

Naval Energy Forum

RADM Nevin P. Carr,
Chief of Naval Research

Shaping the Future Force

Partnership Opportunities
in Energy S&T



S&T Energy Focus

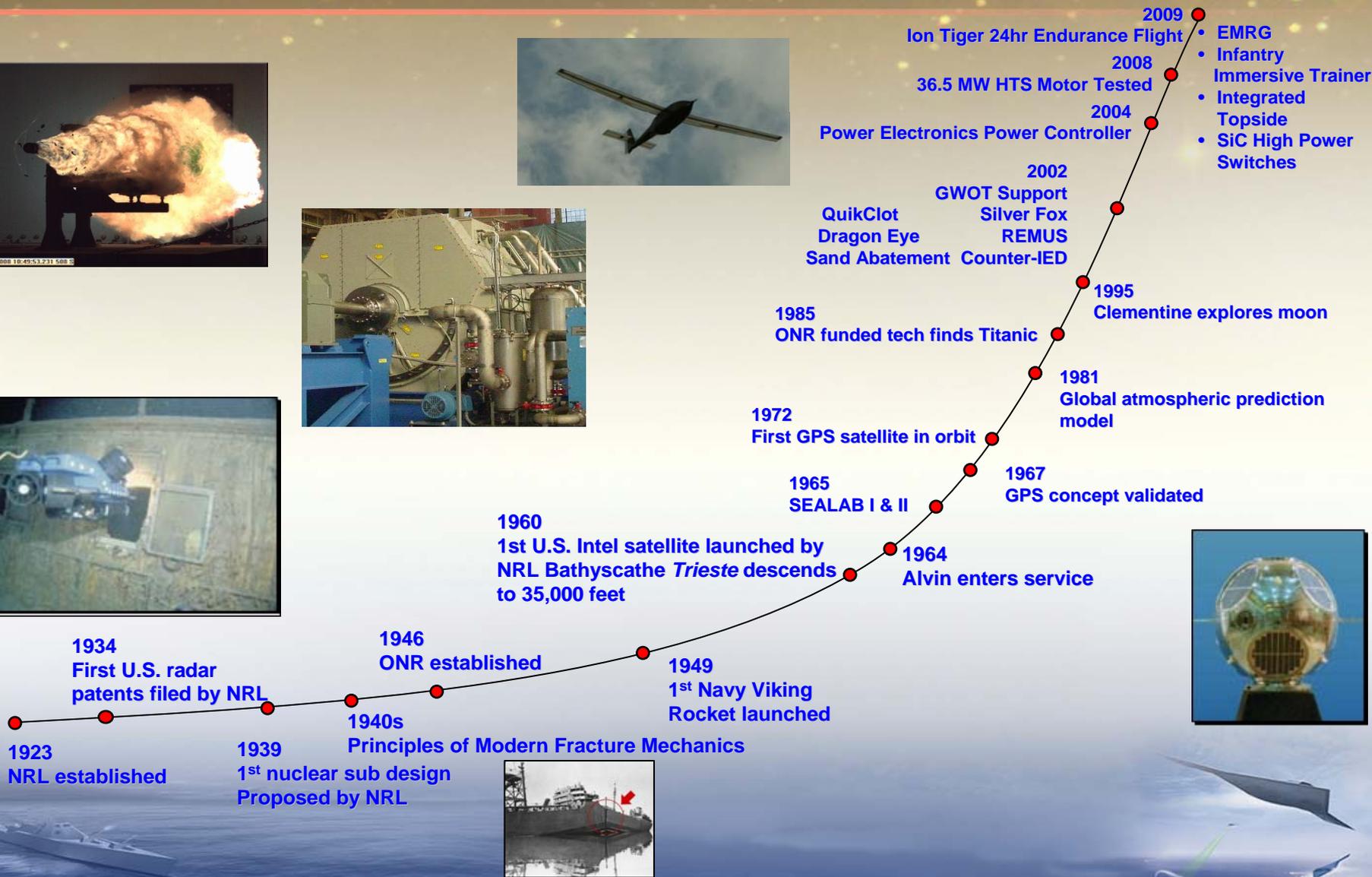
- Energy Security S&T
 - Increase use of alternative fuels
 - Develop renewable energy technologies
- Energy Efficiency S&T
 - Develop energy efficient technologies
 - Assess and understand energy impacts
- Environmental Stewardship S&T
 - Technologies to reduce carbon footprint
 - Environmentally benign solutions

