Electric Ships Office
PMS 320
Directing the Future of Ships Power

Naval Power & Energy Systems: Way Forward

Surface Navy Association: 32nd Annual National Symposium
15 January 2020

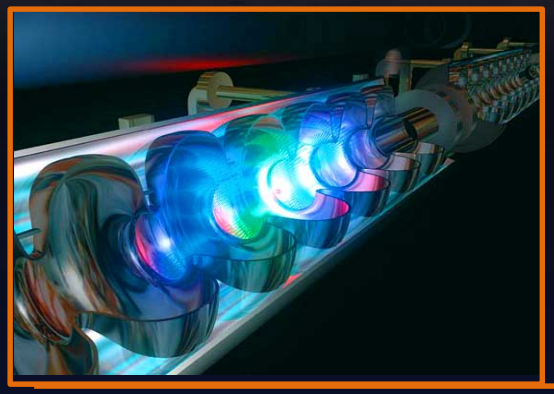
Mr. Stephen P. Markle, PE
Director and Program Manager
Electric Ships Office (PMS320)
stephen.markle@navy.mil
202.781.4427

Disruptive Capability is Coming...

FUTURE FORCE STRUCTURE

Annual Long-Range Plan for Construction of Naval Vessels (2019)

"The prioritized shipbuilding plan assigns the highest priority to frontline combat platforms, affording the opportunity to quickly adopt new capabilities in response to emerging disruptive capabilities…"



Naval Directed Energy Weapons and Sensors

- High energy weapons and sensors required to pace technology, outpace adversaries, and maintain maritime dominance
- Maintain flexibility to rapidly introduce new mission systems

DISRUPTIVE TECHNOLOGY

The Key to Disruptive Technology is an Agile Power System…

Where is Surface Navy Power & Energy Going?

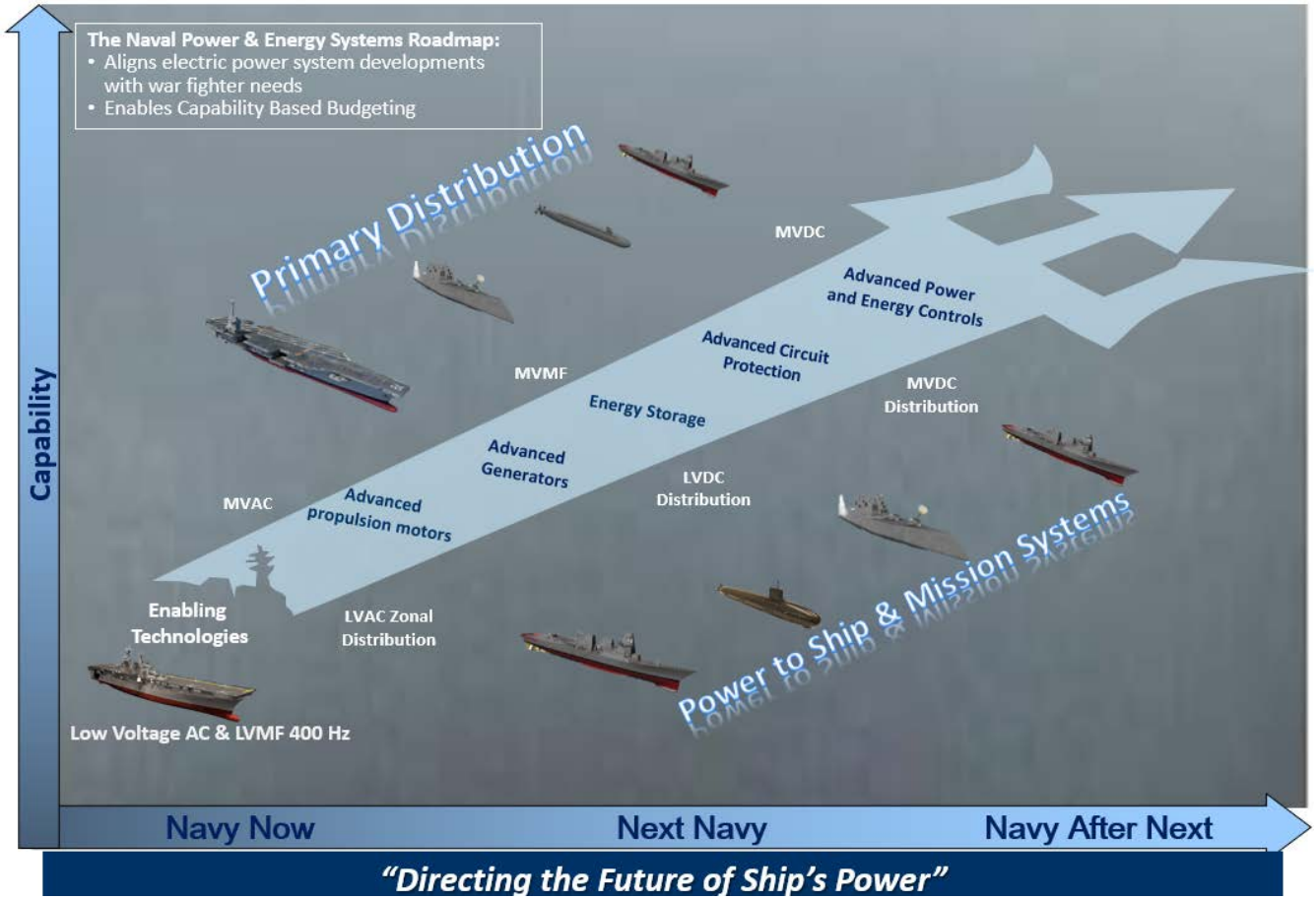
Directed Energy

Pulsed, high powered weapons and sensors required to pace technology, outpace adversaries, and maintain maritime dominance

- These are elastic by nature
- Some are stochastic
- All are DC
- Limited response capability

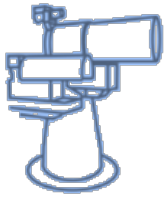
Near Term: MVAC Distribution Systems

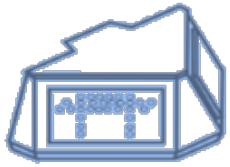
- Build in flexibility to rapidly introduce new mission systems/power gen & distribution
- Incorporate federated Energy Storage as Buffer
- Develop knowledge base for MVDC

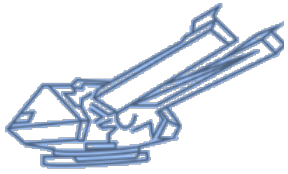


Next: MVDC Distribution Systems

- Integrated & Distributed Energy Storage
- Increased Efficiency & System/Power Density







Path to the Future

Power and Energy are the Foundation of the Kill Chain

- Shared energy storage for new dynamic loads
- Minimize space, weight and cooling impacts
- Utilize all shipboard energy to produce useful power

