Why Electric Ships

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Setting the Scene

"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

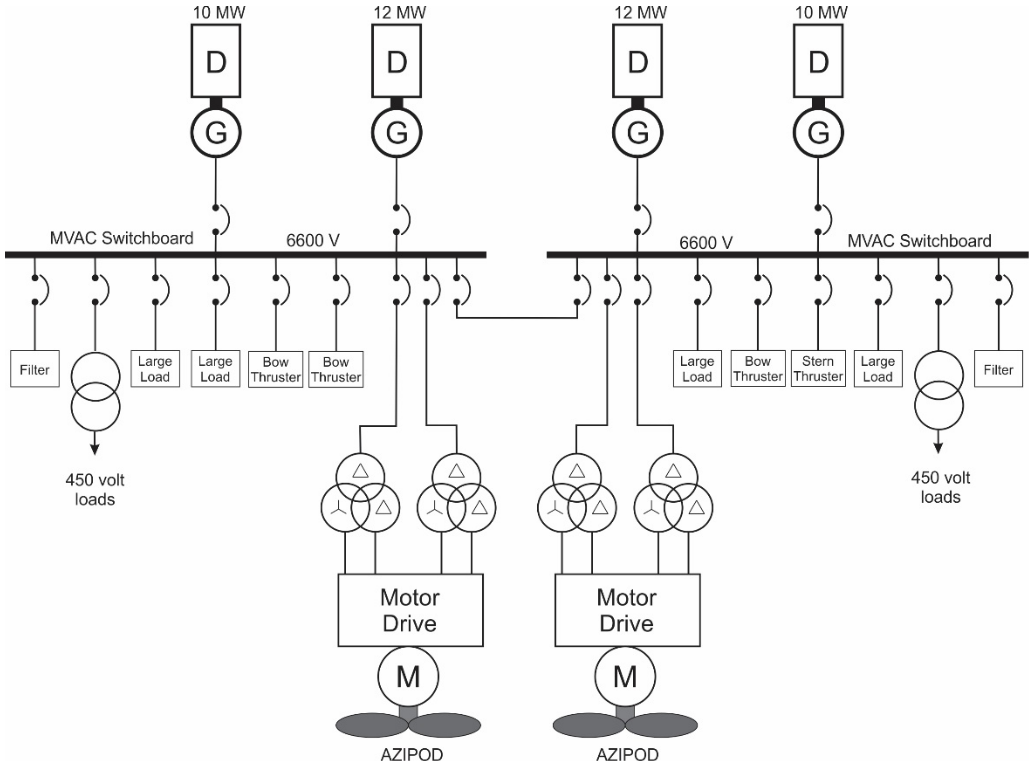
Big differences from DDG 51:

