Electric Ships Office
PMS 320
Directing the Future of Ships Power

IPES – Harnessing Total Ship Energy & Power

Sea-Air-Space Exposition

09 April 2018

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Director & Program Manager

NEXT SURFACE COMBATANT EVOLVED

"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…"

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

Update:

"The prioritized shipbuilding plan assigns the highest priority to these frontline combat platforms, affording the opportunity to quickly adopt new capabilities in response to emerging disruptive capabilities – both ours and theirs – move to a new modernization effort, or move to a new platform design."

Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2019

Future Surface Combatant Force

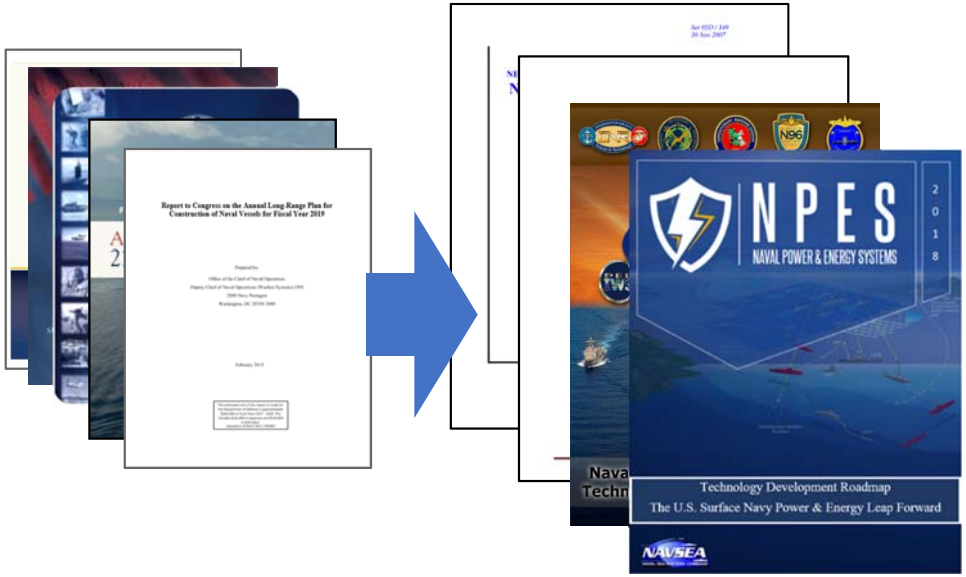
- Large Surface Combatant (LSC)
- Small Surface Combatant (SSC)
- Unmanned Surface Vehicle (USV)
- Integrated Warfare System

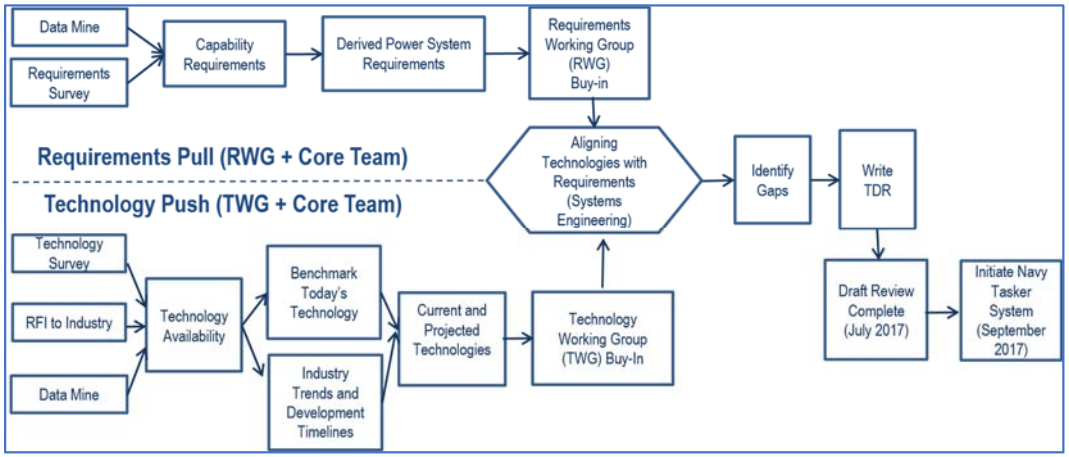
Big Differences:

- 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

Naval Power and Energy Systems Technology Development Roadmap



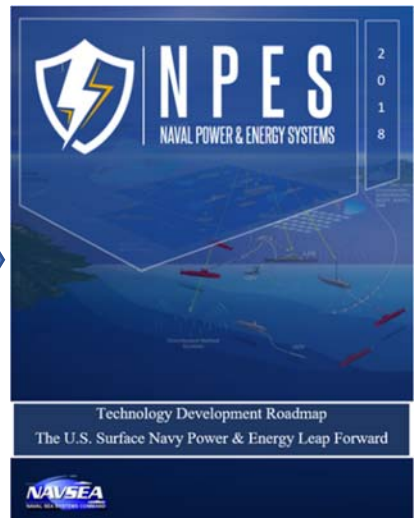


Product Areas

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



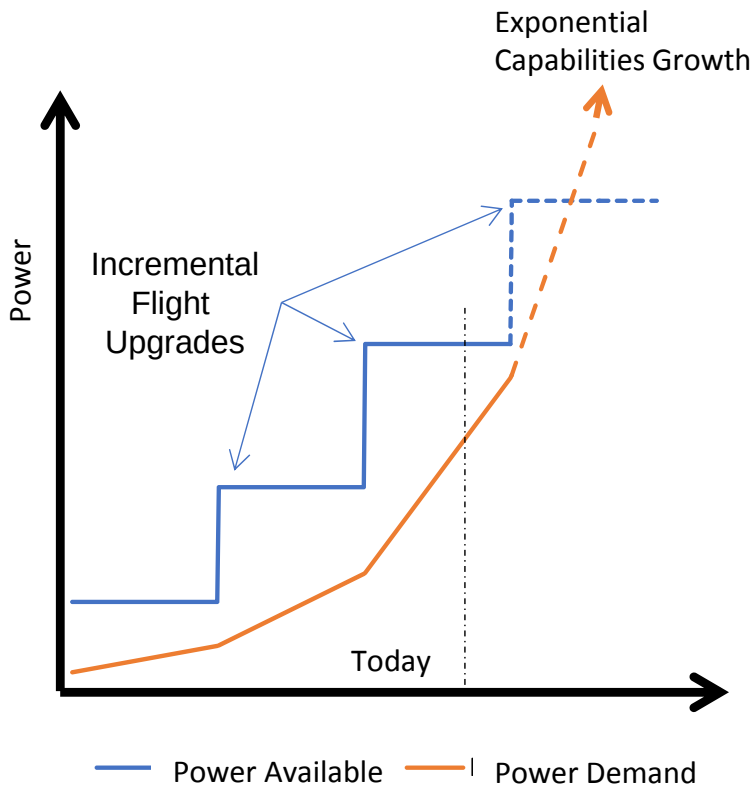
2018 NPES TDR: initiate approval process April 2018

