Open Architecture Approach for the Next Generation Integrated Power System

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Agenda

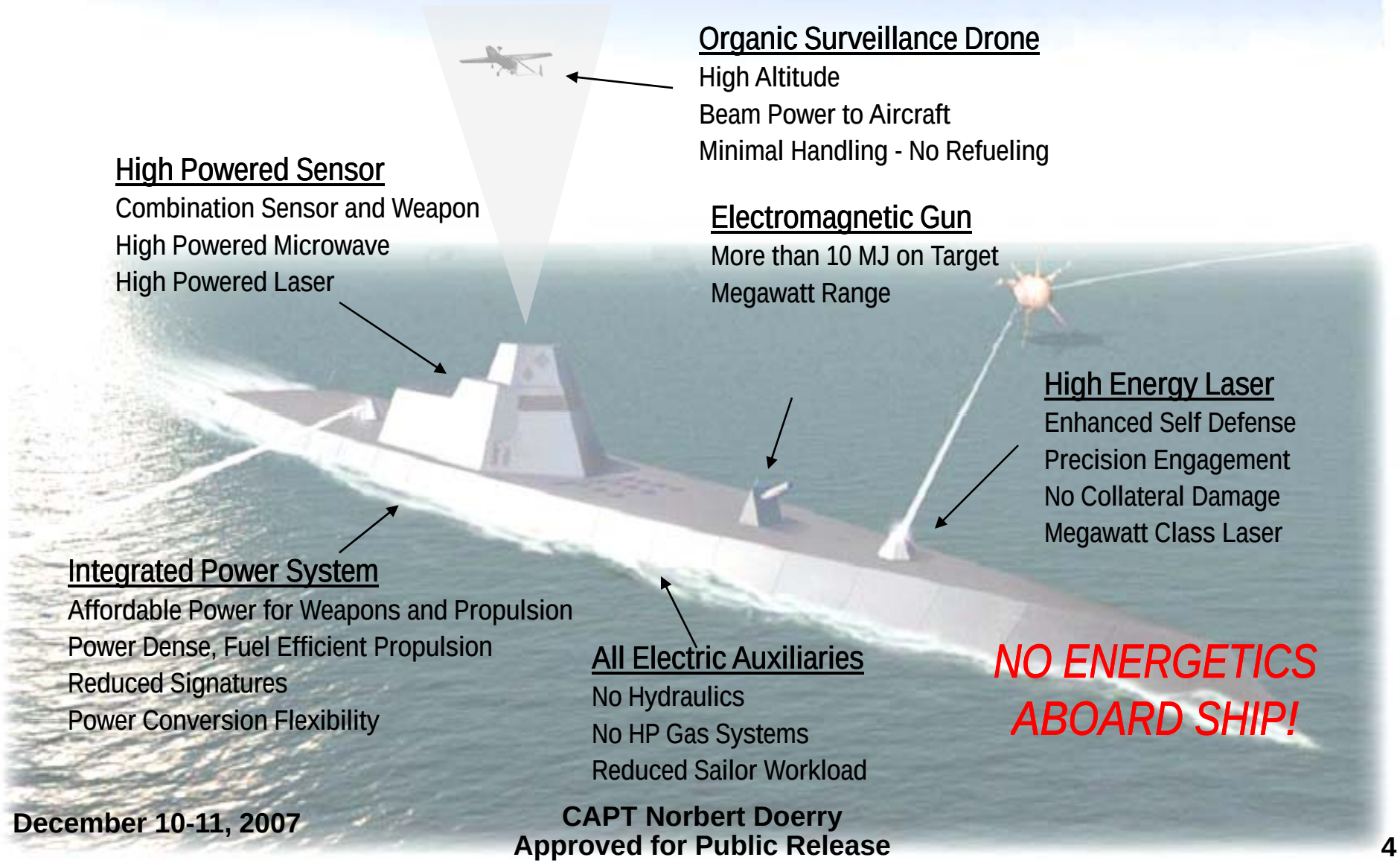
- Electric Warship Vision
- IPS Functional Architecture
- NGIPS
- Technical Architectures
  - MVAC
  - HFAC
  - MVDC
  - ZEDS
- NGIPS Business Architecture

Naval Electric Power System Design

The primary aim of the electric power system design will be for survivability and continuity of the electrical power supply. **To insure continuity of service, consideration shall be given to the number, size and location of generators, switchboards, and to the type of electrical distribution systems to be installed and the suitability for segregating or isolating damaged sections of the system.**