- 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

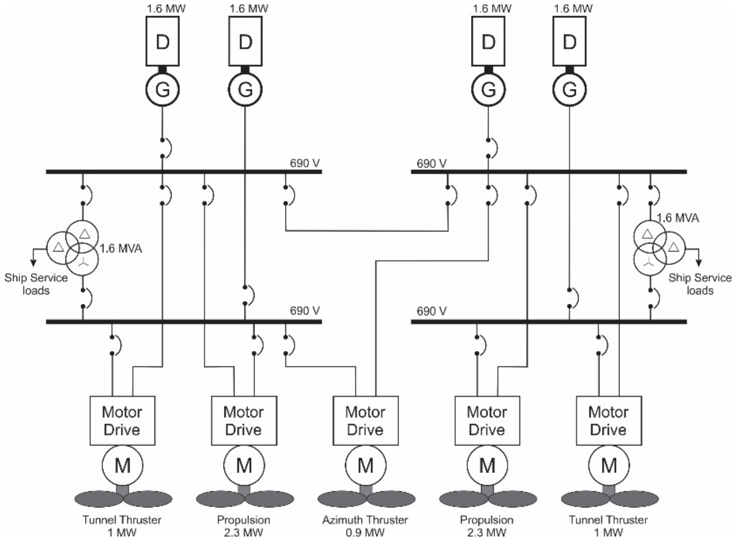
Cruise Ship

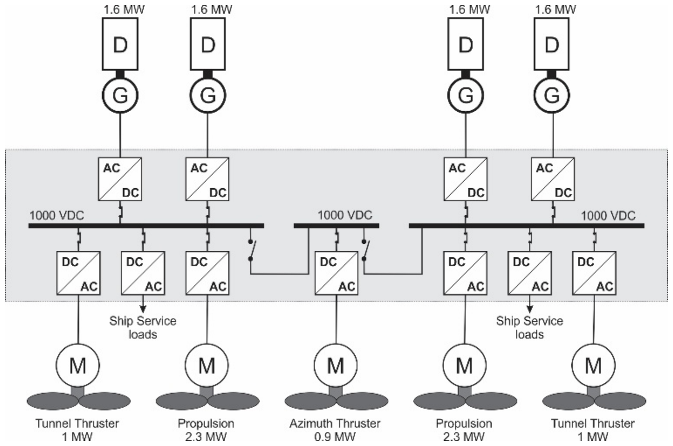
Regal Princess (Photo by Norbert Doerry)



Platform Supply Vessel

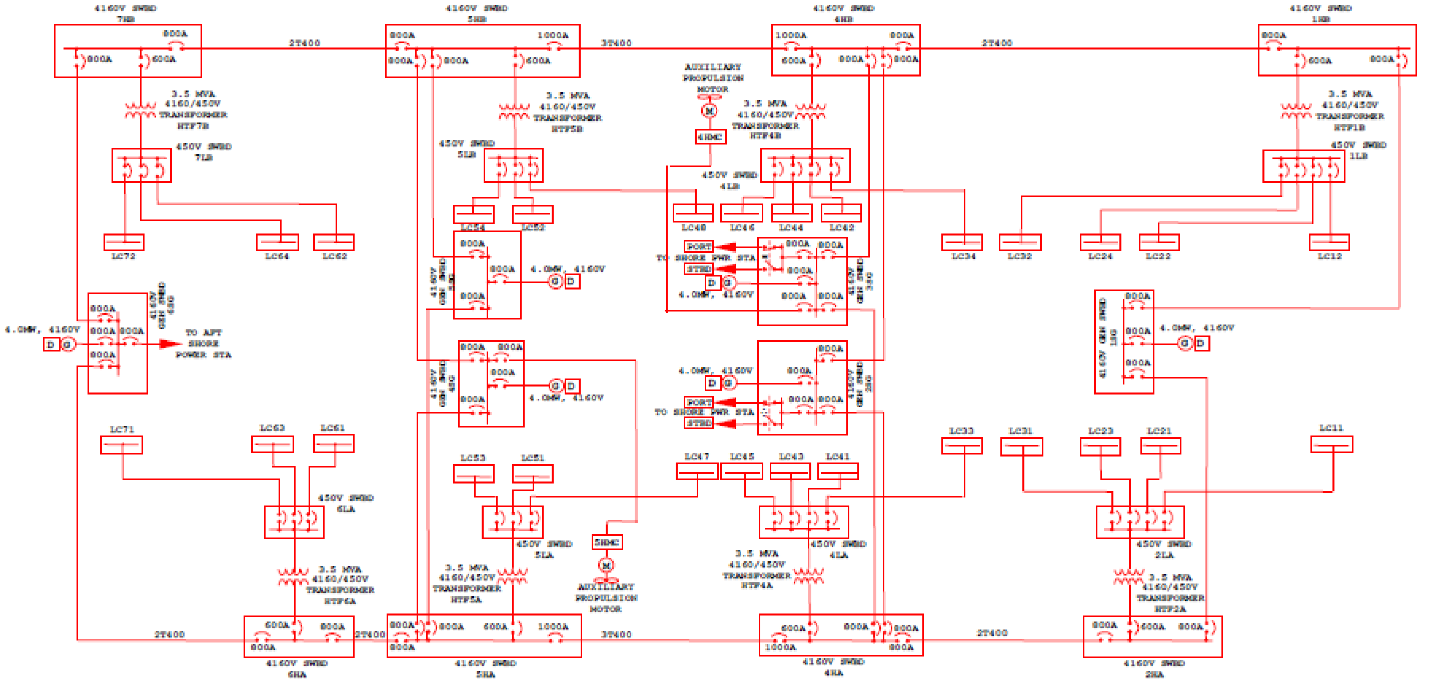
Siem Symphony
(photo by DXR: https://creativecommons.org/licenses/by-sa/4.0/)