Future Power Demands

Increases in Power Requirement Aboard Ships

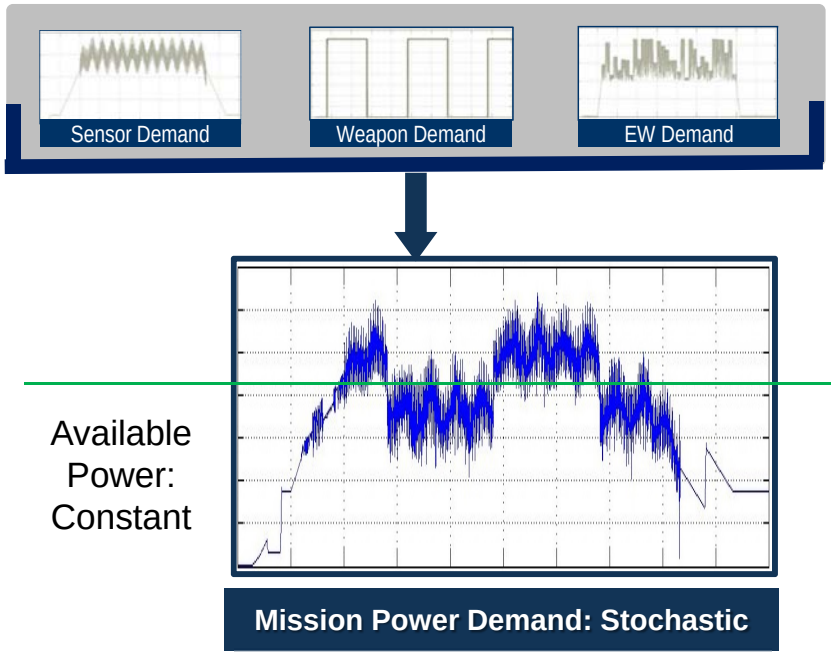
MORE POWER

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



DIFFERENT DEMAND

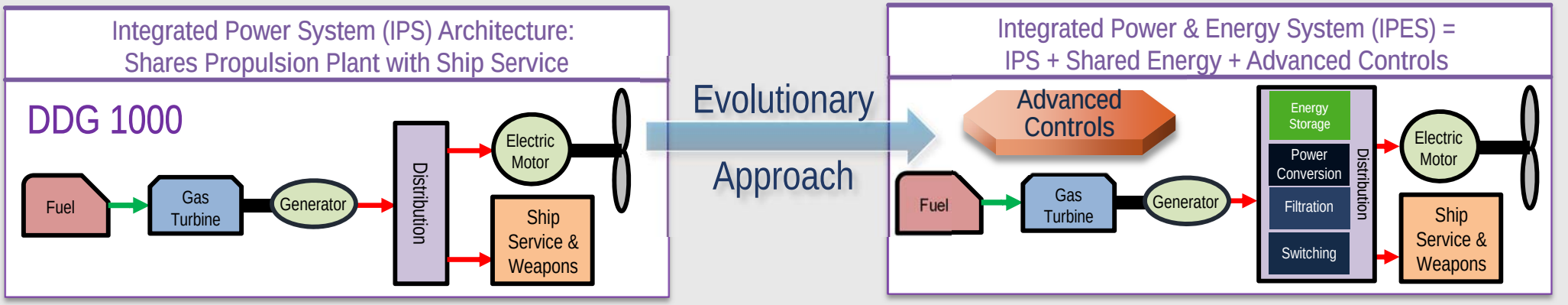
New Capabilities Demand Pulse and Stochastic Power