- ***NAVSEA DESIGN PRACTICES and CRITERIA MANUAL, ELECTRICAL SYSTEMS for SURFACE SHIPS*****, CHAPTER 300**
NAVSEA T9300-AF-PRO-020

Electric Warship Vision



Organic Surveillance Drone
High Altitude
Beam Power to Aircraft
Minimal Handling - No Refueling

High Powered Sensor
Combination Sensor and Weapon
High Powered Microwave
High Powered Laser

Electromagnetic Gun
More than 10 MJ on Target
Megawatt Range

High Energy Laser
Enhanced Self Defense
Precision Engagement
No Collateral Damage
Megawatt Class Laser

Integrated Power System
Affordable Power for Weapons and Propulsion
Power Dense, Fuel Efficient Propulsion
Reduced Signatures
Power Conversion Flexibility

All Electric Auxiliaries
No Hydraulics
No HP Gas Systems
Reduced Sailor Workload

NO ENERGETICS ABOARD SHIP!

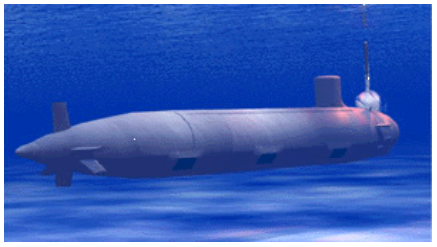
The Road to the Electric Warship

LHD 8
Hybrid Electric Drive

T-AKE
Commercial Integrated
Power System

DD(X)
Military Integrated Power System

CVN 21
High Voltage, High Power
Distribution System
Electric Aircraft Launch



VIRGINIA
Power Electronics

Integrated Power System Functional Architecture

IPS consists of an architecture and a set of modules which together provide the basis for designing, procuring, and supporting marine power systems applicable over a broad range of ship types.

- **Power Generation Module (PGM)**
- **Power Distribution Module (PDM)**
- **Power Conversion Module (PCM)**
- **Power Control (PCON)**
- **Energy Storage Module (ESM)**
- **Load (PLM)**
- **Propulsion Motor Module (PMM)**

