Surface Navy Electrical Leap Forward
Sea-Air-Space Exposition
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Distribution Statement A. Approved for public release: distribution unlimited.
NEXT SURFACE COMBATANT EVOLVED CAPABILITY

“In FY2030, the DON plans to start building an affordable follow-on, multi-mission, mid-sized future surface combatant to replace the Flight IIA DDG 51s that will begin reaching their ESLs [Estimated Service Life] in FY2040.”

Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2015

Update:

“…next Large Surface Combatant will begin in FY2030.”

Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2017

Big Differences:

- High Energy Weapons and Sensors
- Flexibility for affordable capability updates

Photo by CAPT Robert Lang, USN (Ret), from site http://www.public.navy.mil/surfor/swmag/Pages/2014-SNA-Photo-Contest-Winners.aspx
Current Mission System Integration Approach

Each mission load brings a unique point solution-based intermediate power system

Advanced Sensors
- AMDR
- Air and Missile Defense Radar

Electronic Warfare
- SEWIP Block III
- Surface EW Improvement Program

Directed Energy
- SSL-TM
- Solid State Laser Technology Maturation

Future Weapons
- TBD

Intermediate Power Systems: 30-40% of Mission Load Equipment

Current Interface: MIL-STD 1399

Federated Systems:
- High Maintenance
- Difficult Logistics
- Not Easily Integrated
- Not Common
- Cost More
- Waste Space & Weight

Today’s Navy Pays a SWAP-C and Support Penalty

Distribution Statement A. Approved for public release: distribution unlimited.
NAVAL POWER AND ENERGY SYSTEMS TECHNOLOGY DEVELOPMENT ROADMAP (NPES TDR)

Product Areas
- Controls
- Distribution
- Energy Storage
- Generators
- Motors
- Prime Movers
- Power Converters

Metrics
- Efficiency
- Power Density
- Operating range
- Cooling Requirements
- Current Capacity
- Cost
- Operating temperature
- Maintenance
- Fault management
- System response
- System Reconfiguration

Requirements Pull (RWG + Core Team)
Technology Push (TWG + Core Team)


Distribution Statement A. Approved for public release: distribution unlimited.
**Increased Warfighting Capability to Overmatch the Threat Demands Power**

*Future Power Demand Increases in the Fleet*

**Increases in Power Requirement Aboard Ships**

**MORE POWER**

*Step Change Incremental Development of Power Generation vs. Increase in Power Requirement Over Time*

- Exponential Capabilities Growth
- Incremental Flight Upgrades
- Today

**DIFFERENT DEMAND**

*New Capabilities Demand Pulse and Stochastic Power*

- Sensor Demand
- Weapon Demand
- EW Demand

*Current Available Power Aboard Ships Cannot Support Dynamic Loads*

Distribution Statement A. Approved for public release: distribution unlimited.
Challenges of Integrating High Power Mission Systems:

Directed Energy Systems Require Pulse Power & Increased Power

Generators operate at continuous loading for efficiency & reliability

Current generators cannot respond quickly and dynamically for new demands

Solution: Energy Magazine = Energy Storage + Controls

Energy Magazine provides pulse power and load leveling when generators cannot meet demand
Energy Storage Module (ESM) Proof of Concept: Prime - RCT under ONR Swampworks Program

- **Energy Storage Media:** Lead acid batteries installed in a 28' ISO container
- **Functionality:** Stored energy of 100 kW-hr (360 MJ)
- **Status:** Modifications to support ONR laser projects in process

Energy Magazine (EM) Prototype: Prime - DRS under PMS 320, Electric Ships Office

- **Energy Storage Media:** Lithium ion batteries installed in a 78x48x100 inch military designed cabinet
- **Functionality:** Stored energy of 71 kW-hr (256 MJ), between the ship’s electric plant and mission load
- **Status:**
  - Build and subassembly testing in process
  - System testing on track for 1Q/FY18

Energy Magazine Mk II: Prime - DRS under PMS 320, Electric Ships Office

- **Energy Storage Media:** Lithium ion batteries installed in military designed cabinets
- **Functionality:**
  - Stored energy of 153 kW-hr (550 MJ), augments ship’s electric plant by peak shaving
  - Allows energy storage media to be installed separate from power electronics
- **Status:**
  - Evolved EM Prototype Design
  - Ship Production Ready in FY2020
Energy Magazine Demonstration

**Modeling & Simulation**
- DDG 51 Flt IIA & III VV&A’d Electrical System
- Detailed Mission System

+ **Energy Storage Models & Hardware**

- SEWIP
- SSL
- AMDR

+ **Energy Storage Models & Hardware**

- EM-L (DRS)
- FESS (GKN/UK)

**Real Time Dynamic Simulation**

- FSU CAPS

**Knowledge**

- Control Hardware in the loop (CHIL)
- Power Hardware in the loop (PHIL)