Mission: “to plan, foster, and encourage scientific research in recognition of its paramount importance to future Naval power and national security.” - Public Law 588 of 1946

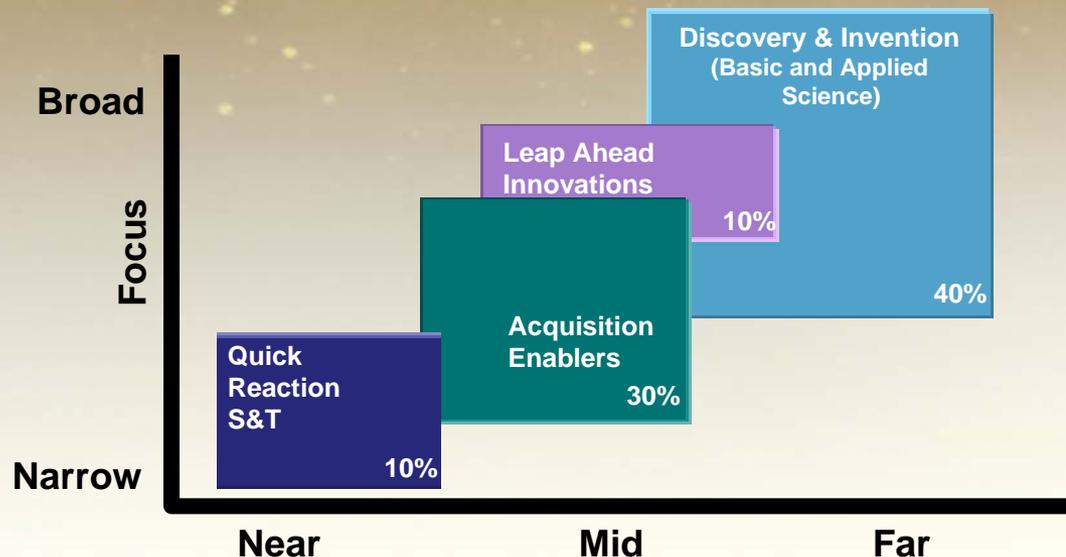
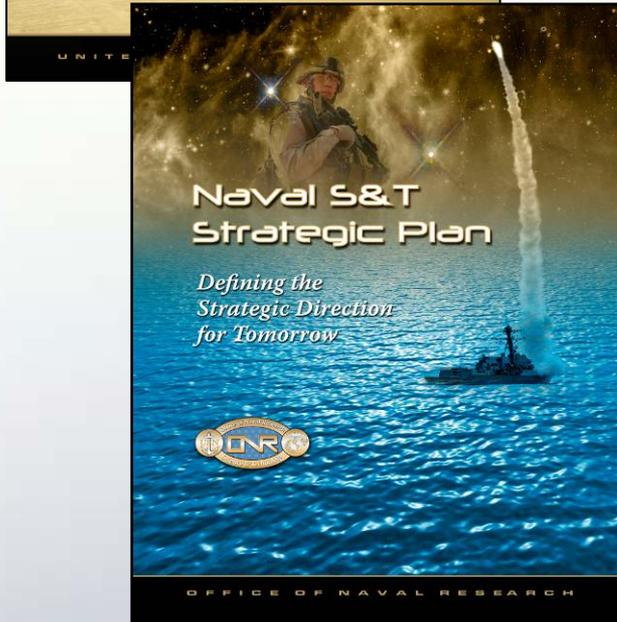
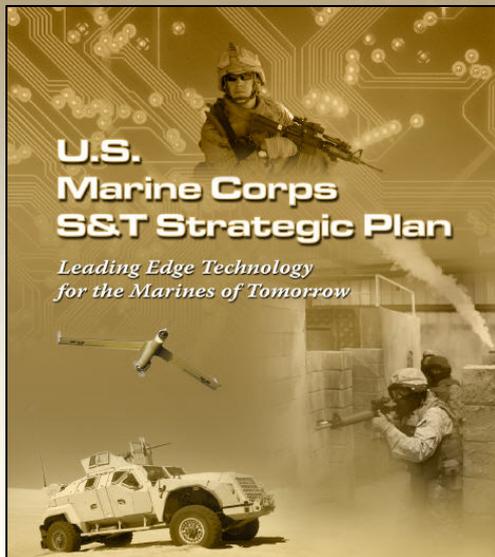