Path to the future

Shift the power interface

MVDC: MIL-STD-1399-300.3
LVDC: MIL-STD-1399-300.4

Develop a common intermediate power and energy system

ENERGY MAGAZINE

Advance Fully Integrated Power and Energy Systems

IPES

Validation

- New DC MIL-STDS

Back fit / Forward fit

New Ship Design

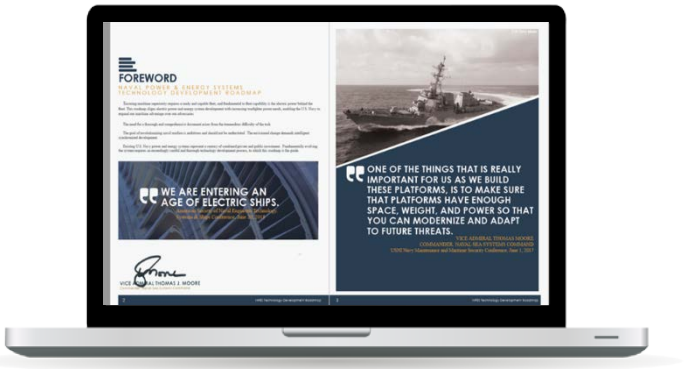
- Near: MVAC with federated energy storage
- Next: MVDC with integrated & distributed energy storage

Naval Power and Energy Systems Technology Development Roadmap

- Aligned to the Navy's 30-year shipbuilding plan and Surface Capability Evolution Plan (SCEP)
- Originally issued in 2007 as part of the ESO stand-up; updated in 2013, 2015 and 2019.
- Includes all major product areas for Naval Power and Energy Systems
- Serves as a Guide for Future Investment by Navy, DoD, Industry, and Academia

PRODUCT AREAS

- Energy Storage
- Power Conversion
- Prime Movers
- Generators
- Electric Motors
- Distribution System
- Controls
- Thermal Management



01 The case for a power and energy leap forward

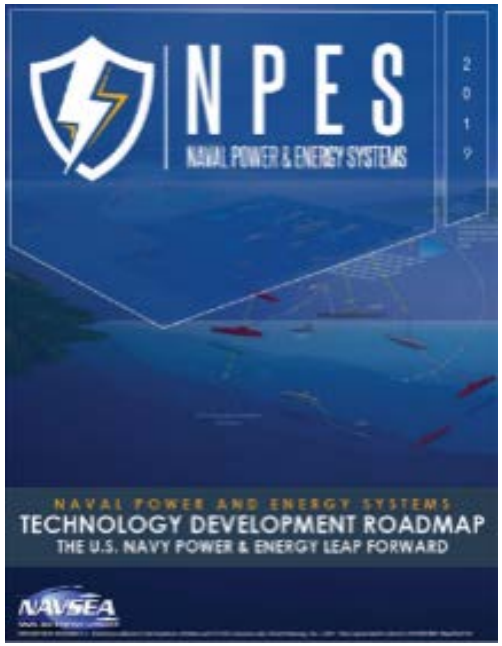
02 Future power and energy requirements

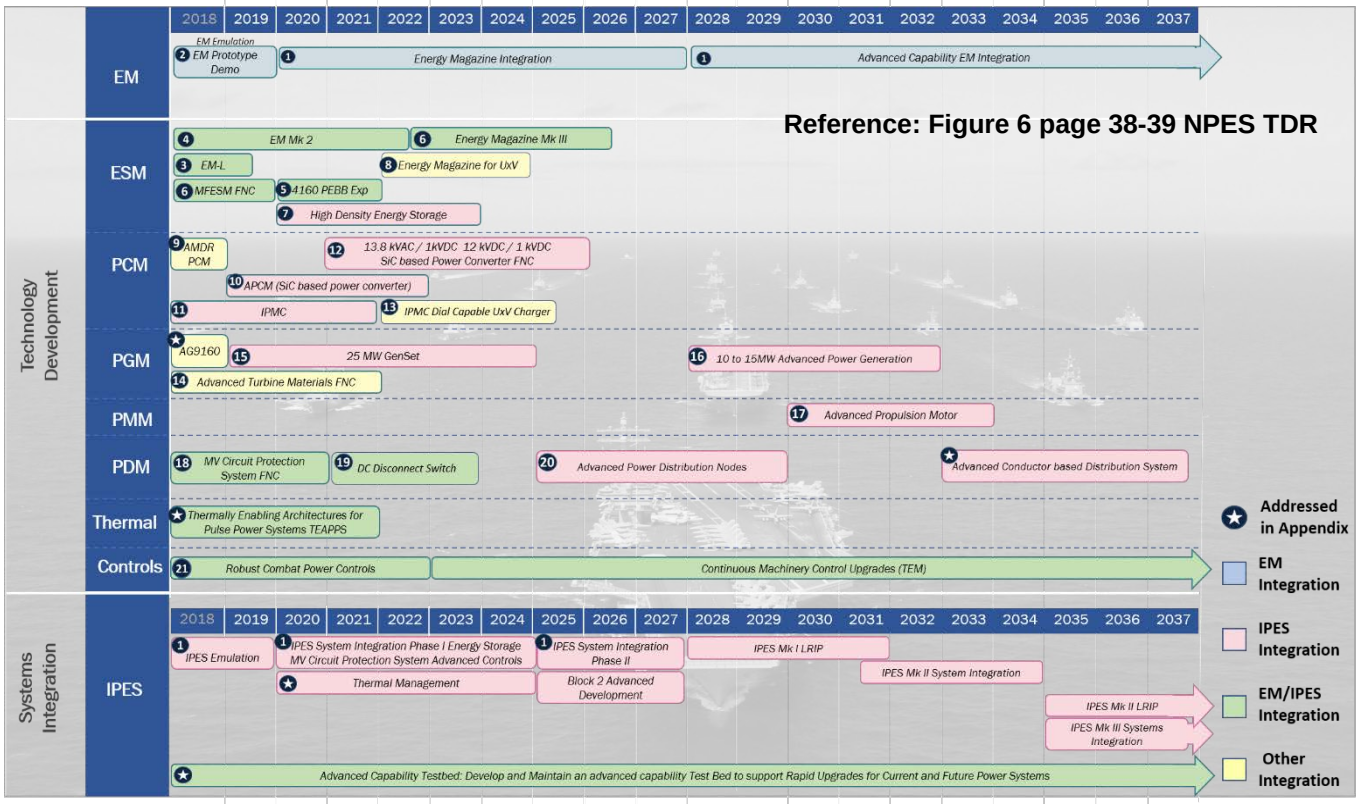
03 Power and energy technology development