USS Makin Island
LHD 8

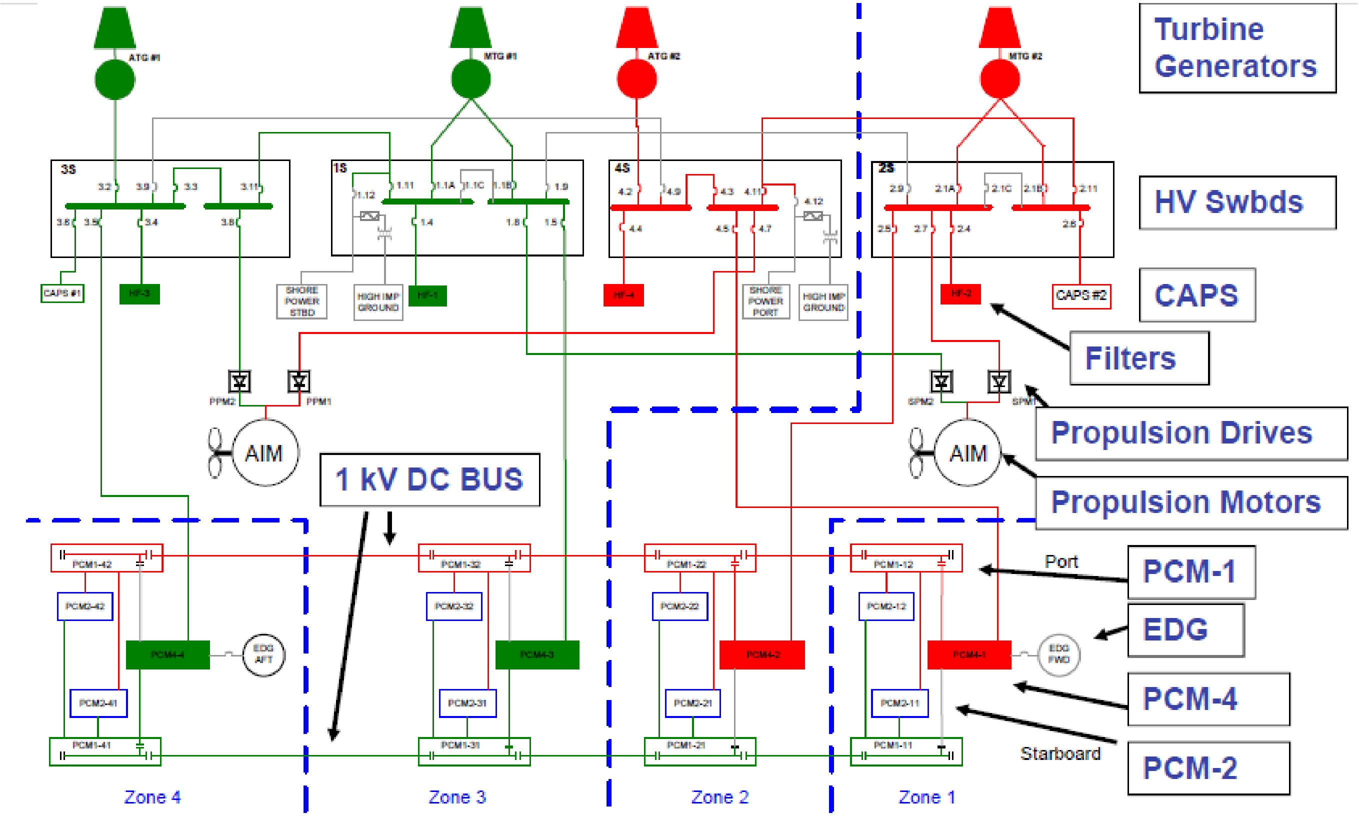

US Navy photo by Brett A. Anderson


Thomas Dalton, Abe Boughner, C. David Mako, and CDR Norbert Doerry, "LHD 8: A step Toward the All Electric Warship", presented at ASNE Day 2002.