Invest in the science and technology that will ensure our warfighters always have the technological edge

A Legacy of Innovation



Naval S&T Strategic Plan



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

Global Energy Consumption



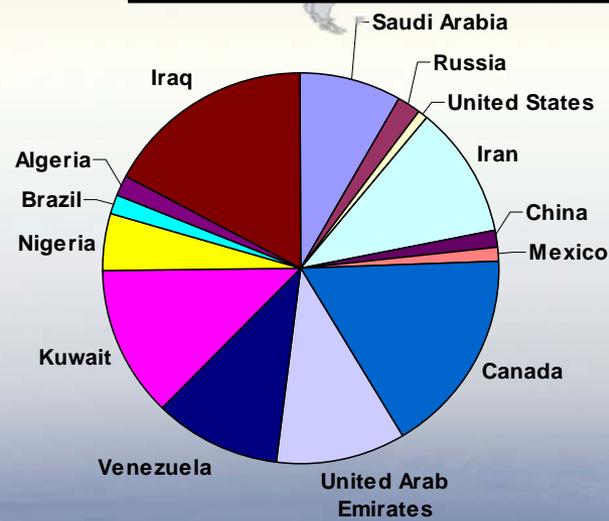
is growing...

World Oil Reserves & Production

Country	Reserves	Production	Reserve Life
	Billion bbl	Million bbl/d	Years
Saudi Arabia	267	10.2	72
Canada	179	3.3	149
Iran	138	4.0	95
Iraq	115	2.1	150
Kuwait	104	2.6	110
United Arab Emirates	98	2.9	93
Venezuela	87	2.7	88
Russia	60	9.9	17
Libya	41	1.7	66
Nigeria	36	2.4	41
Kazakhstan	30	1.4	59
United States	21	7.5	8
China	16	3.9	11
Qatar	15	0.9	46
Algeria	12	2.2	15
Brazil	12	2.3	14
Mexico	12	3.5	9
Total	1,243	63.5	54