04 Delivering capability through power and energy modernization

2019 NPES TDR at: http://www.navsea.navy.mil/resources/npes-tech-development-roadmap/

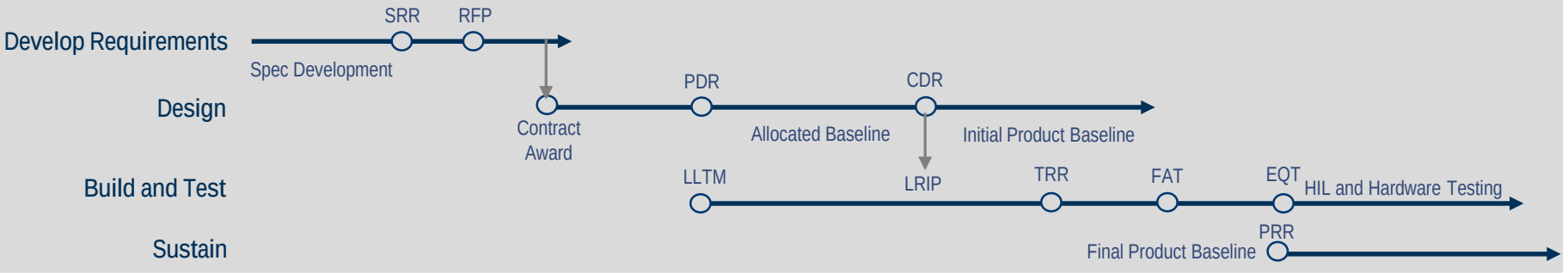
Established NPES Plan & Development Processes





Reference: Figure 6 page 38-39 NPES TDR

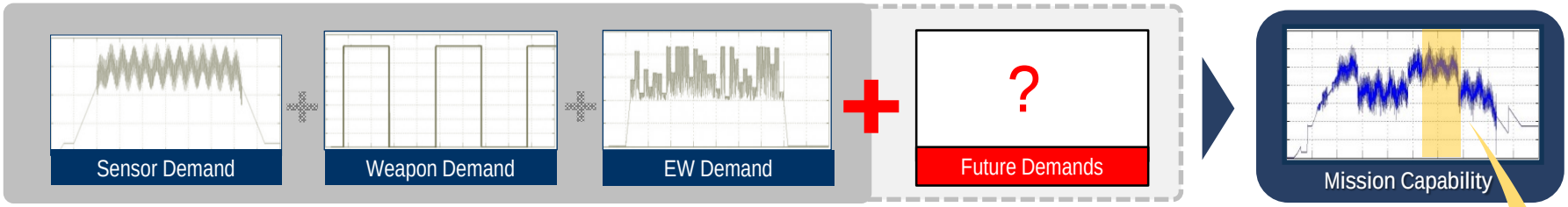
*(#) corresponds to required initiative that activity supports from Section 3



2019 NPES BAA: https://beta.sam.gov and Search the Solicitation Number N0002419R4145

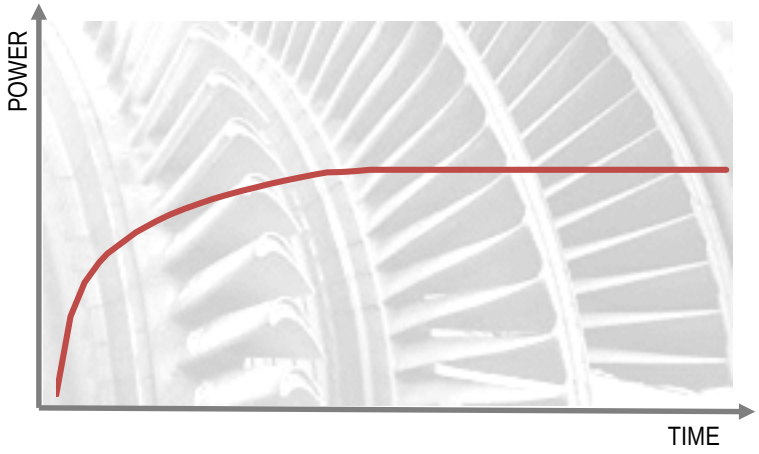
Future Power and Energy Requirements

Mission, power, and energy demands outpace ship capability without investment



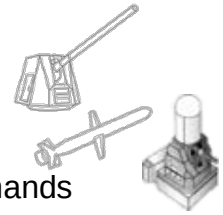
Power is Energy divided by time (P = E / t) *or* Energy equals Power times time (E = P * t)

Current: Generator Response to Load

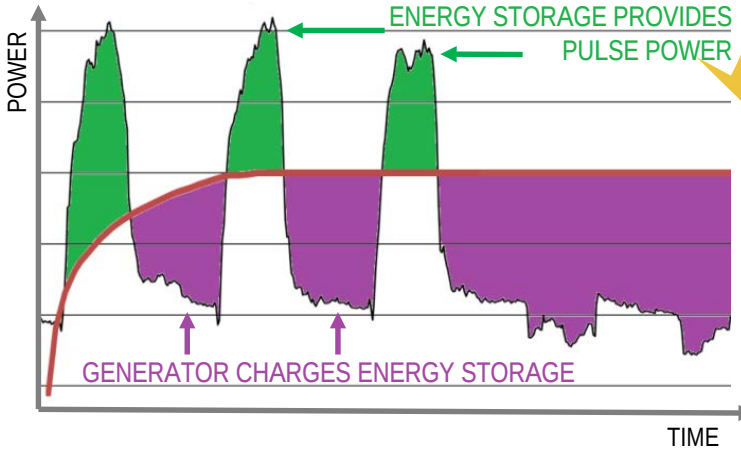


Kinetic Weapons

- Generators operate at continuous loading for efficiency and reliability
- Current generators cannot respond quickly and dynamically to new demands