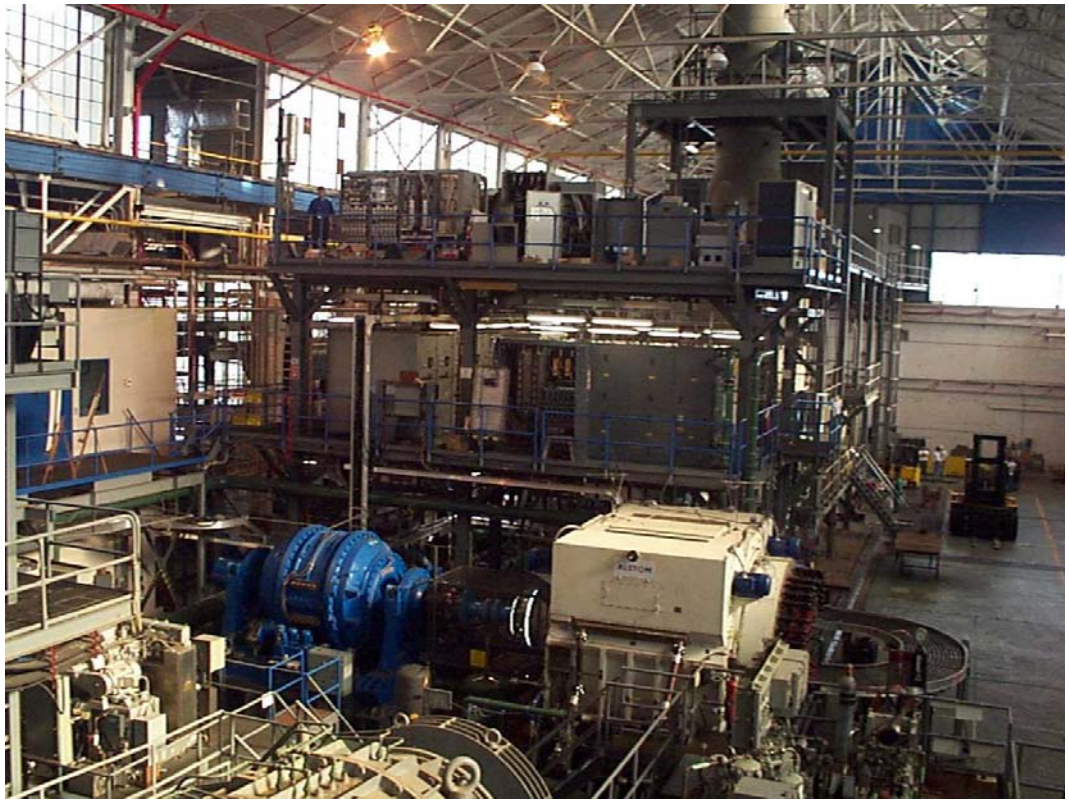
IPS Architecture

Integrated Power

- Propulsion and Ship Service Loads provided power from same prime movers

Zonal Distribution

- Longitudinal Distribution buses connect prime movers to loads via zonal distribution nodes (switchboards or load centers).



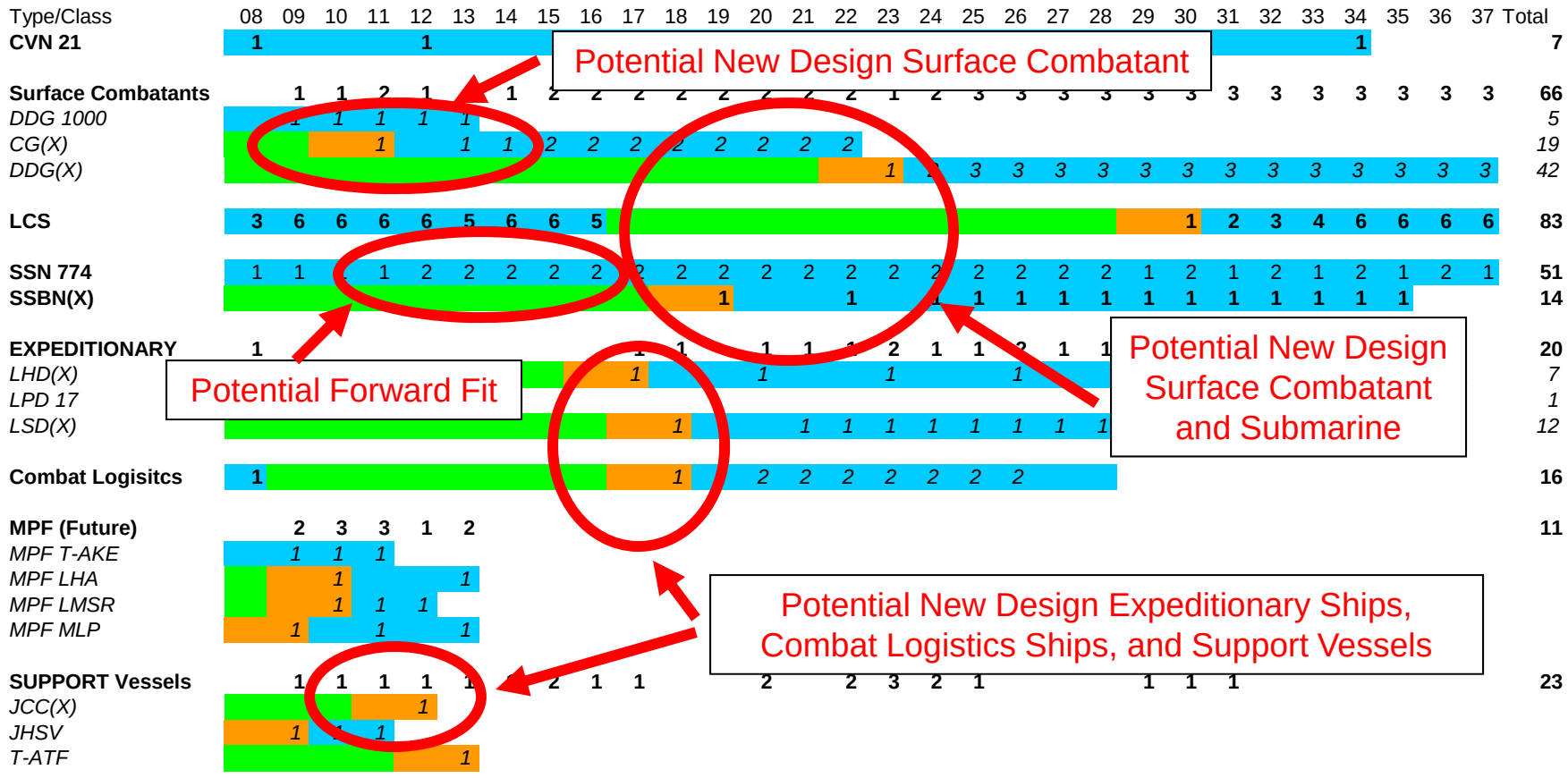
IPS Test Site: NAVSSES Philadelphia

Next Generation IPS – What's New?