U.S. Imports 60% of Petroleum Needs



Oil Reserve Life for Countries with >2M bbl/d Production

Investment Time Horizon

Near-term – Today's Battle

Maintenance for Energy Efficiency & Affordability



Platform Energy Efficiency



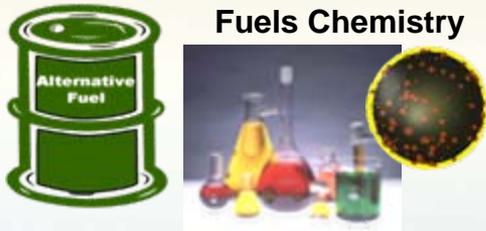
Long Endurance Autonomous Systems



Mid-term – Responding to Change

Alternative Fuels

Fuels Chemistry

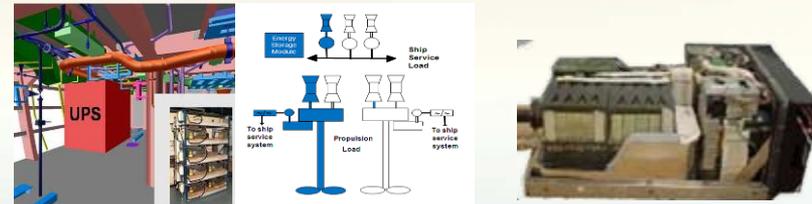


Energy Efficient Water Production

Desalination System



Fuel Efficient Power Systems



Long-term – Shaping the Future Forces