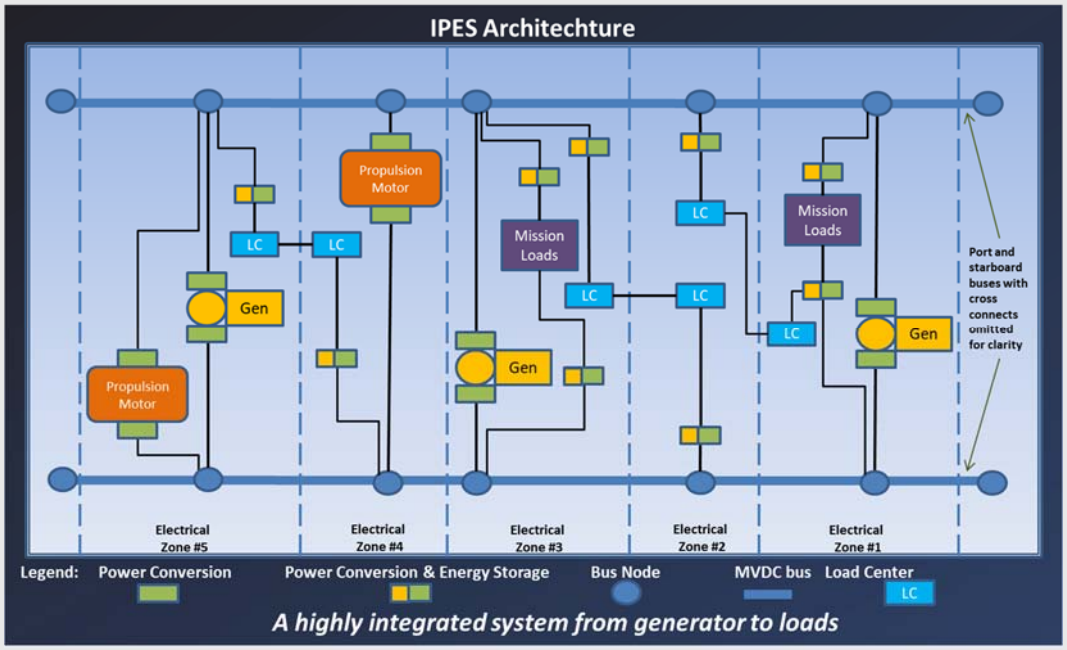


Current Available Power Aboard Ships Cannot Support Dynamic Loads

Current Power Systems Cannot Support Evolving Power Demands

IPES Required to Access Total Ship Power





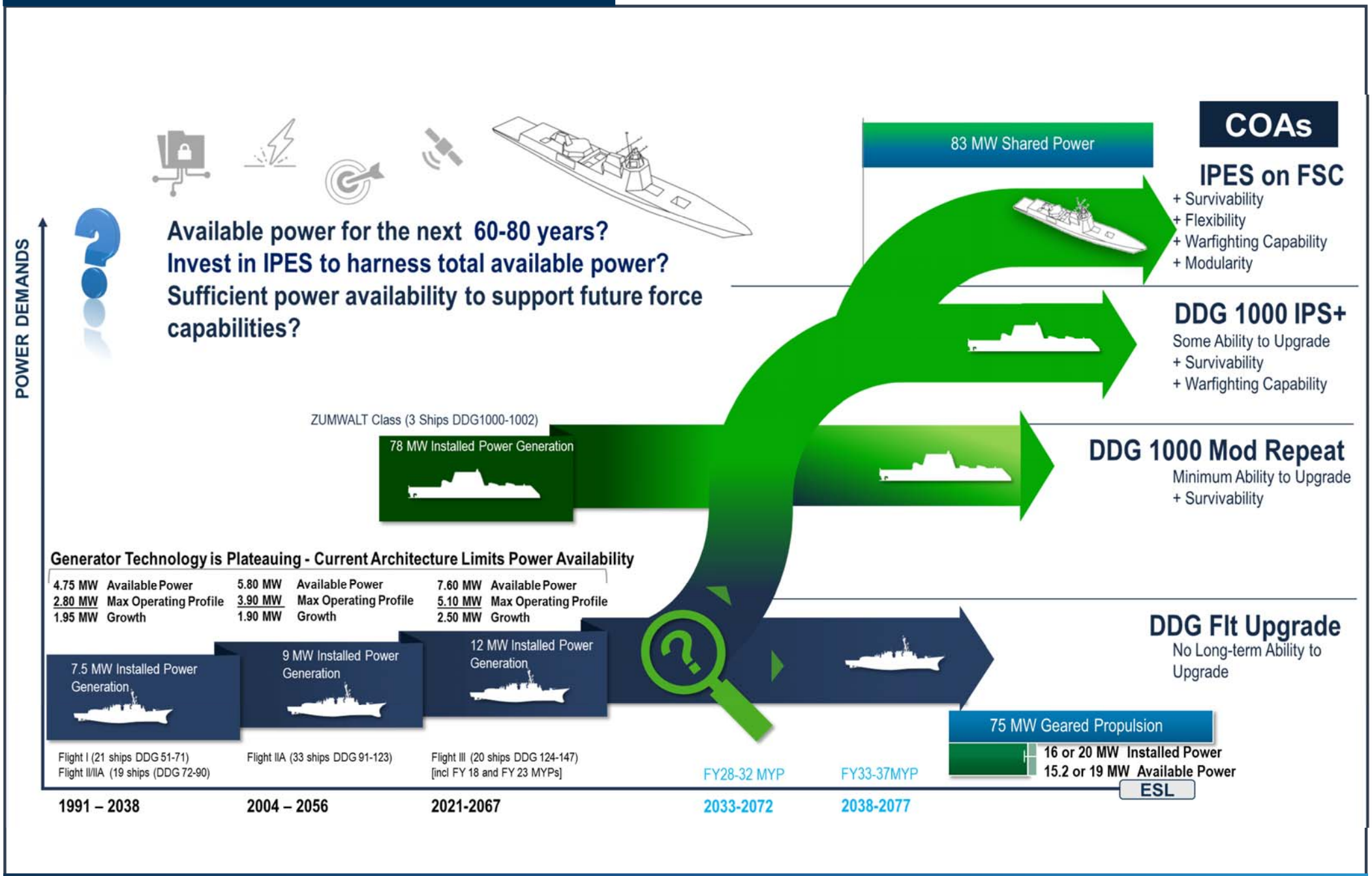
IPES Tactical Advantages:

- Flexibility
  - Enable Undefined Future Warfare Capability
- Adaptability
  - Support Evolving Mission Requirements/ Systems
- Survivability
  - Limit Casualty Impact and Speed Recovery
  - Whole Ship Power Backup
  - Maneuver on “Battery”
  - Engage Until Last Drop of Fuel Expended
- Endurance/Efficiency
  - Greater Range & Time on Station

Industry is currently implementing this concept, e.g. Siemens BlueDrive, providing similar benefits with a significantly smaller footprint, reduced weight, and lower operating costs.

Notional Offshore Service Vessel (OSV) with BlueDrive

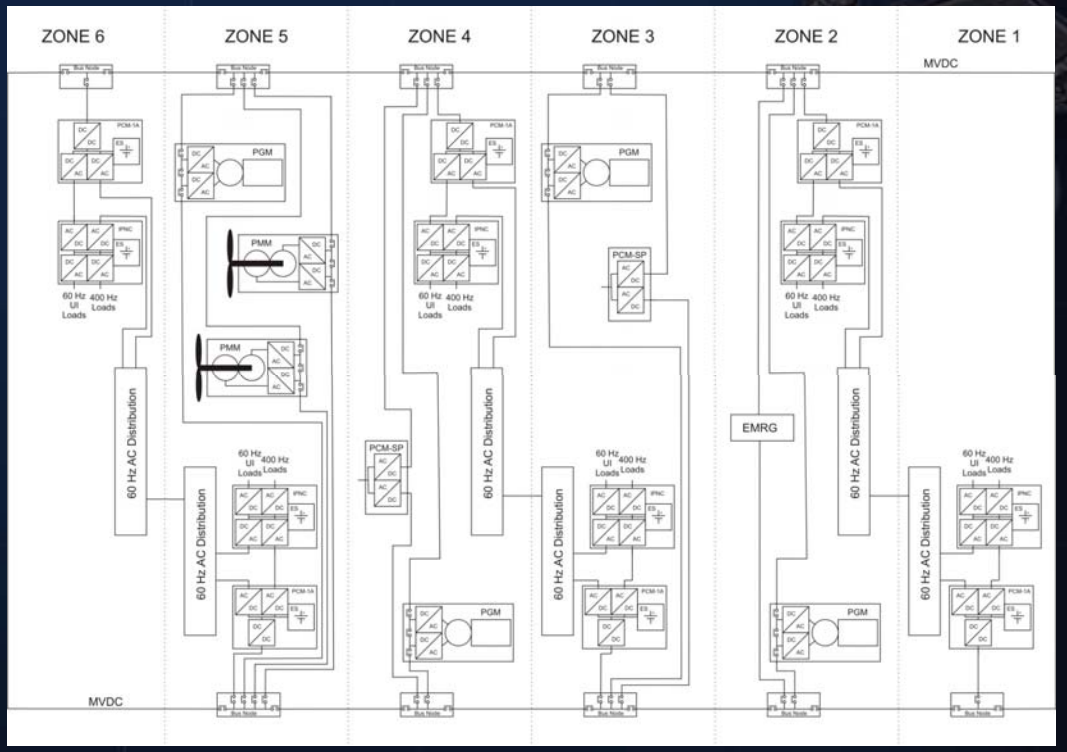
PLANNING FOR FULL SHIP'S SERVICE LIFE



Critical Decision Point for FSC

What Is IPES Emulation?