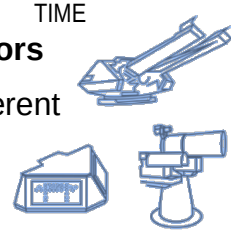


Future: Energy Storage Response to Load



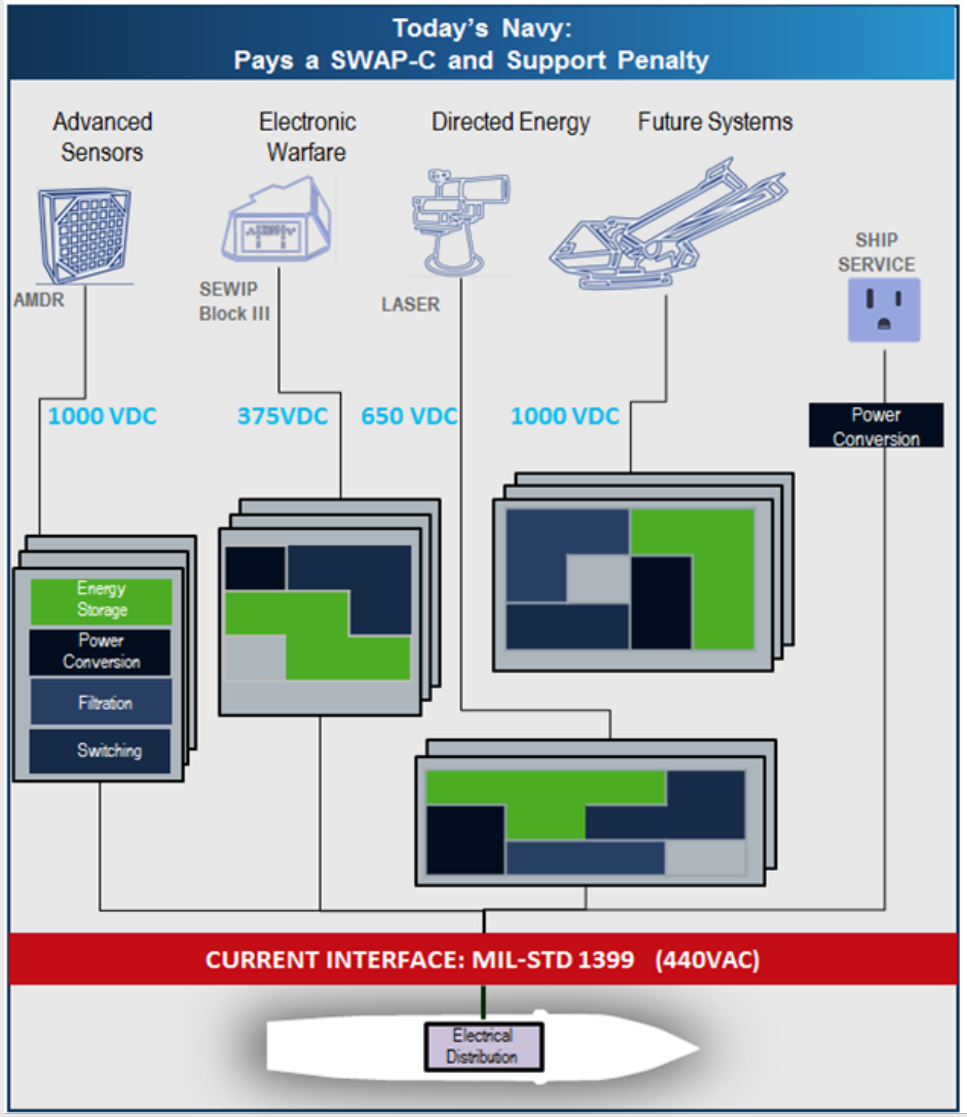
Directed Energy Weapons and Sensors

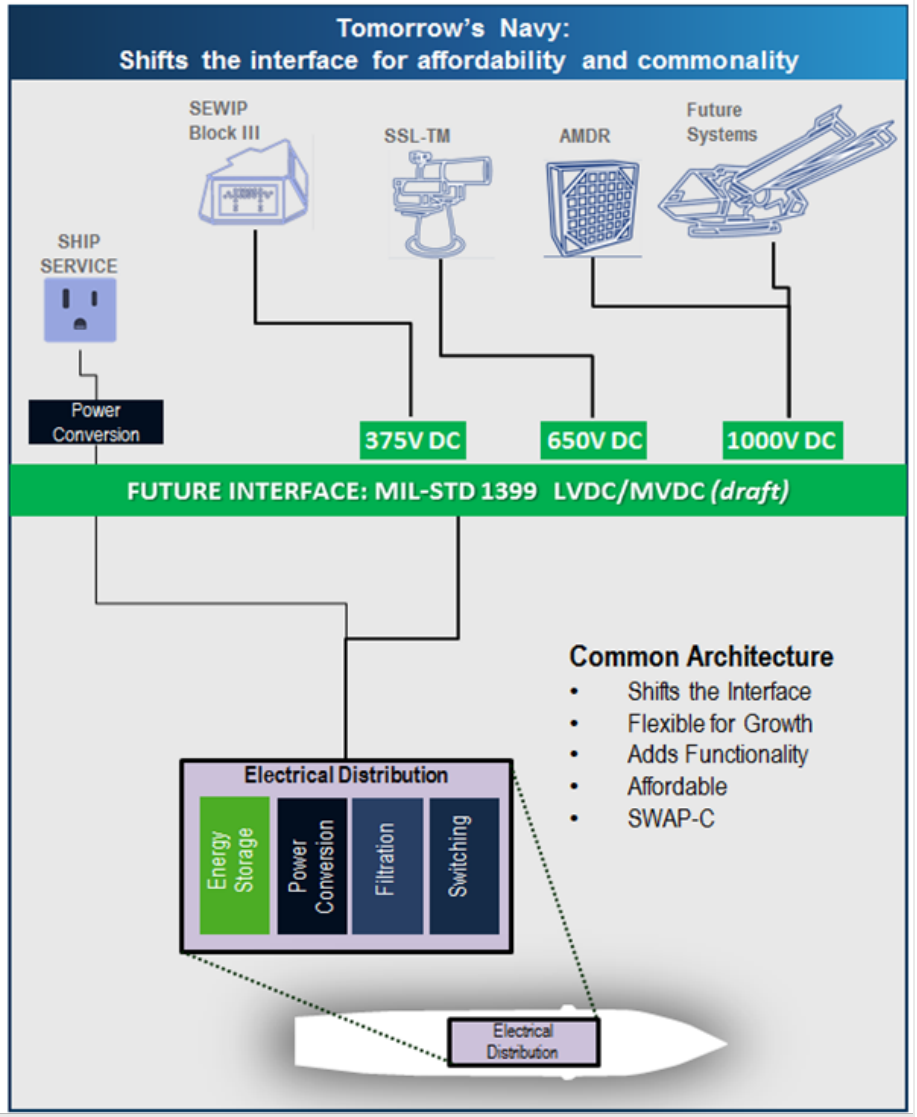
- Pulses of a different nature require different ranges of pulse power technologies
- Future directed energy demands need common large-scale energy storage