Advanced Efficient Propulsion & Power Systems



Power for Advanced Sensors & Directed Energy Weapons



Power & Energy – Broad Spectrum

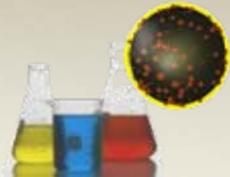
Commercial



Military

The Energy Chain

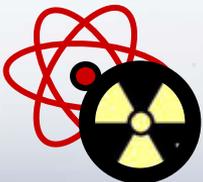
Fuel



Fuels Chemistry



Alternative Fuels



Nuclear

Power Generation



"Ion Tiger"
UAV Fuel Cell



Fuel Cells



Aircraft Engines

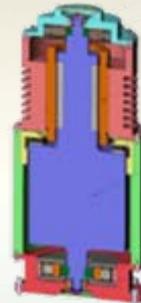


Gas Turbine Generators

Energy Storage



Batteries

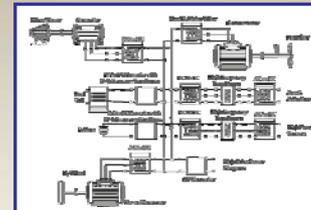


Flywheels

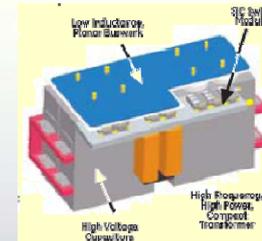