- **Built on an Open Architecture Business and Technical Model**
  - **Near term focus is on standards development**
- **Reflects lessons learned from IPS**
- **Covers full range of ships in the 30 year shipbuilding plan.**
  - **3 Power Generation Technical Architectures**
  - **Zonal Ship Service Power Architecture**

AFFORDABLY MEET THE POWER NEEDS OF OUR FUTURE FLEET

The Opportunity



Type/Class	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Total
CVN 21	1				1																						1				7
Surface Combatants		1	1	2	1		1	2	2	2	2	2	2	2	2	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	66
DDG 1000		1	1	1	1	1																									5
CG(X)				1			1	1	2	2	2	2	2	2	2	2															19
DDG(X)																1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	42
LCS	3	6	6	6	6	5	6	6	5														1	2	3	4	6	6	6	6	83
SSN 774	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	1	2	1	2	1	51
SSBN(X)												1			1		1	1	1	1	1	1	1	1	1	1	1				14
EXPEDITIONARY	1									1	1		1	1	1	2	1	1	2	1	1										20
LHD(X)										1			1			1			1												7
LPD 17																															1
LSD(X)										1		1		1	1	1	1	1	1	1	1										12
Combat Logisitcs	1									1		2	2	2	2	2	2	2													16
MPF (Future)		2	3	3	1	2																									11
MPF T-AKE		1	1	1																											
MPF LHA			1			1																									
MPF LMSR			1	1	1																										
MPF MLP		1		1		1																									
SUPPORT Vessels		1	1	1	1	1		2	1	1			2		2	3	2	1					1	1	1						23
JCC(X)					1																										
JHSV		1		1																											
T-ATF						1																									
New Const	7	11	12	13	12	12	10	12	11	6	6	5	9	8	10	10	10	11	10	7	7	9	9	9	10	9	13	12	11	10	291

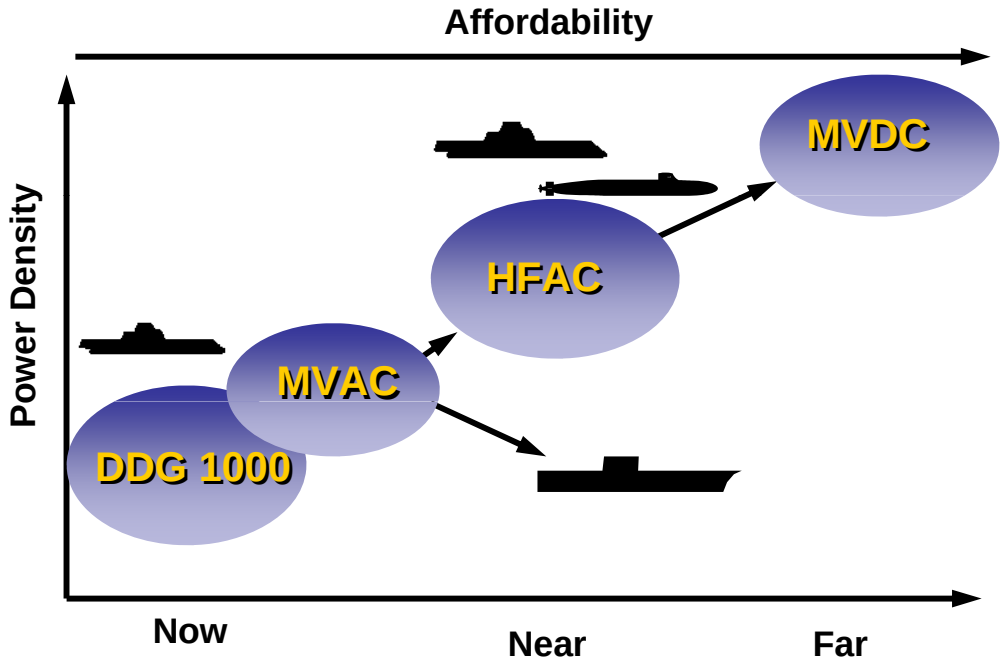
NOTE

Each ship class has an Analysis of Alternatives that derives the requirements for that class. This AOA may be five years before the lead ship contract award. The PDR/CDR is generally 3/2 years prior to contracting the ship. Acquisition decisions must be made prior to these milestones.

