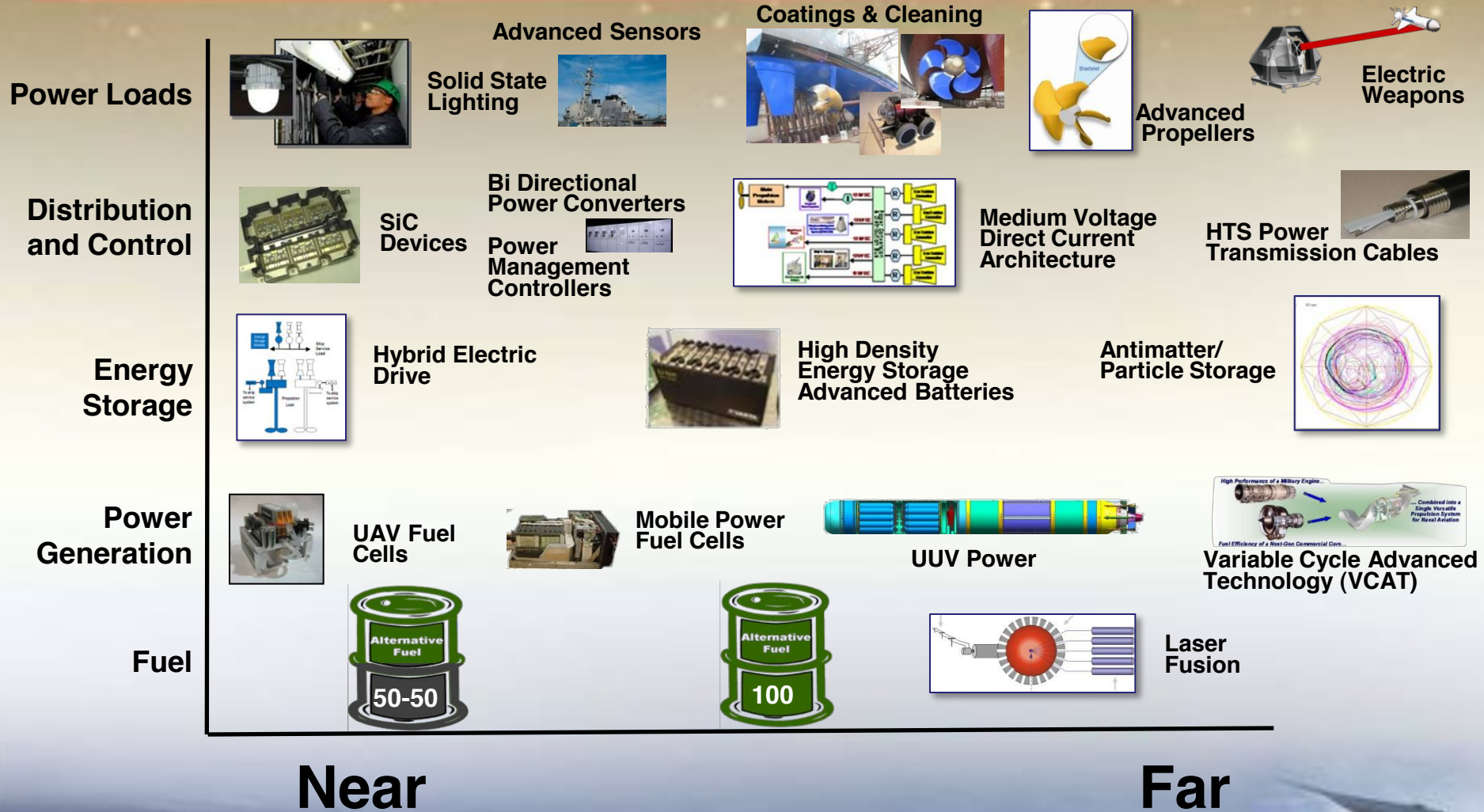


UV Sensor Loads

Reconfigurable Blades /  
Blade Loading



# S&T Energy Investments





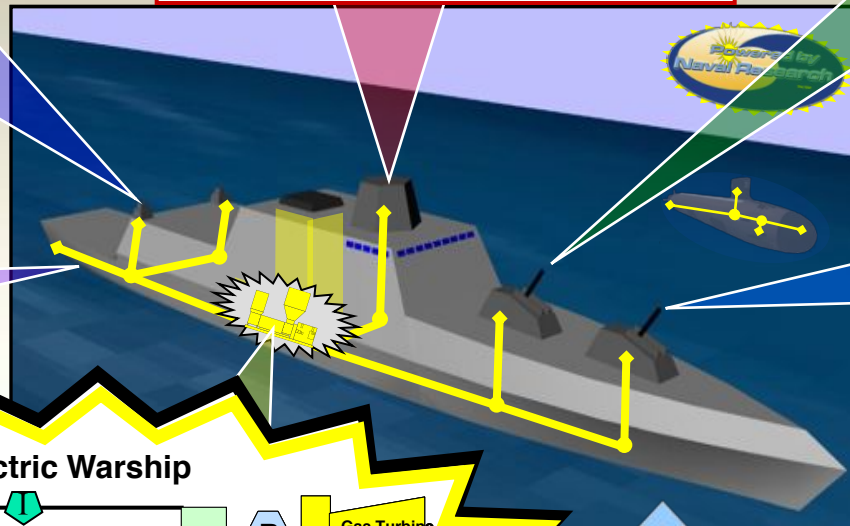
# Advanced Electric Warship Next Generation Integrated Power System (NGIPS)