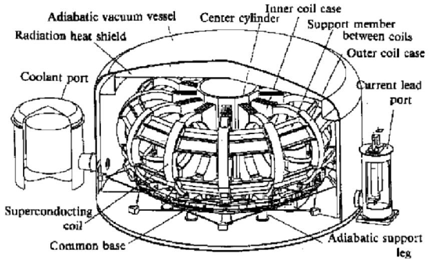
NOTES: 1) ALL LOAD CENTERS ARE 2000A
2) "*", "◆", "⊹", "✣" = INTERLOCKED
3) ALL 4160V CABLE TO BE TYPE LS5KV

USS Zumwalt DDG 1000

Sposato, Bill, “DDG 1000 Class Destroyer” Presented to U.S. Navy Port Engineers, 31 August 2011

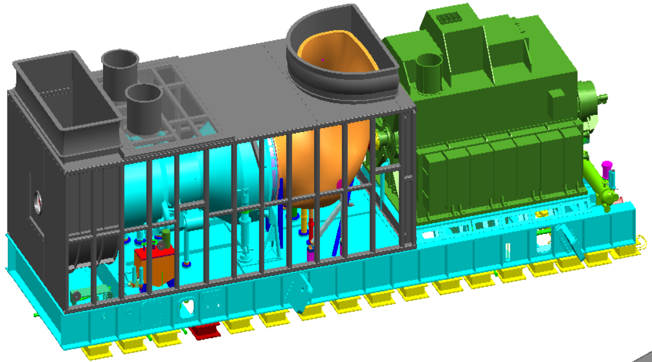


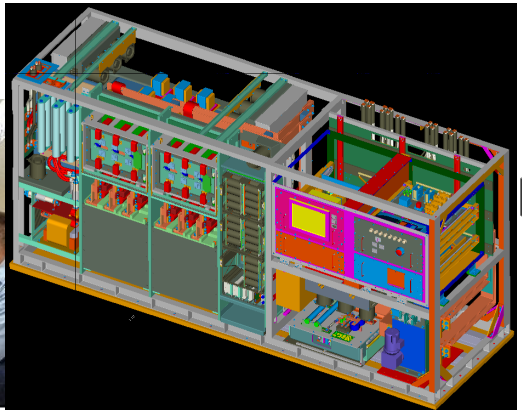
Integrated Power System (IPS)

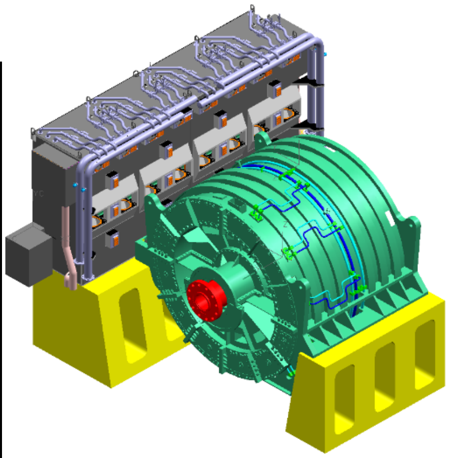


IPS consists of an architecture and a set of modules which together provide the basis for designing, procuring, and supporting marine power systems applicable over a broad range of ship types:

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







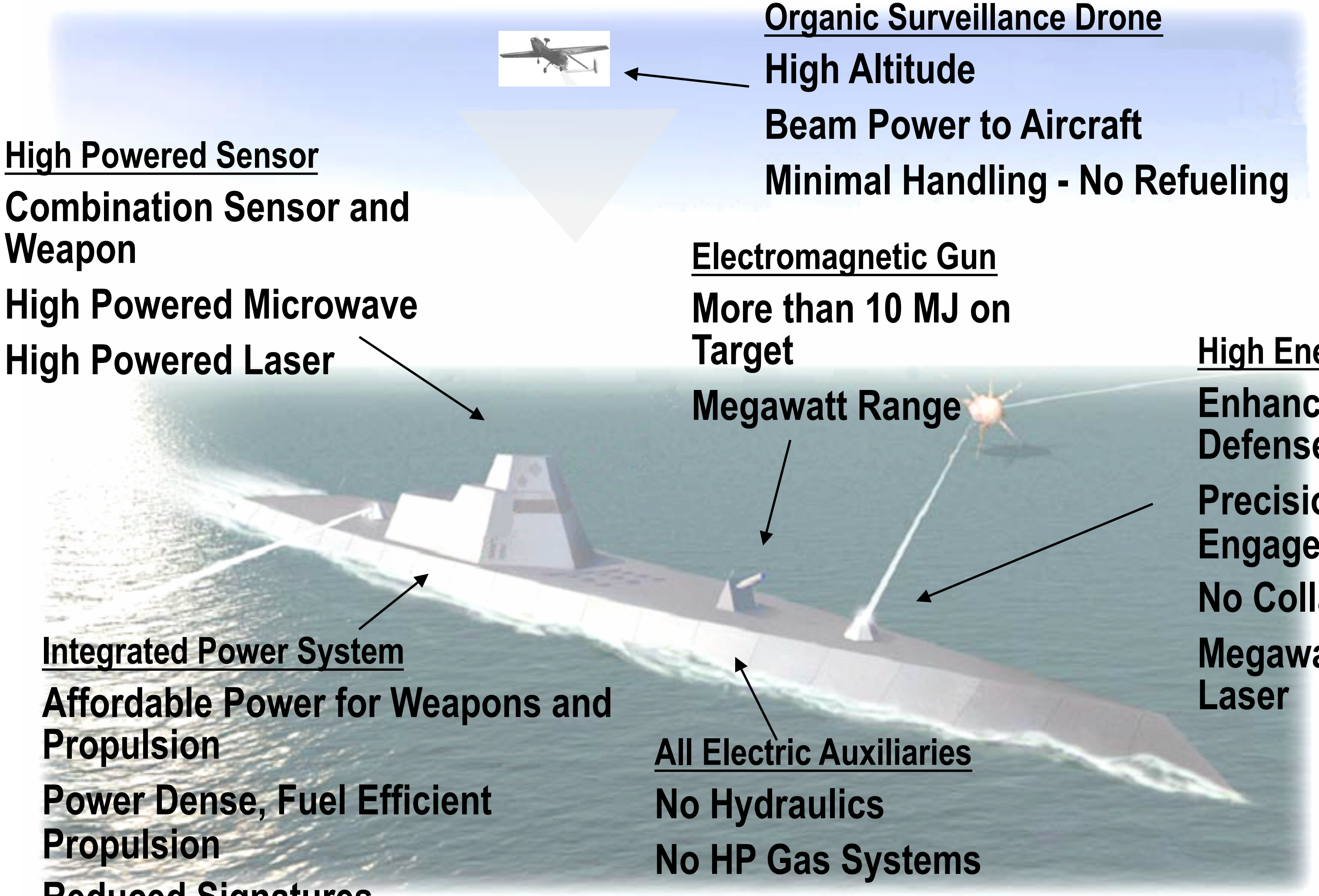
IPS Architecture

- 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).