- An M&S articulation of the IPES 1.0 architecture at FSU CAPS running in real time to better define IPES, identify issues, mitigate known risks and facilitate CHIL and PHIL
- IPES Emulation builds off knowledge base developed by:
  - EM Demonstration
  - US/UK Advanced Electric Power & Propulsion Project Arrangement
  - SNL Advanced Controls Project
  - ONR ESRDC Knowledge & Products
- Test Plan development In Progress
  - If we do not know, guess, test, evaluate, adjust, test…..
  - What questions are being answered, what knowledge is being developed?



IPES Emulation buys down risk and informs ITF efforts

What Is IPES Test Facility (ITF)?

- Physical Embodiment of the approved IPES development strategy at Naval Warfare Center Philadelphia
- Philosophy: Begin with functional equivalent modules (FEMs) to be replaced with developmental or tactical hardware when it becomes available. The ITF will evolve as knowledge is gained and technology progresses.
- A 3-zone, ~30-50 MW, 12 kVDC facility at NSWCPD designed to validate interfaces, power system technologies and controls.

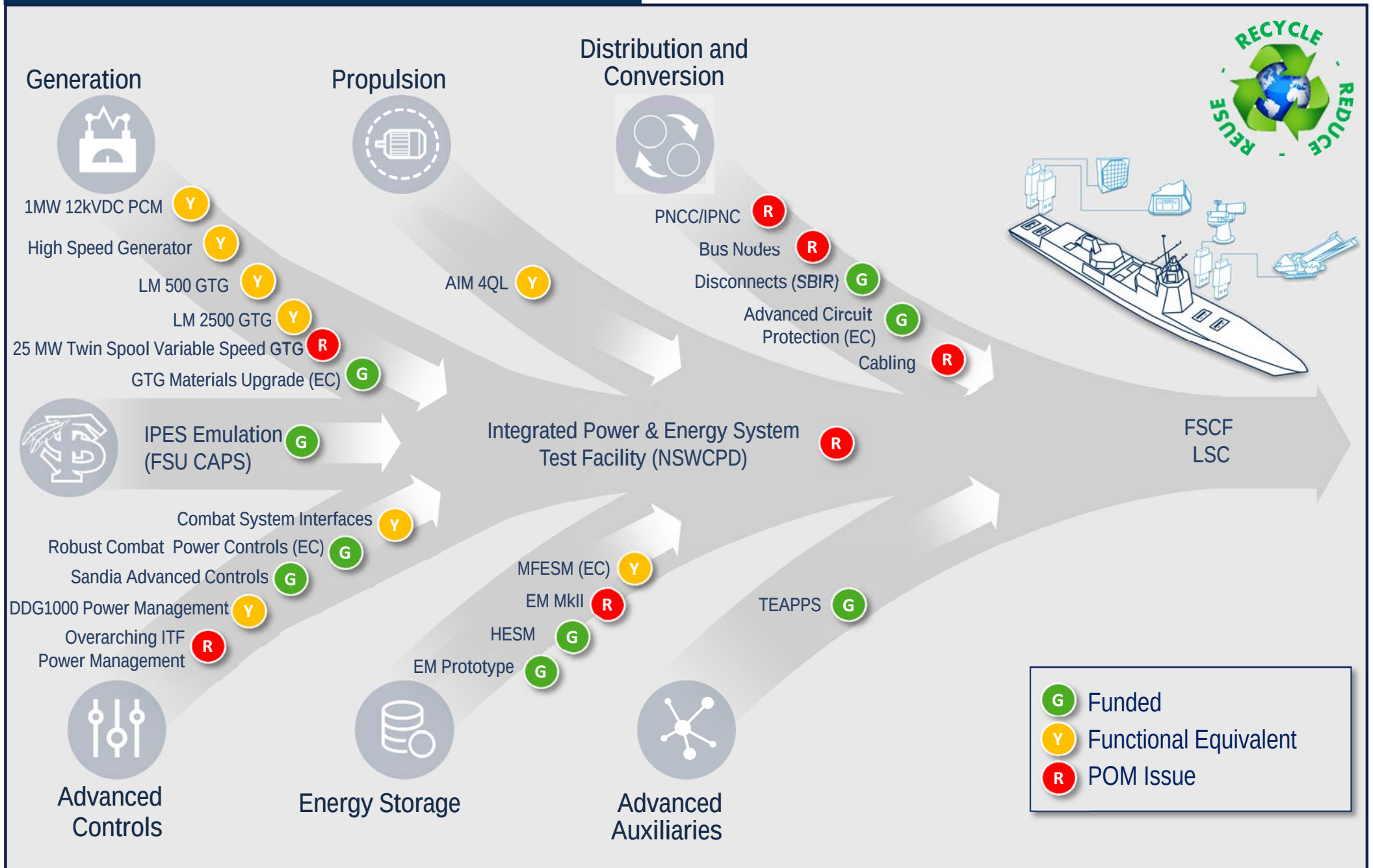
Purpose:

Demonstrate a 12kVDC Bus Voltage IPES ITF, capable of supplying and controlling electric power to platform and mission systems, as an evolutionary step from DDG1000 to Future Surface Combatants.

Objectives:

1. Develop Notional IPES ITF Architecture and Assess Performance
2. Develop IPES component interfaces and specifications
3. Mature Active Control Systems including Power Management and Cybersecurity
4. De-risk integration of modular energy storage primary and in-zone power distribution
5. Develop and validate interfaces with combat systems
6. Inform IPES and ship CONOPS capabilities and limitations

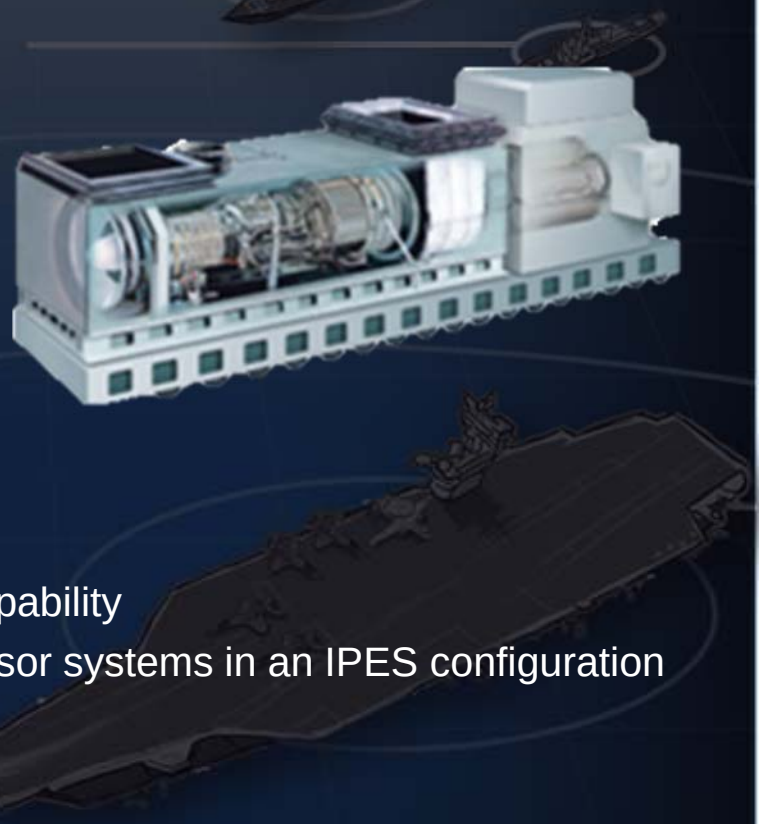
IPES Test Facility (ITF) Concept



FEMs Will Be Replaced with Tactical Hardware

25 MW Gas Turbine Generator

- Description
  - High Power Density
    - Fits in a warship less than 10,000 tons (ER<46')
  - DC permits use of variable speed to optimize efficiency
  - Dual windings for independent buses
  - Dual output
  - Independent rectifiers convert AC → DC
  - Module levels controls
  - Isolation from pulsed and/or stochastic load profiles
  - Accommodation of high energy weapons (DC loads)
- Warfighter 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 ITF upon delivery
- Status
  - M&S and small scale testing underway at Sandia National Laboratory
  - Requirements definition is continuing
    - BAA whitepapers received and being actioned



Requirements Definition Currently Underway

Program Manager Thoughts

- Fruits of multiple investments in warfighting technology are maturing in near future
- Power system attributes driven by evolving ICD/CCD/PCD