Key to Success = Energy Storage and Advanced Controls

Shifting the Electrical Interface Towards Mission Systems



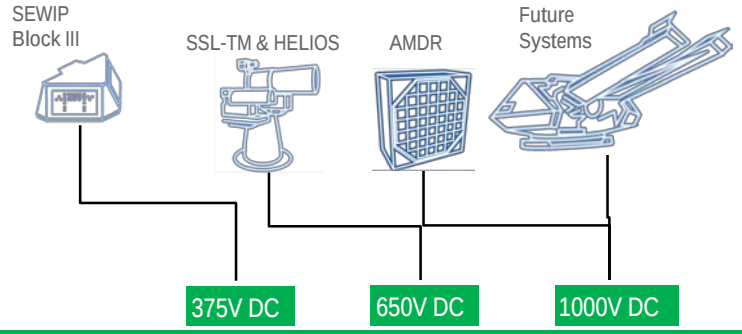


Tomorrow's Navy shifts the interface for affordability and commonality

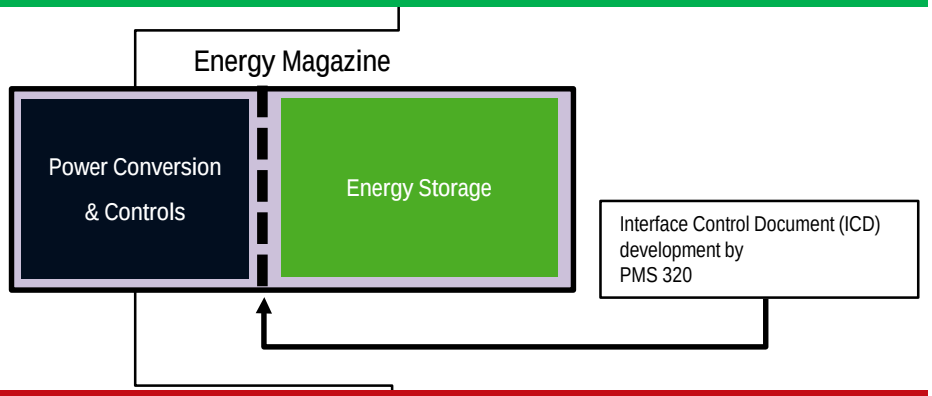
Shifting the Interface: Energy Magazine

Energy Magazine Bridges the path to the Future with Back-fit Installations

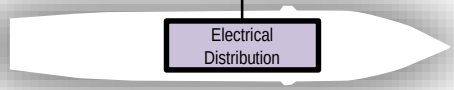
Intermediate Navy
Uses Current and Future Naval Interfaces



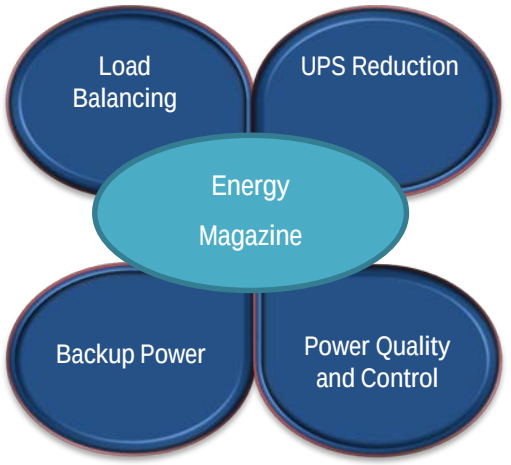
FUTURE INTERFACE: MIL-STD 1399 LVDC/MVDC *(draft)*

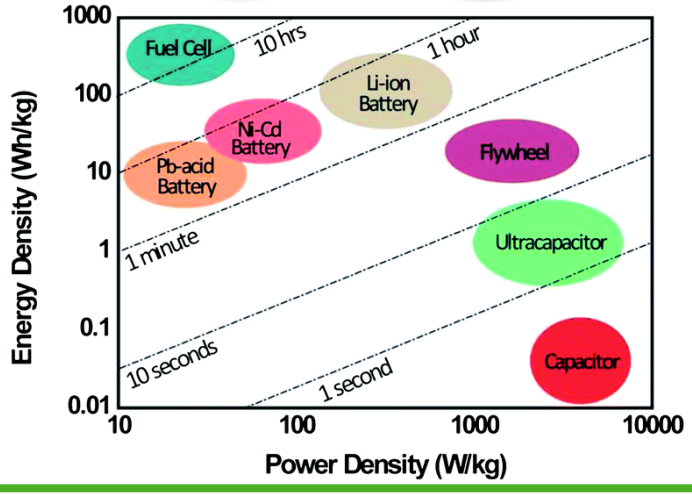


CURRENT INTERFACE: MIL-STD 1399 (440VAC)