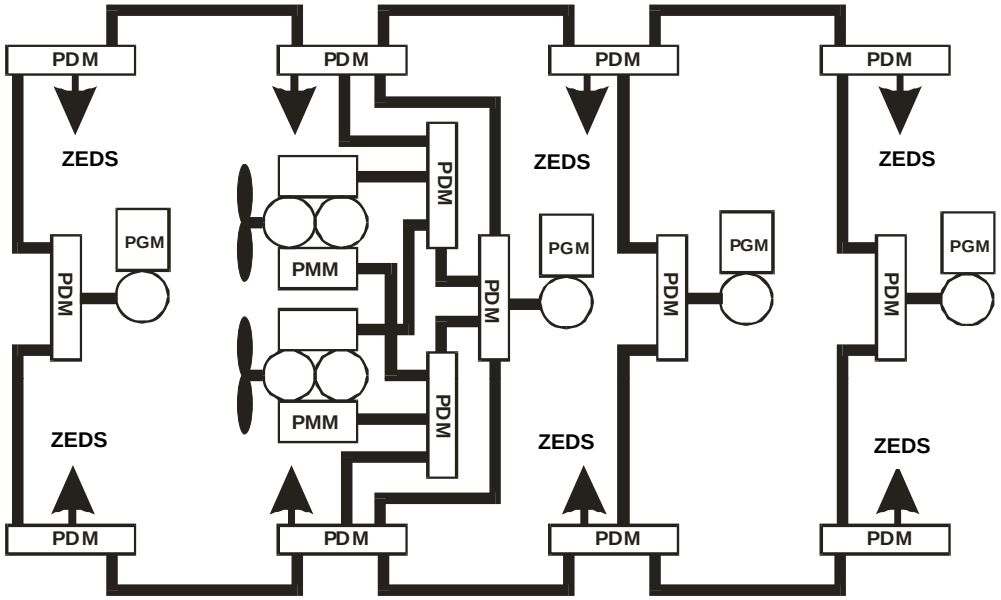
Low integration risk if Technology achieves TRL 7 in this year
Moderate to High Integration Risk if Technology achieves TRL 7 in this year
Achieving TRL 7 in these years is only appropropriate for Component Upgrades

NGIPS Technical Architectures

- **Power Generation**
  - Medium Voltage AC (MVAC)
    - Today's Technology
    - Appropriate for ships without power density requirements
  - High Frequency AC (HFAC)
    - Intermediate Step towards MVDC for ships with high power density requirements
  - Medium Voltage DC (MVDC)
    - Target Architecture for ships with high power density requirements
- **Zonal Ship Service Distribution**
  - Common to all Power Generation Systems
  - Affordably provide requisite level of Survivability and Quality of Service
    - Zonal Survivability – limit impact of damage to affected zones
    - Quality of Service – Ensure reliable power under normal operating conditions