Capacitors

Distribution & Control



Electrical Architectures
& Pulse Forming
Networks

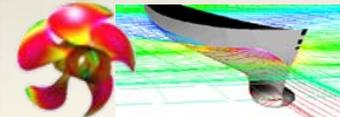


High Voltage Silicon
Carbide (SiC)
Switches

Power Loads



Electric
Weapons



Powering & Resistance

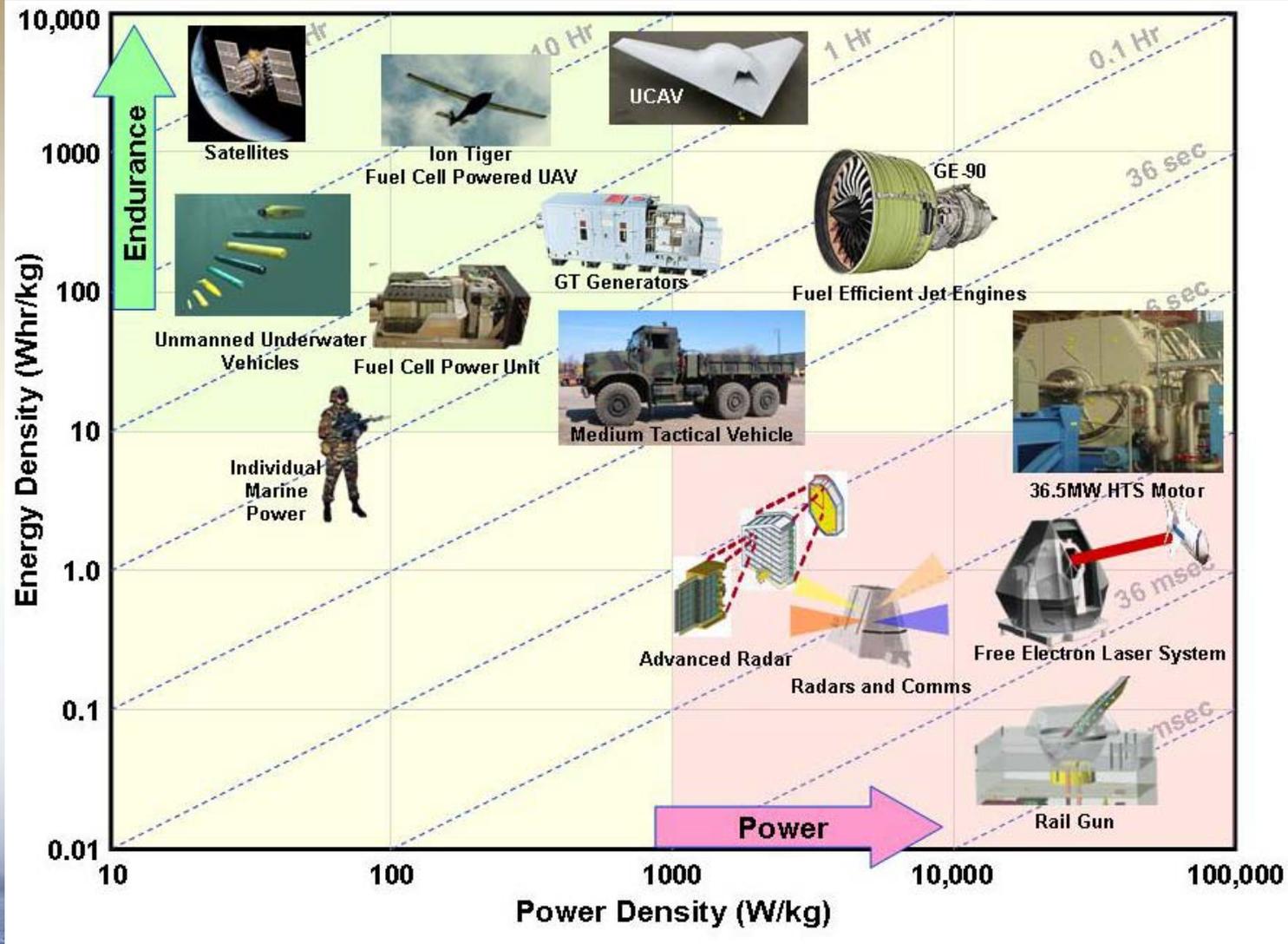


UV Sensor Loads

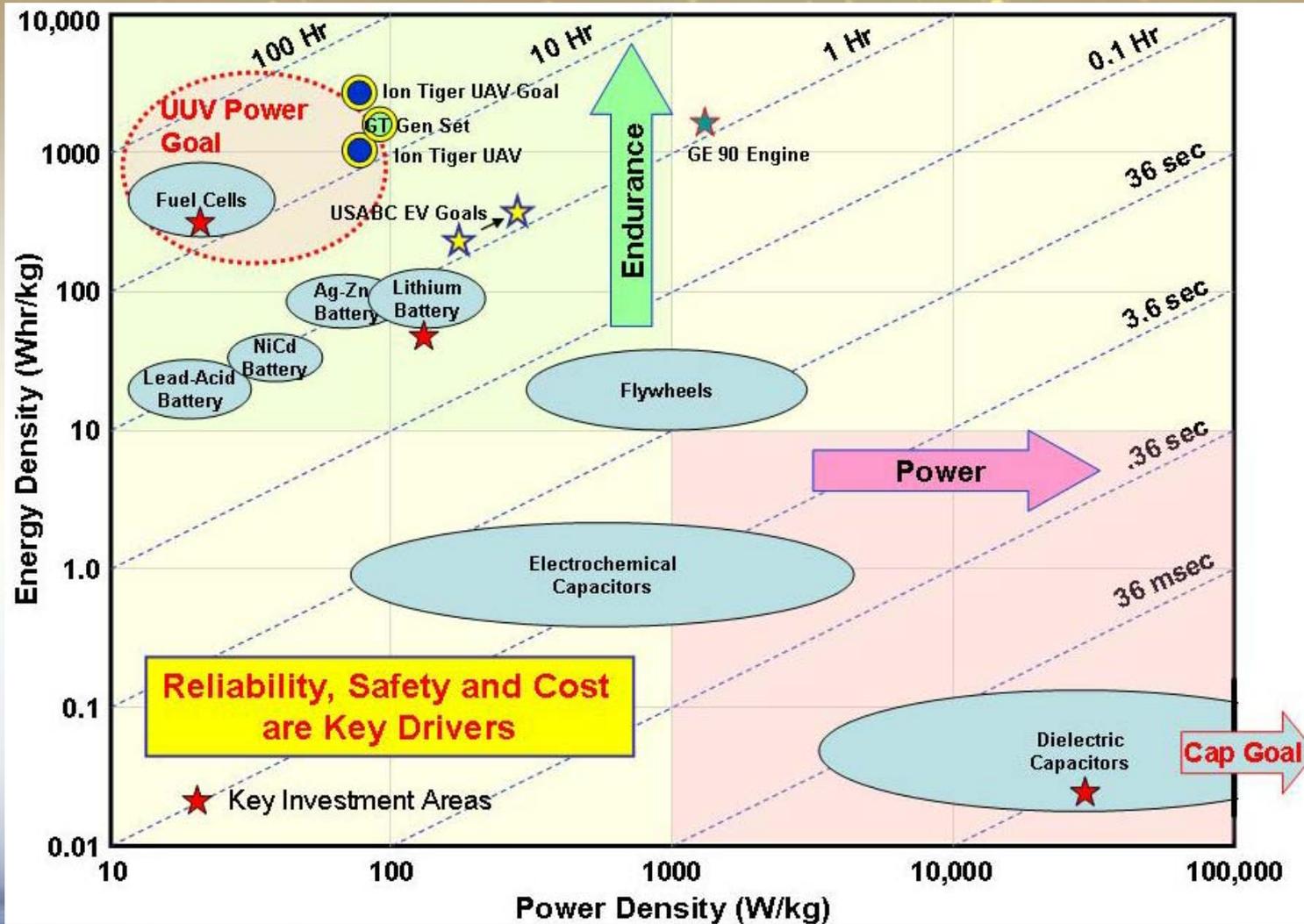


Reconfigurable Blades /
Blade Loading

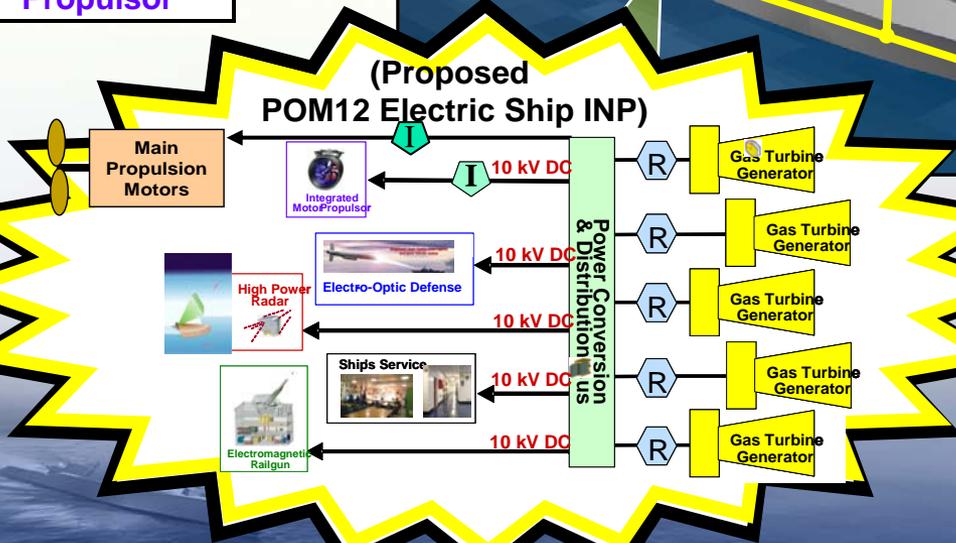
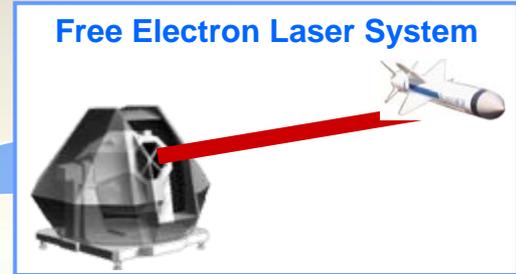
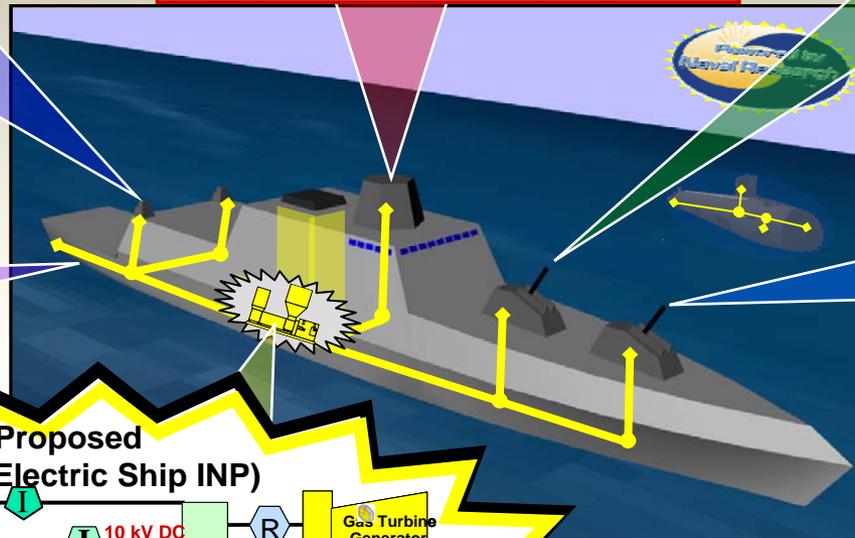
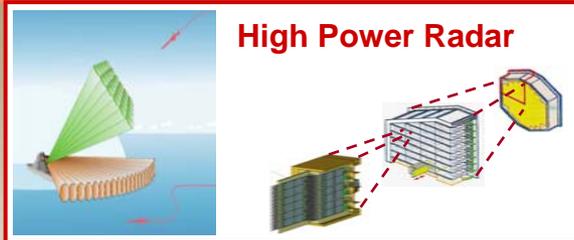
Platform Trade Space