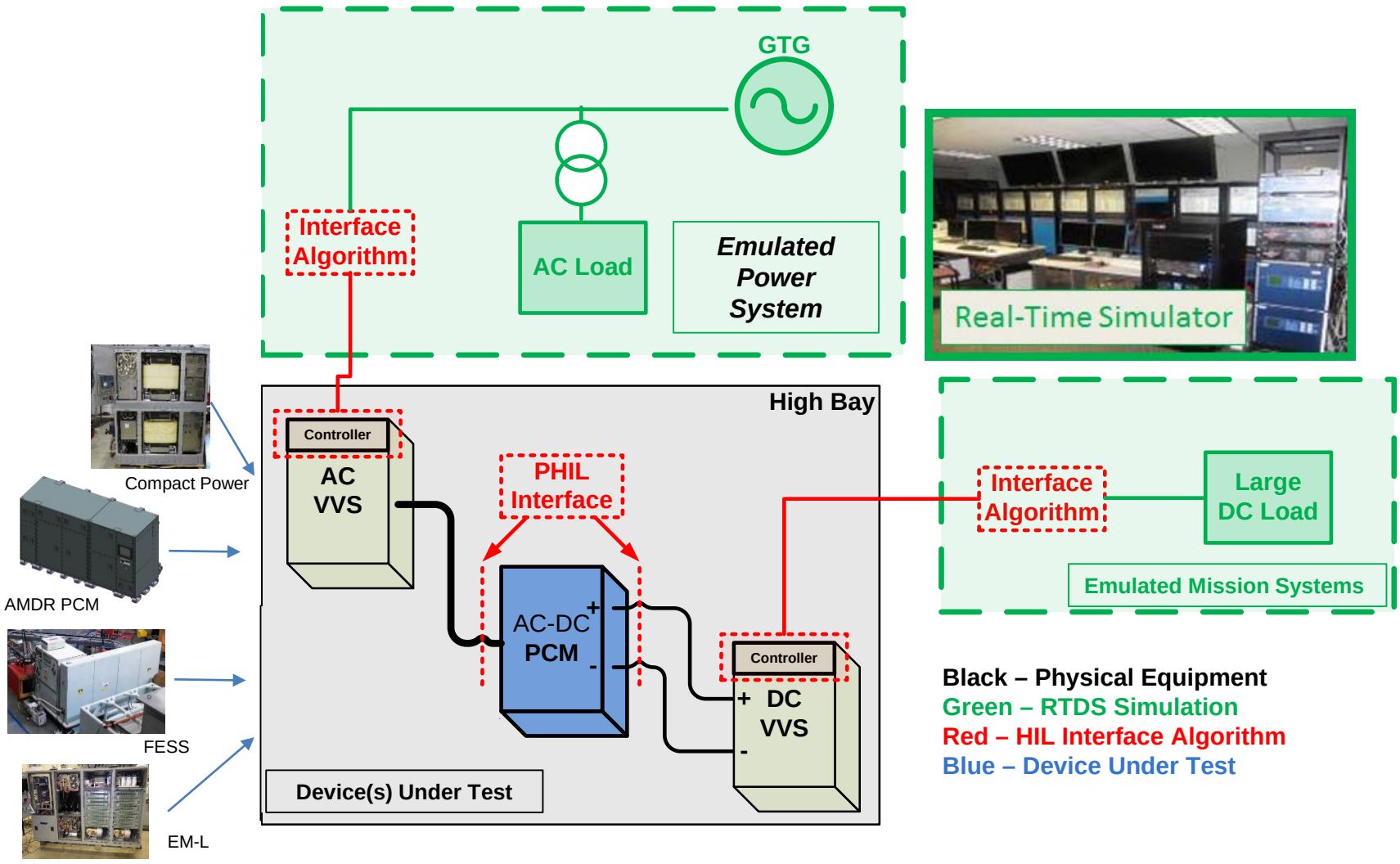
Energy Storage Types & Functions





Energy storage couples todays ships with tomorrows technology

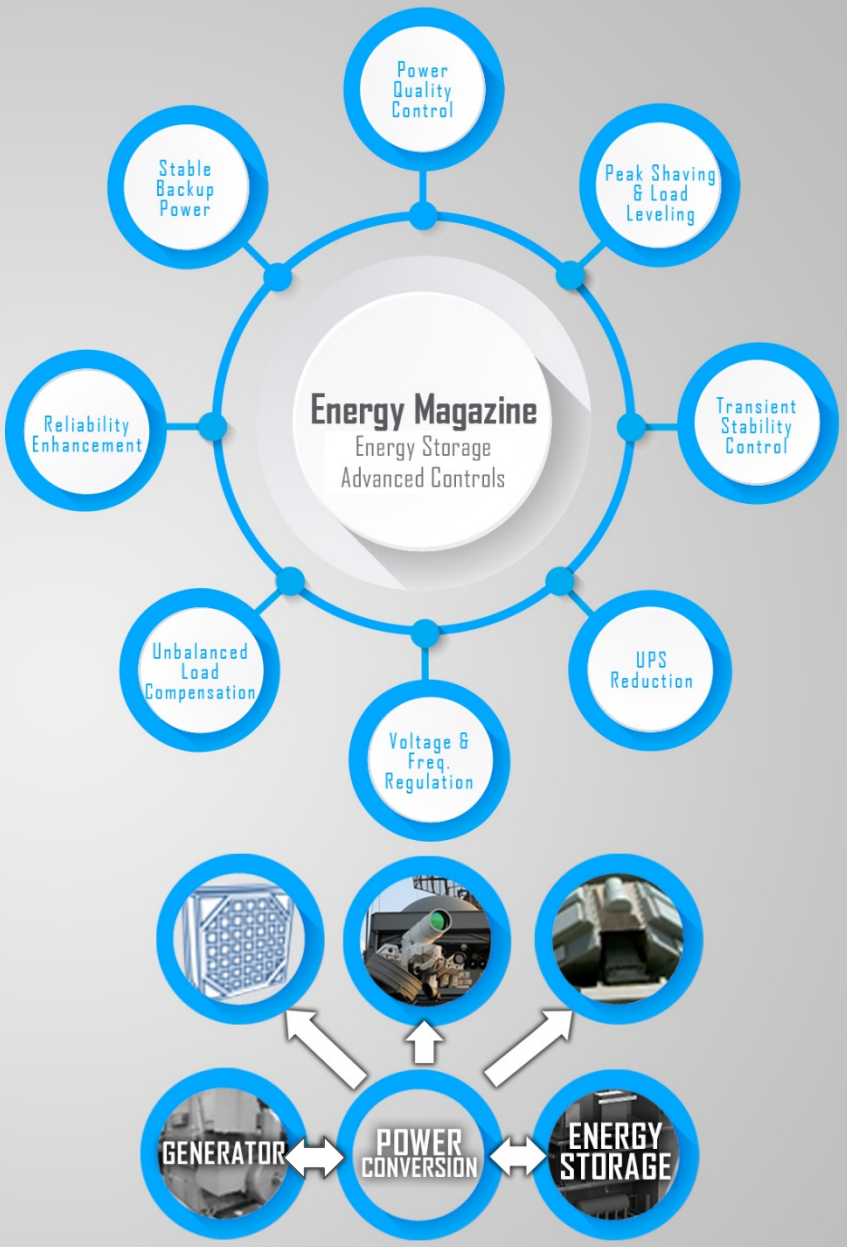
Digital Engineering & Power Hardware in the Loop Testing



Real Time Simulation: Technical and Programmatic Risk Reduction

ENERGY MAGAZINE (EM)

Provides shipboard ready power system support for Pulsed High Power, High Energy Weapons and Sensors for Backfit and Forward Fit. The system is a modular, configurable, and scalable design with multiple input and output modules.



Input: 450VAC, 4160VAC, 12kVDC

Output: 375VDC, 650VDC, 1kVDC
Type 11kVDC Type II

Dimensions (Threshold)
Power Control Cabinet (PCC):
75" (W) x 48"(D) x 78" (H)
Energy Storage Cabinet (ESC):
75"(W) x 48"(D) x 78" (H)
Total: 150"(W) x 48"(D)
x 78"(H);
Weight (Threshold)
PCC: 16000 lbs ;
ECC: 9000 lbs;
Total : 25000 lbs; adjustable depending on application

Energy Storage:
153 KWhr (550 MJ) Battery, Capacitor, or Flywheel Stored energy, augments ship's electric plant by peak shaving.
Qualified, shipboard ready, 9310 characterized storage system

SPECIFICATIONS

ENERGY MAGAZINE: POWER FOR PULSED MISSION SYSTEMS

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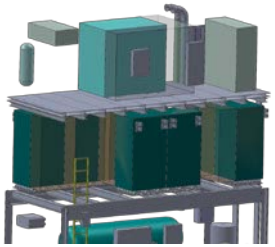
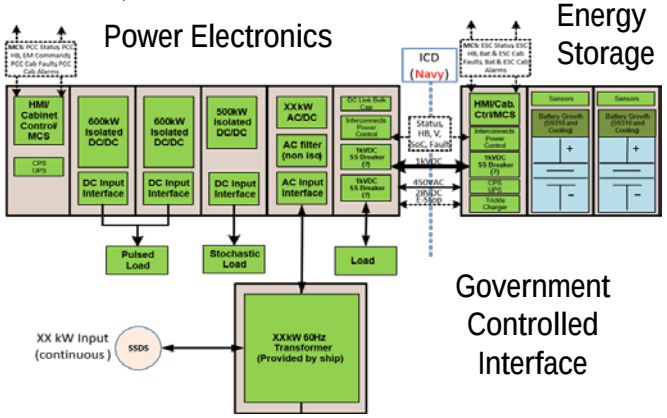
Energy Magazine: Leveraging 9 Years of Investment