**Laser Self-Defense System**

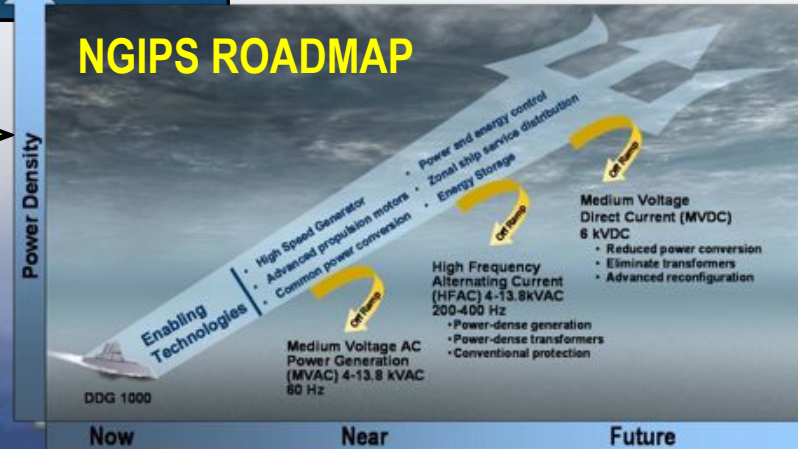
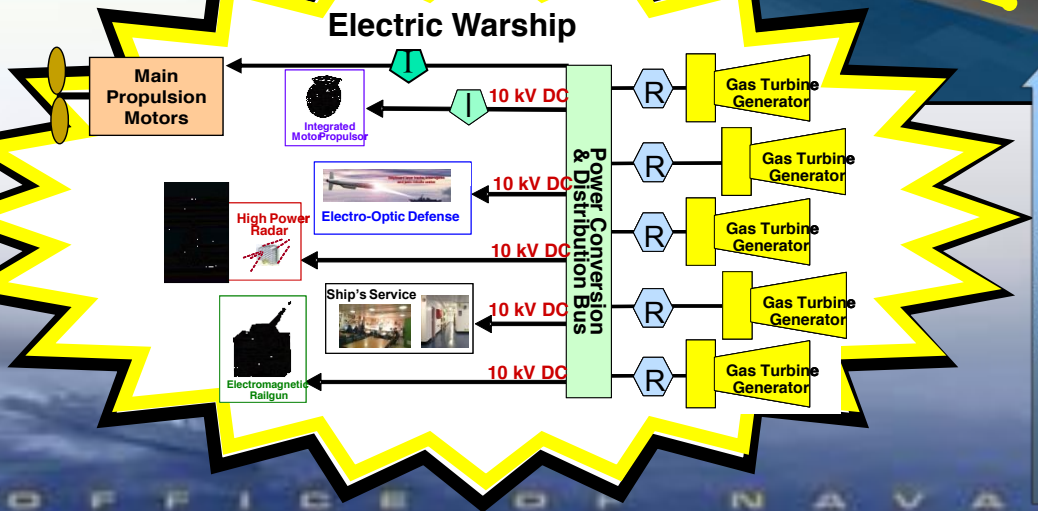
**High Power Radar**