+ **Power & Energy Management**

- Sandia NL Distributed Energy Management

**Demonstrations Validate Interfaces for Pulsed High Energy Systems**
**FUTURE MISSION INTEGRATION SOLUTION**

**Common Shared Energy Storage and Services with an Integrated Management System to Support Load Demands and Lower Ownership Costs**

- **Advanced Sensors**
  - AMDR: Air and Missile Defense Radar

- **Electronic Warfare**
  - SEWIP Block III: Surface EW Improvement Program

- **Directed Energy**
  - SSL-TM: Solid State Laser Technology Maturation

- **Future Weapons**
  - TBD

**FUTURE INTERFACE:** MIL-STD 1399 LVDC/MVDC *(draft)*

**Common Architecture**

- Shifts the Interface
- Flexible for Growth
- Adds Functionality
- Affordable
- Saves Space & Weight

**Shifts the interface towards the loads for affordability and commonality**
Evolved Integrated Power System:
Flexible | Affordable | Common
IPES allows propulsion and ships service to share their power source. Energy is stored and controlled in the electrical distribution of the ship so power is available where and when we need it.
The Right Power in the Right Place at the Right Time
In the diagram, the IPES Power Architecture is illustrated with various components labeled and connected to represent an integrated power and energy system. The IPES: Power Architecture section includes a list of notional schedule activities and milestones. The diagram also outlines the following benefits:

- Decouples mission system pulse loads from power generation
- Seamlessly transitions power and energy to high power pulsed weapons and sensors as required while maintaining system stability
- Matures and tests control system Active Power Management and Cybersecurity
- De-risks integration of modular energy storage at the main distribution and/or zonal levels

The notional schedule outlines key activities from FY17 to FY26, with milestones for Advanced Development & Testing, Design & Build, System Testing, DC Circuit Protection, Shared Energy Storage, Advanced Cyber-Safe Controls, and Advanced Generator Integration & Test. The schedule also highlights ONR FNCs (Operational Needs and Capabilities) with upward and downward arrows indicating progression.

The text further elaborates on the benefits, such as:

- Evolutionary from DDG1000 IPS
- Shared energy storage
- Advanced controls with combat systems interface
- Affordable, Scalable, and Flexible
- Zonal 12KVDC integrated power and energy

Additionally, it references the MVDC IPES ADM White Paper of 08 April 2016 containing a full description.
ADVANCED POWER GENERATION MODULE (APGM)

25MW 12KVDC GTG

**Key Attributes:**
- High Power Density
  - Fits in a warship less than 10,000 tons
- DC permits use of variable speed to optimize efficiency
- Dual windings for independent buses
- Independent rectifiers convert AC → DC
- Module level controls
- Isolation from pulsed and/or stochastic load profiles
- Accommodation of high energy weapons (DC loads)

**Warfighting Benefits:**
- Provides power dense and fuel efficient electrical generation capability
- Supports ships with future high power pulsed weapons and sensor systems in an IPES configuration
- Will be incorporated into IPES ADM upon delivery

**Planning:**
- FY16: Industry RFI and Industry Day
- FY17/18: Industry/Government Studies
  - Sandia: Building scale APGM emulator, test in 300 VDC microgrid lab to inform system performance requirements.
  - Study contracts being prepared

**Notional Schedule:**

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- **RFI / BAA**
- **Concept Studies/Analyses**
- **Design**
- **Build**
- **ADM Testing**
• Industry Day Held 3 August 2016
  – 156 people from Industry, Academia, and Government Stakeholder Organizations

• BAA White Papers Received for 25 MW GTG at 12KVDC

• Continuing to Develop supporting M&S and power hardware in the loop test capabilities

• Functional / Component Deep Dives in progress

• See BAA N0002410R4215

2017 Industry Day being planned for Mid-August
In 2007, ASN(RDA) established PMS 320, the Electric Ships Office (ESO) within PEO SHIPS to facilitate the high degree of technical integration with ship platforms and power systems, scope future technology development, and support critical concept decisions.

**OVERVIEW**

The mission of PMS 320 is to develop and provide affordable, capable Naval power and energy system integration solutions to meet evolving customer demands by:

- Defining common open architectures and interface standards,
- Developing common solutions,
- and Focusing Navy and informing Industry investments

**OUR MISSION**

PMS 320 will work across the Navy’s Research & Development Enterprise in partnership with industry to develop and introduce innovative technologies to enable the Navy’s distributed lethality principles through efficient power & energy management.

**OUR VISION**

- Manages the Combat Power and Energy Systems OIPT
- Works with the S&T community to apply new technologies to solve fleet problems
- Works in conjunction with ONR, DARPA, Academia, Industry Professionals, and Warfare Centers
- Aligns developments with warfighter need
- Supports SECNAV and CNO initiatives to reduce energy use


**WHAT WE PRODUCE**

- Smaller, simpler, and more affordable ship power systems
- Power for pulsed high energy weapons and sensor systems
- Future Naval Power Systems and transition appropriate Science & Technology to the fleet
- Naval Power and Energy Systems Technology Development Roadmap (TDR)