2011: Energy Storage Module-Land (ESM-L):
Proof of Concept for SSL-TM Land Demo Testing
Lead acid battery based technology in 28' conex box

Upgrade for Shipboard Use

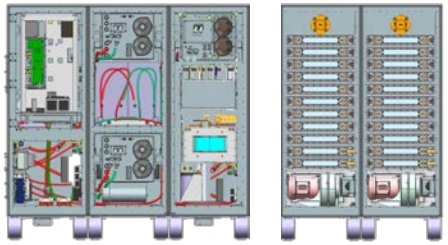


2019: Energy Storage Module-Ship (ESM-S):
Second ESM Unit Modified for SSL-TM on LPD 27



2018: Energy Magazine Laser (EM-L)
ESM Capability in 1/10 the size with lithium batteries (EaglePicher)
Supports Laser Engagement Profiles

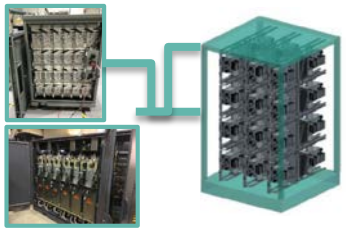
Define internal interfaces



2021: Energy Magazine Prototype (EM-P)
Separate the interface between Power Electronics and Batteries, Faster Recharge

2023: Multi-function Energy Magazine
Supports laser, SEWIP, AMDR UPS, & bus stability

RFP 2nd QTR FY20

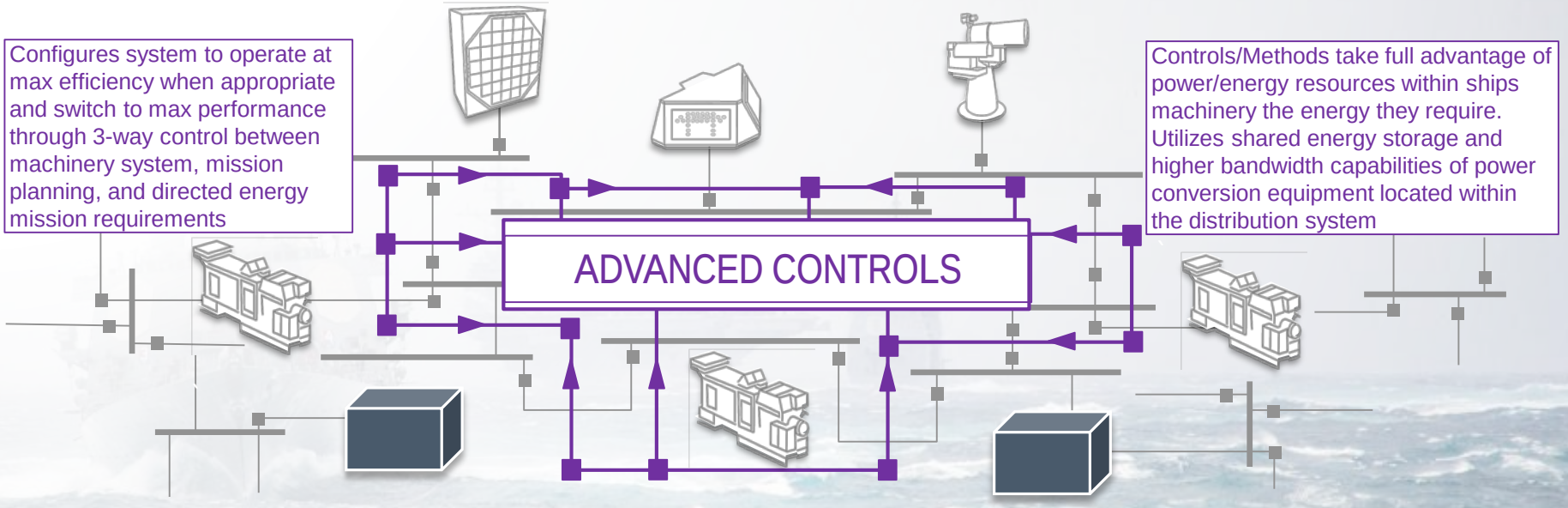


2019: Multi-function Energy Storage Module (MFESM)
Power Electronics with Hybridized Energy Storage: Batteries + Capacitors

Leverage early investment

2020: Energy Magazine Laser (EM-L) MK 2
Early Transition of MFESM; Batteries (SAFT) with Energy Magazine Laser Prototype

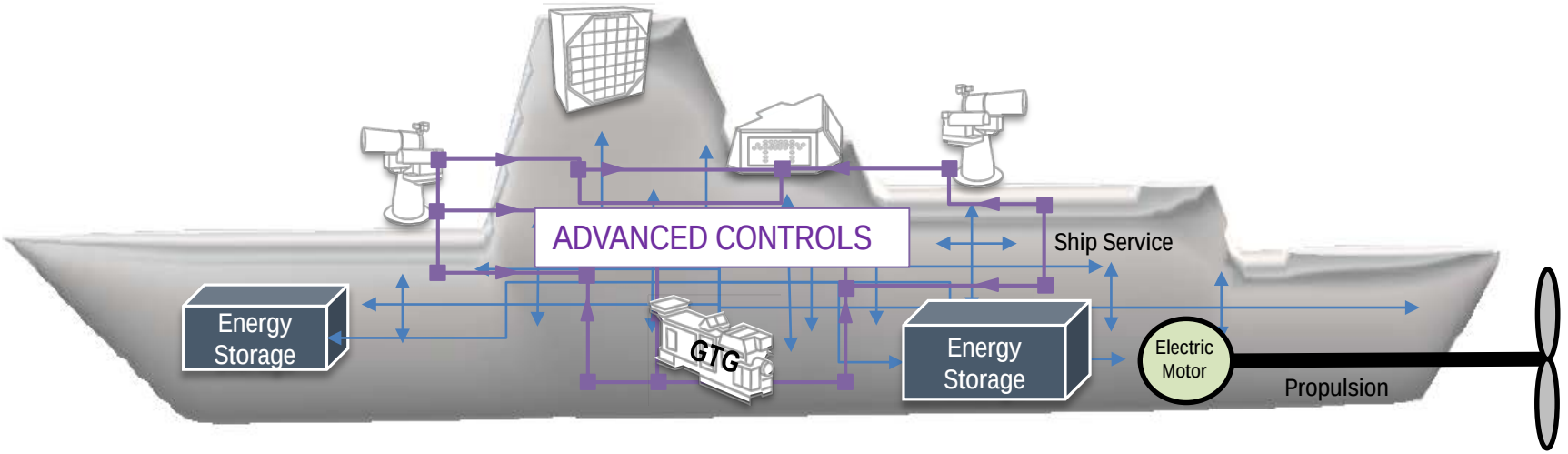
The introduction of agent-based, distributed, nonlinear control will be a revolutionary step to tackle pulsed load challenges