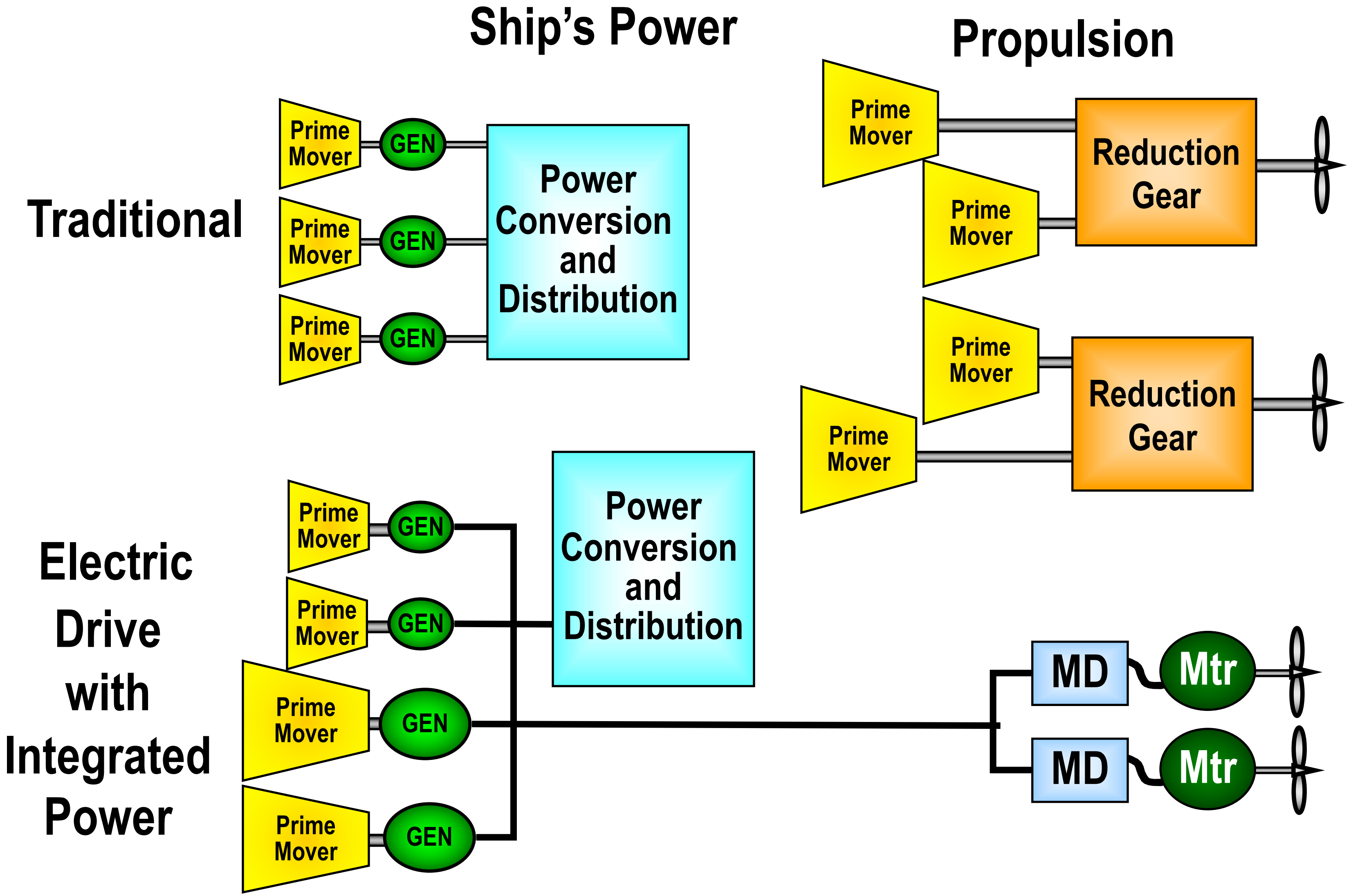
IPS Design Opportunities

- Support High Power Mission Systems
- Reduce Number of Prime Movers
- Improve System Efficiency
- Provide General Arrangements Flexibility
- Improve Ship Producibility
- Support Zonal Survivability
- Facilitate Fuel Cell Integration

Support High Power Mission Systems



Reduce Number of Prime Movers



Improve System Efficiency

- A generator, motor drive and motor will generally be less efficient than a reduction gear ….
- But electric drive enables the prime mover and propulsor to be more efficient, as well as reducing drag.

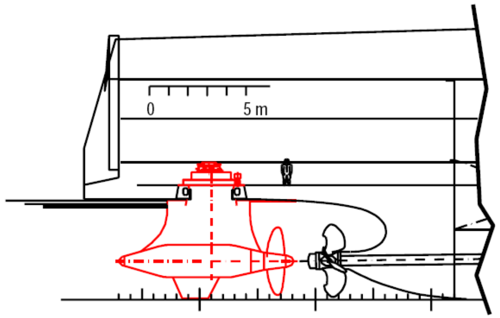
	Mechanical Drive	Electric Drive
Gas Turbine	30%	35%
Reduction Gear	99%	
Generator		96%
Drive		95%
Motor		98%
Propeller	70%	75%
Relative Drag Coefficient	100%	97%
Total	21%	24%
Ratio		116%

Representative values: not universally true

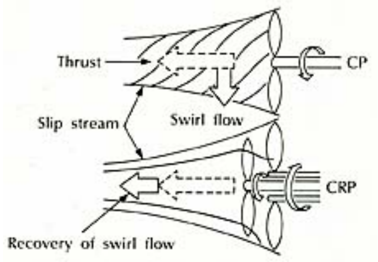
TRADE TRANSMISSION EFFICIENCY TO REDUCE DRAG
AND IMPROVE PRIME MOVER AND PROPELLER EFFICIENCY

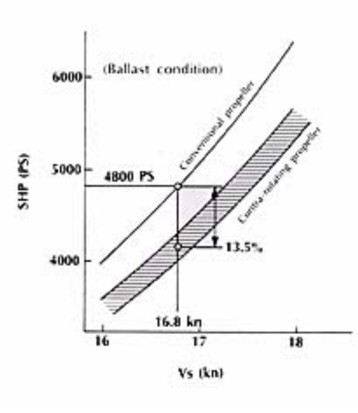
Improve System Efficiency: Contra-Rotating Propellers