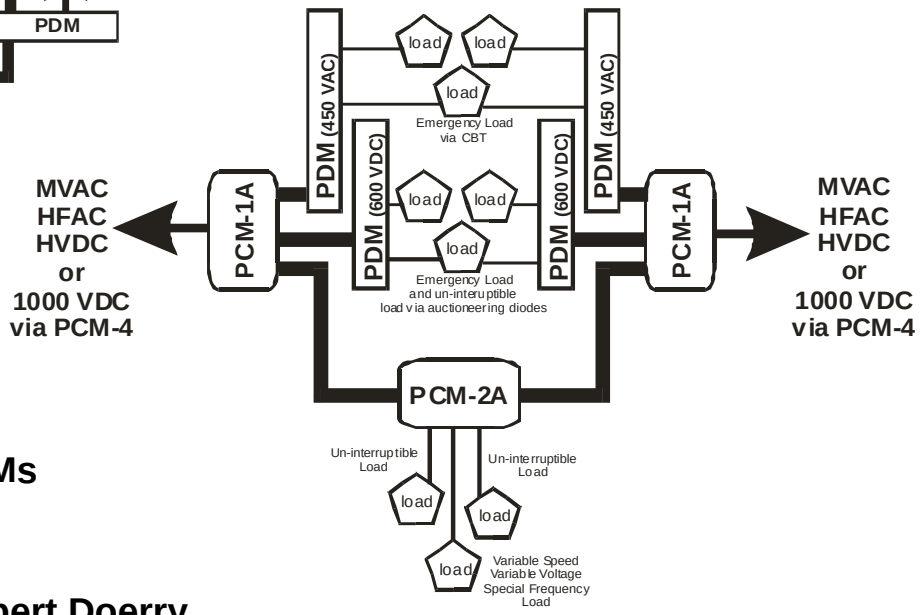


Power System Architectures



Notional
Power Generation Bus
(MVAC, HFAC, MVDC)

Notional
Zonal Electrical Distribution



Power Generation Bus configurations (including number of zones and number and location of PGMs / PMMs) will vary based on ship requirements

Open Architecture Business Model

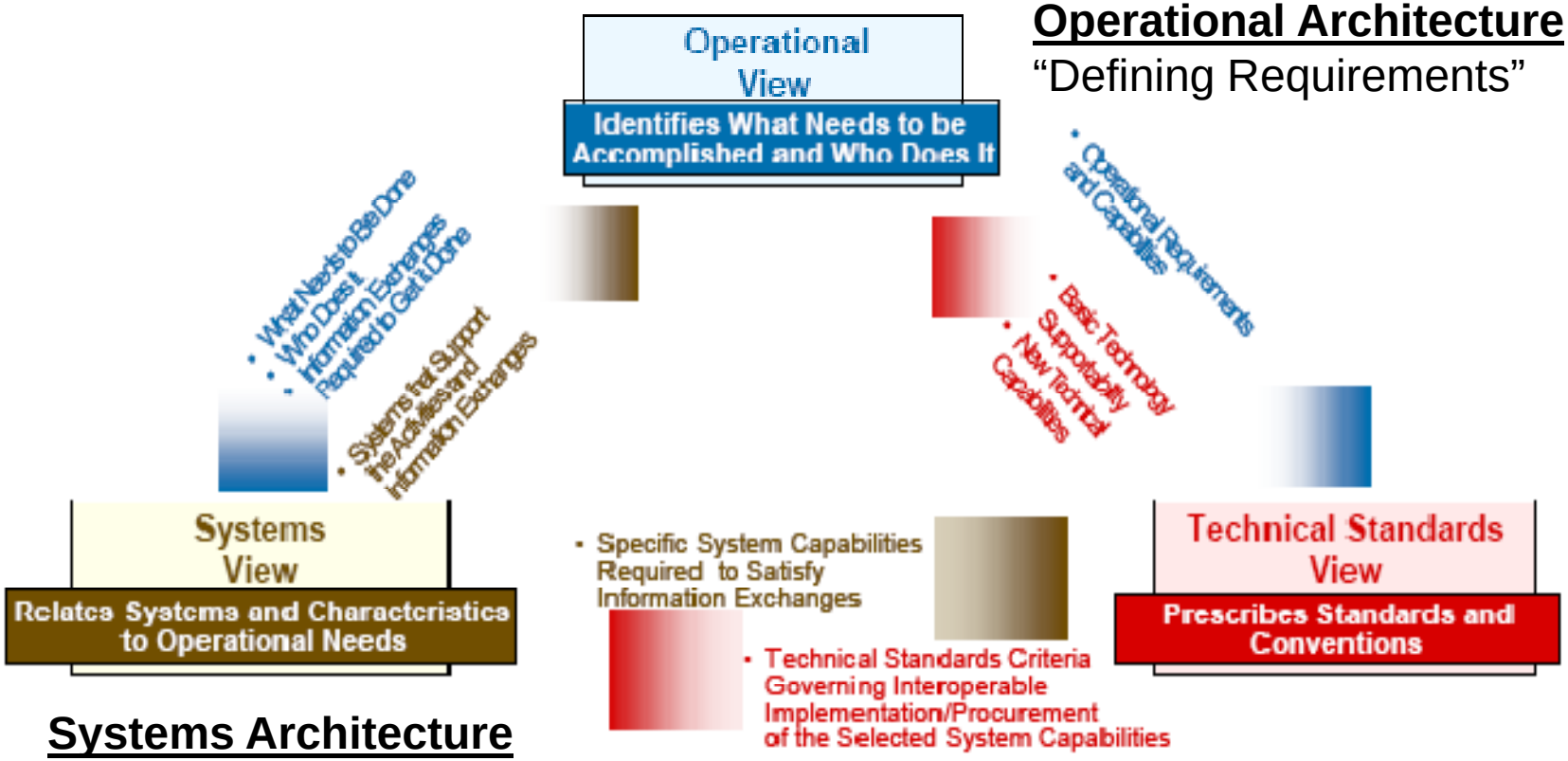
"Naval OA is a combination of collaborative-competition business and technical practices; including Peer Reviews for cost-effective innovation, with rapid Technology Insertion processes fostering third-party developed modules (hardware and/or software), for continuous, incremental increases in warfighting capability, while reducing cost."