Active state anticipation provides the ability to meet pulsed load challenges while reducing energy storage capacity and overall power requirements

Advanced Controls Provide Flexibility

IPES= IPS + Energy Storage and Advanced Controls



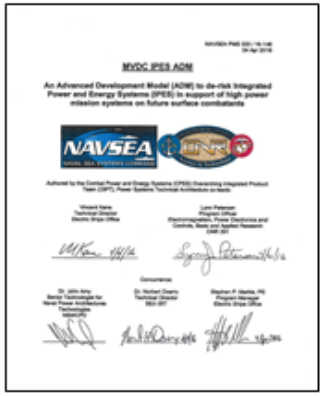
Enable high power directed energy weapons and advanced sensors through automated control of distributed, shared power generation and energy storage resources

An Integrated Power and Energy System Unlocks Total Ship Power

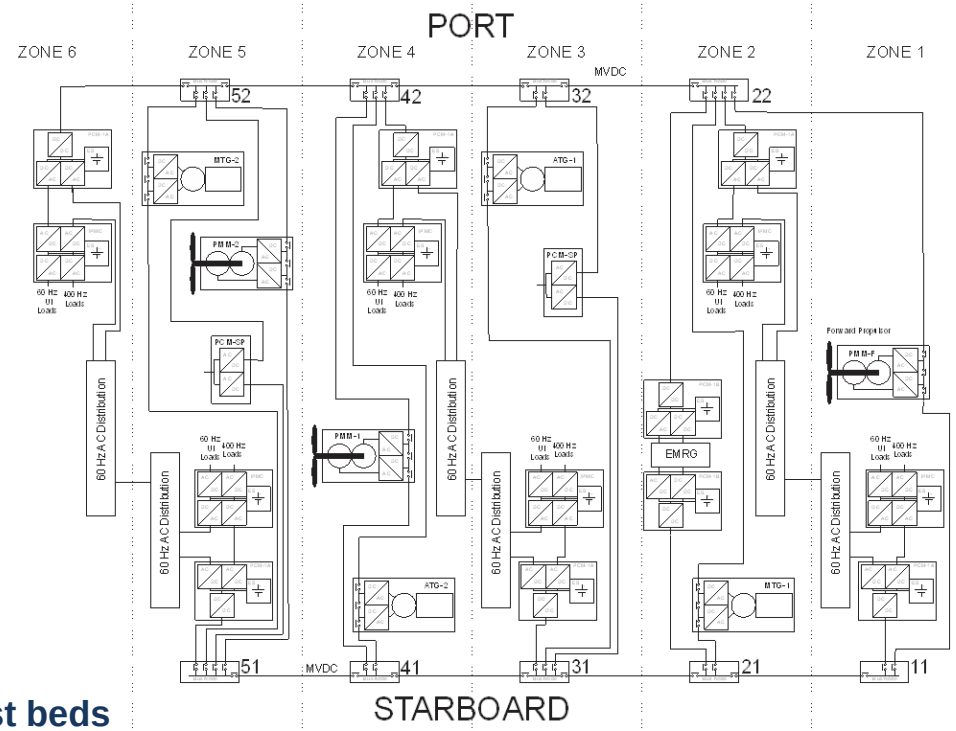
MVDC Today – A Decade Down the Road

Integrated Power and Energy Systems (IPES)

- **Integrated Power and Energy System (IPES)**
  - IPES Background
  - MVDC Background: why MVDC?
  - NPES TDR Recommendations
  - IPES MVDC Technical Task Structure
    - Near term Task: Develop DC Interface
- **Why IPES MVDC ADM?**
  - Risk Reduction
  - ADM Results Supports AoA



IPES: highly integrated system from generator to loads



- **Articulated MVDC reference architecture**
- **Modeling and simulation analyses/Subscale test beds**
- **Energy Magazine Demonstrations – Integrate Energy Storage**
- **Initiated procurement of MVDC test equipment at NSWC**
- **Various ESRDC, SBIR, and STTR projects**
- **Transition advanced controls (now a pre-FNC)**
- **Energy Magazine Installations and Demonstrations – Integrate Energy Storage**
- **Full scale hardware demonstration, validation of models**
- **MIL-STD-1399-300-3 MVDC Interface Standard & MIL-STD-1399-300-4 LVDC Interface Standard**
- **T9300-AF-PRO-510 MVDC Design Practices and Criteria Manual**

The Quest Continues

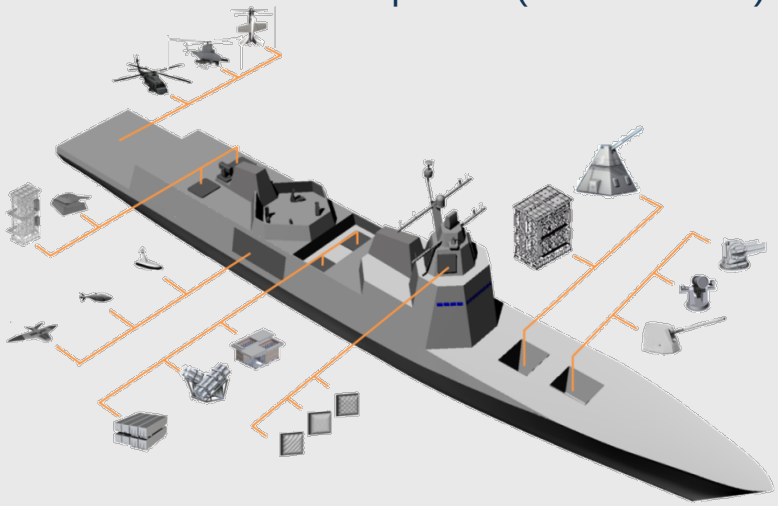
Takeaways

Increasing demand for high quality power to support a variety of loads

Successful shipboard integration of advanced weapons, sensors, and C2 will be directly dependent on the ability to effectively and efficiently distribute the right amount of power to the right place at the right time

Operational Energy Imperative

> Increase the effective use, conversion, storage, distribution, and control of energy to enable the integration of future weapons and sensors onto platforms.
>
> - Hon. Richard V. Spencer (27 June 2019)



Key Takeaways

- **Tactical Energy Management (Energy Storage & Advanced Controls)** – provides the foundation for an affordable, scalable, and flexible power system
- **Power conversion** – advances in SiC will enable affordable upgrades for high power, mission-critical applications
- **Integration testing** – leading edge system models, test capabilities, and facilities required to fully characterize and de-risk NPES technology

Power is the Foundation of Disruptive Warfighting Capability

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 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)

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

Providing Affordable, Integrated Power and Energy Solutions