Technology Trade Space



Next Generation Integrated Power System (NGIPS)



Next Generation Integrated Power Systems

ONR Partnerships

Interagency Advanced Power Group

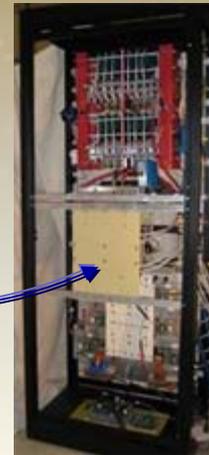
Logos for: US, UK, DARPA, MIT, NASA, and other partner organizations.

Silicon Carbide (SiC) Wide Band-Gap Power Electronics

Partnership



10kV SiC Module



**1 Stage
AC-AC
building block**



SiC Ship Service Power Station

- 2.7 MVA
- Multiple outputs
- Switching Frequency: 20 kHz
- 2 tons and 6.5 m³

Increase efficiency
Reduce weight and volume
Improved thermal management

Low Frequency Conventional Transformer

- 13.8kV to 450VAC, 60Hz
- Fixed, Single Output
- 2.7 MVA
- 6 tons
- 10m³



Advanced Aerospace Propulsion Science and Technology

- **Develop and transition advanced airbreathing propulsion technology to F/A-18, F-35**
 - Engine materials
 - Critical propulsion system component technologies
 - Modeling and Simulation
 - Propulsion Health Management
- **Basic and applied research into advanced propulsion system principles, processes, components and concepts**
 - Combustion technology
 - Advance propulsion cycles such as pulse detonation/constant volume combustion technology
- **Current programmatic efforts:**
 - Turbine Engine Technologies (FNC)
 - Airbreathing Propulsion Basic Research (D&I)
 - Propulsion Safety and Affordable Readiness (D&I)
 - Jet Noise Reduction (D&I)
- **Potential future opportunities:**
 - NAVCENT (Naval Variable Cycle Engine Technology) – Variable/adaptive cycle engine technology for future air platforms such as N-UCAS and F/A-XX (FY12 proposed INP)



Potential Payoffs:

- ❖ Reduced fuel consumption
- ❖ Higher performance
- ❖ Increased range and loiter
- ❖ Lower life cycle costs
- ❖ Improved environmental compliance

Power Systems for Unmanned Vehicles

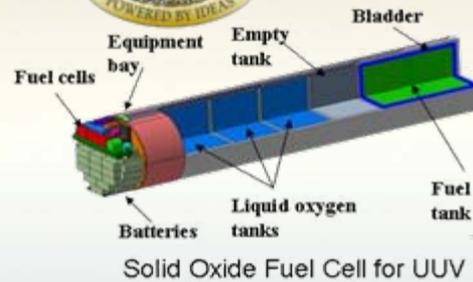
Air Vehicles

- Long endurance fuel cell power (24h)
- Low noise & heat signature
- Affordable (\$80K/vehicle)