**Electromagnetic Railgun**

**Integrated Motor Propulsor**

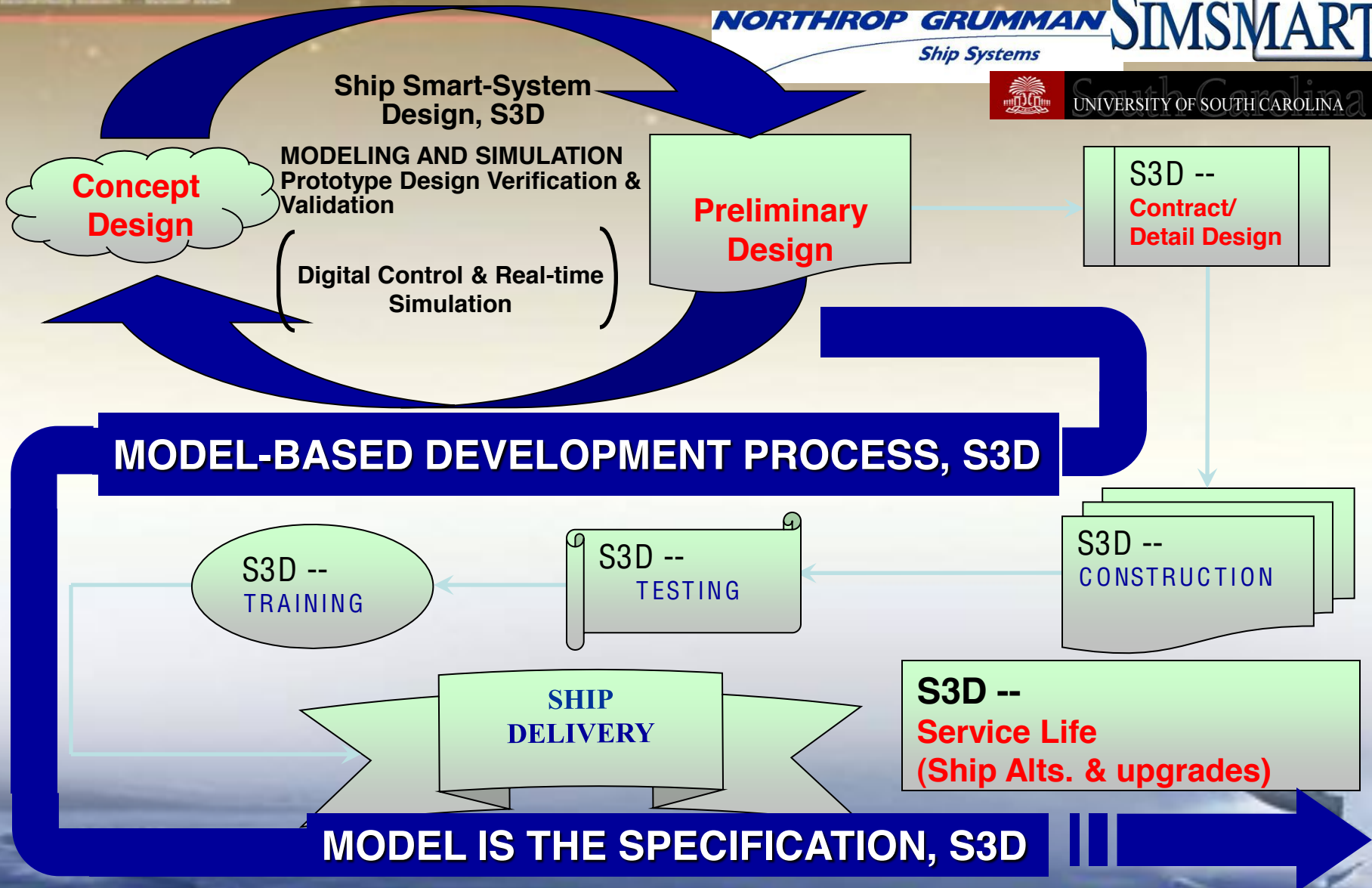


**Free Electron Laser System**





# Future Vision of Shipboard Electrical Design Development Process



# Electric Ship Research and Development Consortium

Consortium of universities with industry partnerships established in 2002 to address fundamental science and technology issues in power distribution and control.

Electric Ship Research and Development Consortium



Florida State University

Massachusetts Institute of Technology

Mississippi State University

Purdue University

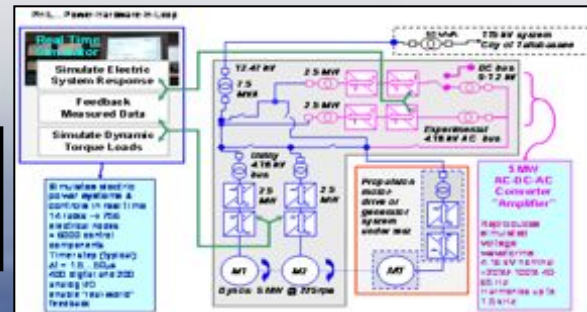
University of South Carolina

University of Texas at Austin

U.S. Naval Academy

## A Center for:

- 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)



# Other P&E Considerations

## 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

High Performance of a Military Engine...  
 ... Combined into a Single Versatile Propulsion System for Naval Aviation  
 Fuel Efficiency of a Next-Gen Commercial Core...

**Payoffs:**

- Reduced fuel consumption
- Lower life cycle costs
- Higher performance and increased durability
- Improved environmental compliance

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## Unmanned Systems Power

### Unmanned Air Vehicle Power

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

Ion Tiger in Flight  
 550 W fuel cell

### Unmanned Undersea Vehicle Power

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

Placement of Stirling Engines in Sea Lion Section  
 3 kW per Stirling Engine  
 50 Inch Hull Dia.

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## 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  
 Diamond core metal matrix  
 Pressure P  
 Compressive yield strength  
 Al-alloy formed pyramidal core  
 Desalination System

No wear after 4 yrs in in-service

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# 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**