Open Architecture Task Force (OATF)
December 2006

Open Architecture (OA) Business Model

- **Using Performance Specifications that define "what" is needed not "how" it is designed**
  - **Includes extensive use of well-defined and detailed interface specifications (Technical Architecture)**
  - **Includes well defined validation methods**
- **Subdividing labor and specialization at the module or component level**
- **Defining and segregating roles and responsibilities for component delivery, system integration and life cycle support**
- **Including a "spiral" process to provide feedback from the evaluation of fielded systems to update architecture documentation and module designs**

Department of Defense Architectural Framework



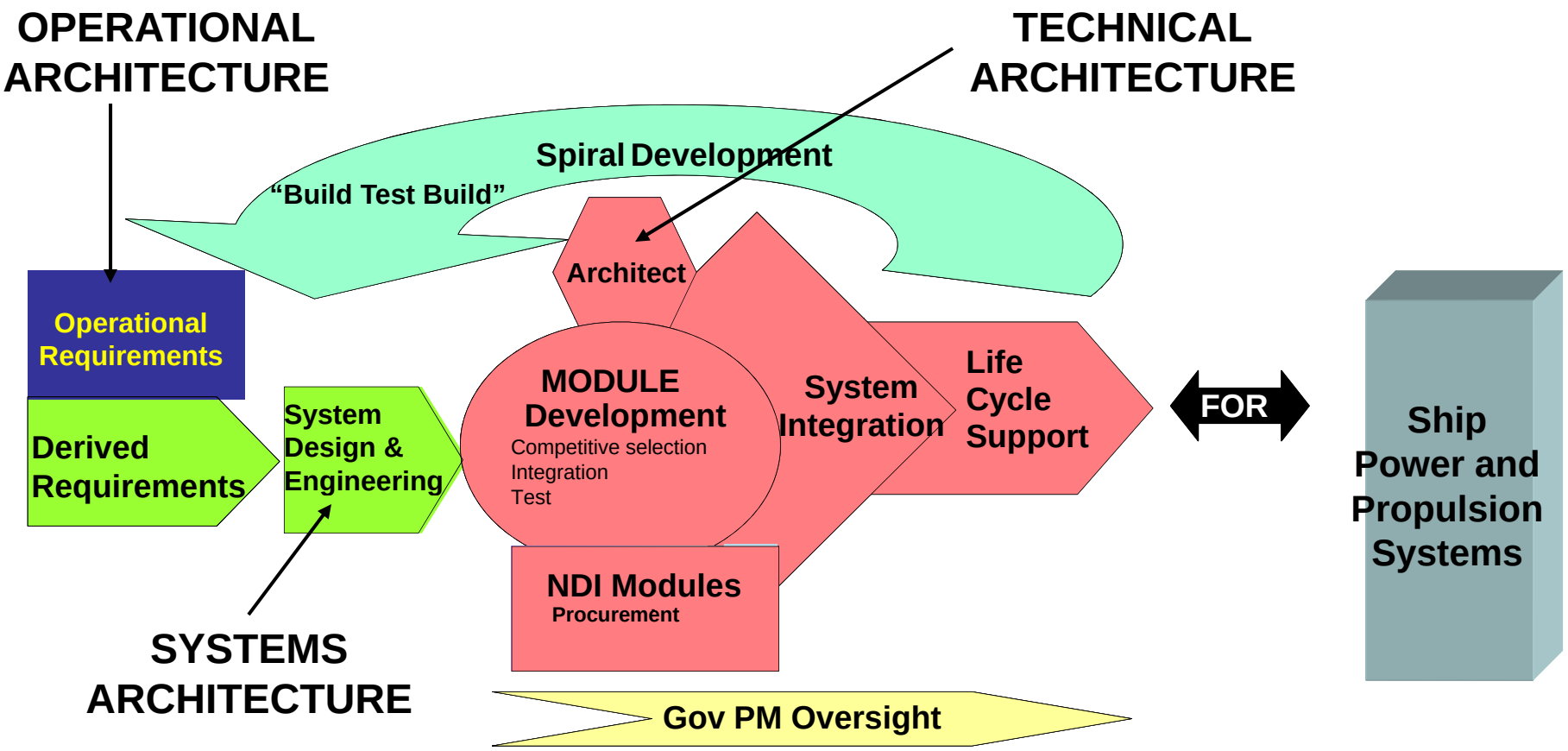
Operational Architecture
"Defining Requirements"