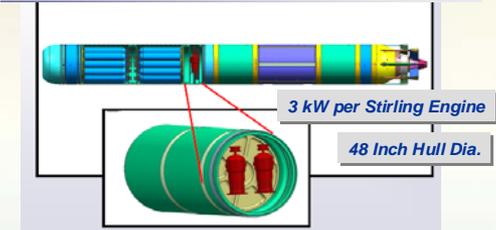
Undersea Vehicles

- Lithium-ion battery safety
- Air independent power systems: fuel cell, hybrid electric, Al-water



ONR Swampworks

Placement of Stirling Engines in Sea Lion Section



Sea Surface Vehicles

- Advanced platform designs
- Launch & recovery
- Autonomous operation



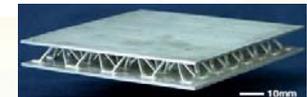
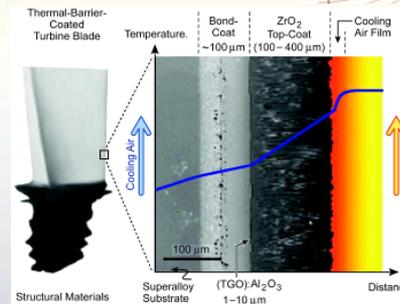
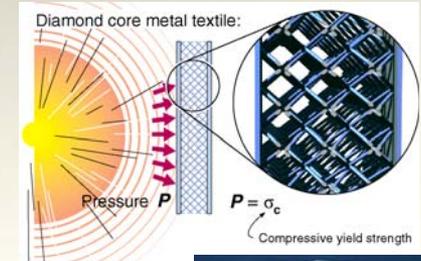
- Anti-Biofouling Coatings & Hull Husbandry
- Lightweight Structural Materials
- HTS Degaussing Cable
- Turbine Engine Materials Systems
- Corrosion Prevention and Mitigation
- Advanced Shipboard Water Desalination
- Nano-Ceramic Coatings for Life-of-System Wear Surfaces



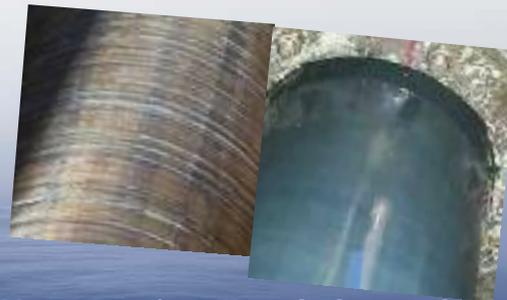
Hull Bug



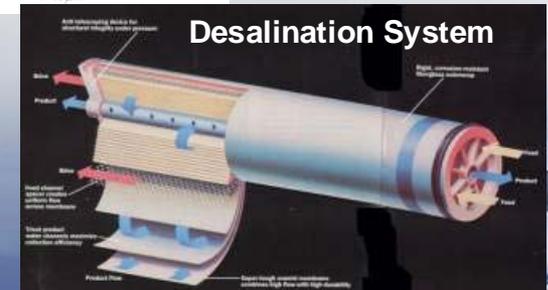
HTS Degaussing Cable



Al-alloy formed pyramidal core



No wear after 4 yrs in in-service



Shaping the Future

- Energy Security
 - Alternative fuels and chemistry programs
 - Renewable energy programs
- Energy Efficiency
 - System architectures; efficient hulls; lightweight materials
 - Analysis tools that help designers understand tech tradespace
- Environmental Stewardship
 - Reduce carbon emissions
 - Reduce environmental impact

S&T Partnering is key to success

Challenges

- **Change the way we award contracts**
- **Demo a Green Strike Group - Sail a Great Green Fleet**
- **Near Term - Reduce commercial vehicle petroleum use**
- **Long Term - Increase use of alternative energy ashore**
- **Long Term - Increase use of alternative energy across DoN**

Opportunities

***“I never, ever, want to see a
Sailor or a Marine in a fair fight!”***

*– Adm. Gary Roughead
Chief of Naval Operations*