- Markle Crystal Ball
  - Stable Bus servicing highly dynamic DC loads
  - Marriage between Combat Systems and Machinery Control Systems
    - "Active State Anticipation"
  - Uninterruptable Stable Back Up Power
  - New way to look at Service Life Margin
    - Total Ship Power Perspective
    - Flexibility for the Future
      - Interfaces
      - Design "For" but "Not Fit With" at build
  - Innovative data analysis → automated decision making

- Technological enablers for the future:
  - Expanded use of M&S to include heavy reliance on CHIL and PHIL
    - 12 kVDC IPES Emulation at FSU CAPS FY19
  - 12 kVDC power generation and distribution
    - Dual-wound variable speed prime movers
    - Efficient low loss power conversion
  - High frequency power conversion
    - Wide Band Gap Materials (SiC, GaN, Ga_2O_3 based devices)
  - Agile Advanced Controls
  - Integrated shared and distributed energy storage
    - Media selected by dynamic responses required
  - Thermal Electric Power Generation part of the Holy Grail
  - Thermal Management Technologies
  - Validated Specifications and Standards

Continued Active Partnership with Academia & Industry is Vital

Electric Ships Office

PMS 320

Directing the Future of Ships Power

OVERVIEW

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.

OUR MISSION

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 VISION

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.

PMS 320…

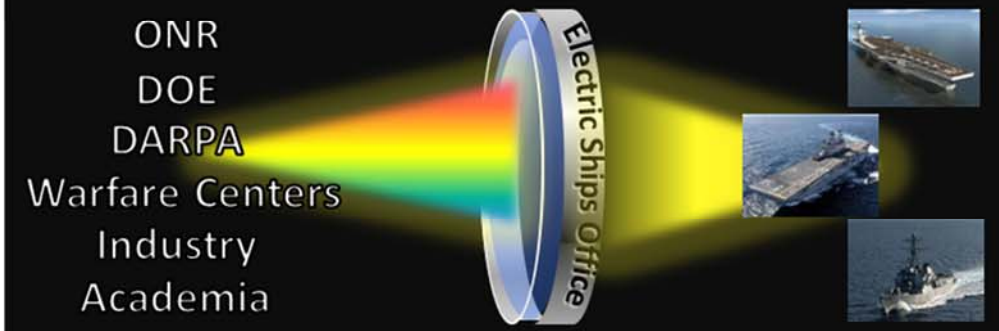
- Manages the Combat Power and Energy Systems OIPT
- Works with the S&T community to apply new technologies to solve fleet problems
- Works in conjunction with ONR, DARPA, Academia, Industry Professionals, and Warfare Centers
- Aligns developments with warfighter needs
- Supports SECNAV and CNO initiatives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

NPES TDR: http://www.navsea.navy.mil/teamships/PEOS_ElectricShips/default.aspx

Providing Affordable, Integrated Power and Energy Solutions



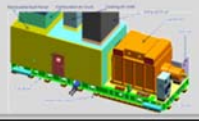
- Provide fuel efficient and affordable power to meet power requirements for advanced sensors and future weapons
- Reduction in weight and lower life cycle costs
- DDG 51 Flight III AG9160RF rating is 4MW with 3.3% fuel efficiency improvement from DDG 1000 RR4500 3.85MW ATG

- Provides power conversion from DDG 51 Flight III 4160 VAC distribution system to 1000VDC at 1.42 MW/unit output power
- The two PCM cabinets can be paralleled via auctioneering diodes (in AMDR) and will share the AMDR load

- 12 kVDC Architecture
- IPS + Shared Energy Storage + Advanced Controls
- Enables multiple pulsed, high power mission systems

- De-risks SSL for all ships; creates modular building block for flexible commonality
- Facilitates integration of future weapon/sensor systems

- Fit into a DDG-51 size ship
- 25 MW
- Variable speed DC output



- Reduce DDG 51 FLT IIA Class in-service fuel consumption and increase on station time
- Provides propulsion at low ship speeds without the need for LM 2500 main engines
- Output Power: 2550 HP (1.9MW) - port shaft only