Systems Architecture
"Designing the System"

Technical Architecture
"Defining Standards"

http://www.dod.mil/cio-nii/docs/DoDAF_v1_Volume_I.pdf

NGIPS Business Model Structure



Architect

What (Technical Architecture – Not Ship Specific)

- Develop and Maintain standards and specifications such as NVR , MIL-SPECs as well as participation in industry standards bodies such as IEEE.
- Develop and Maintain interface specifications and validation / testing standards for NGIPS modules.
- Develop and Maintain standard Performance Specifications for NGIPS modules
- Develop and Maintain design data sheets and associated design and analysis tools.
- Develop and Maintain Module Characterization Sheets for capturing data on qualified and developmental modules for use with design and analysis tools.
- In collaboration with a Peer Review process and ship concept analysis, develop and maintain a technology roadmap / priority list for desired technology improvements.

Who

- Led by a Government Technical Warrant Holder
- Assisted by a Government / Industry Peer Review

Works Cross-Platform – Not Ship Specific

Module Development

What

- Mature technology to produce a “qualified” module ready for integration with other modules and insertion into a ship acquisition program.

Who

- ONR and / or Industry matures technology to TRL 5 or 6
- For Government matured technologies, a Government program office prepares specifications / SOWs for Development contracts in conformance with the NGIPS Technical Architecture to mature technology to TRL 7 or 8
- Industry, as the module developer, is responsible for maturing the technology and “qualifying” the module through the module validation and testing standards.

NGIPS Systems Integrator

What

- Use the derived requirements from the systems engineering process, the technical architecture, and results from analysis, modeling and simulation to produce the ship specific Systems Architecture and associated module procurement specifications.
- Once the module procurement is made
  - Assist the government / ship integrator in ensuring the vendor is meeting the procurement specifications
  - Continue to validate that the Power and Propulsion system will work (and if not, what ECPs are needed to make it work)
  - Participate in component and system testing.
- Is not a decision authority for module procurement.

Who (options)

- Industry partner chosen by ship integrator for a specific ship acquisition
- Industry partner chosen by Government for a specific ship acquisition
- Industry partner(s) chosen by Government for a given period of time to serve multiple ship acquisitions.

Life Cycle Support

What

- Manage modernization of power and propulsion systems (including software support)
- Provide technical support to the Fleet and Maintenance activities
- Manage obsolescence and diminishing sources issues.
- Implement condition based maintenance monitoring.
- Improve reliability and maintainability.
- Provide feedback to the Architect

Who (options)

- NSWC
- Integrator
- PARM support contractor

NGIPS OA Business Model Wrap-up

- **Base IPS Technical Architecture on Module Performance Specifications that define "what" is needed not "how" it is designed**
  - Include precise definition of Module Boundaries
  - Include extensive use of well-defined and detailed interface specifications
  - Include well defined validation methods
- **Subdivide labor and specialization at the module or component level**
  - Compete modules (components) independently
- **Segregate roles and responsibilities for component delivery, system integration and life cycle support**
  - System Integrator does not select modules – done by Navy / Ship Integrator.
- **Include a "spiral" process to provide feedback from the evaluation of fielded systems to update architecture documentation and module designs**

NGIPS Take - Aways

- **Affordability**
  - Commonality where it makes sense
    - Fleet perspective
  - Each ship must affordably satisfy its requirements
    - Quality of Service
    - Survivability
  - NGIPS Open Architecture Business Model
- **Technical Architectures**
  - 3 Power Generation Architectures
    - MVAC – today and for ships without power density requirements
    - HFAC – Interim Step to MVDC for ships with power density requirements
    - MVDC – Goal for ships with power density requirements
  - Zonal Ship Service Distribution Architecture