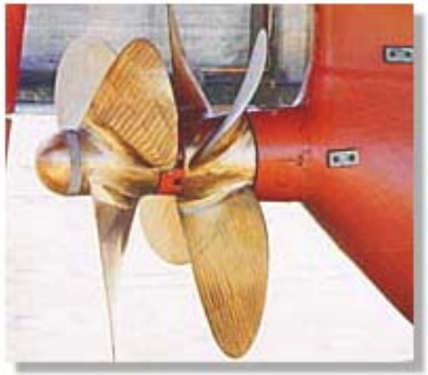
- Increased Efficiency
  - Recover Swirl Flow
  - 10 – 15% improvement
- Requires special bearings for inner shaft if using common shaft line
- Recent examples feature Pod for aft propeller



Anders Backlund and Jukka Kuuskoski,
"The Contra Rotating Propeller (CRP) Concept with a Podded Drive"



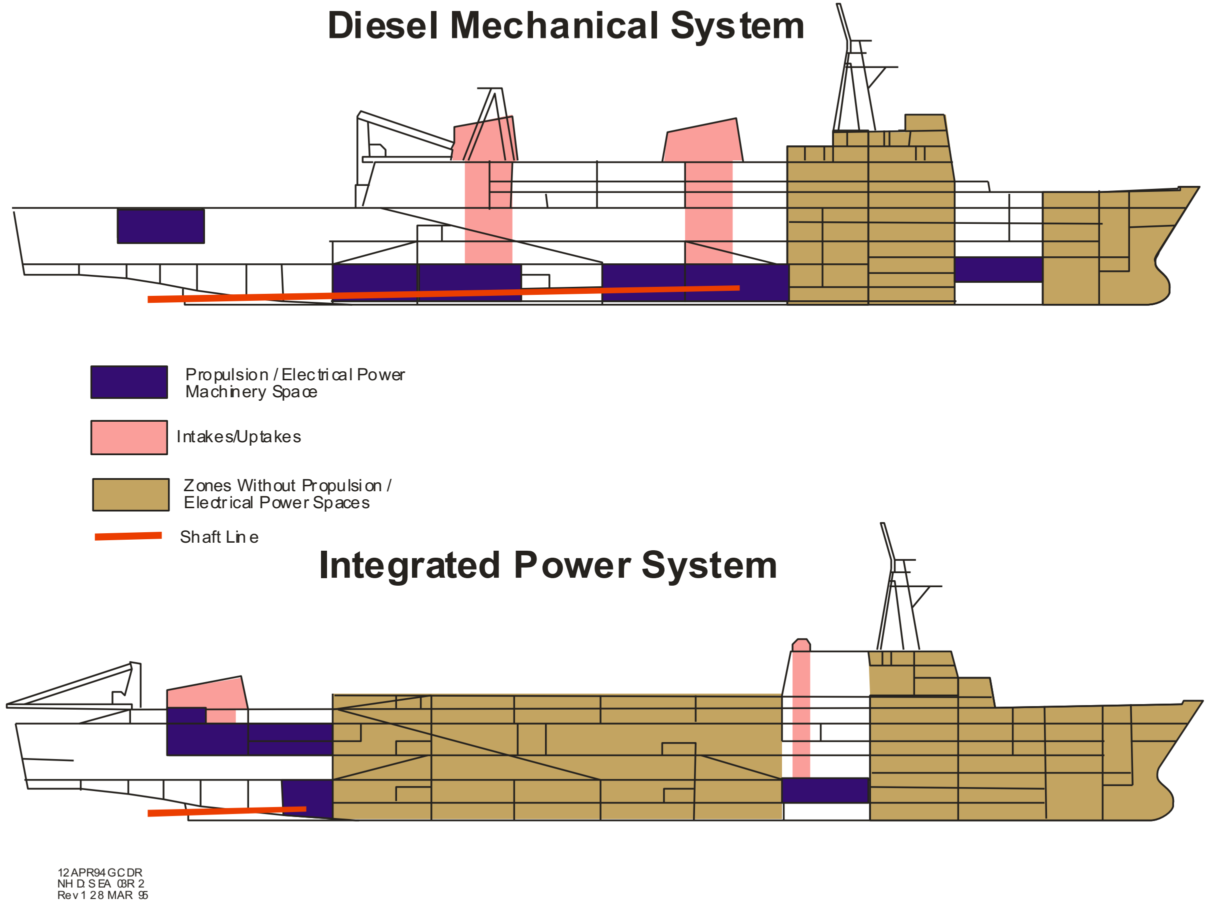




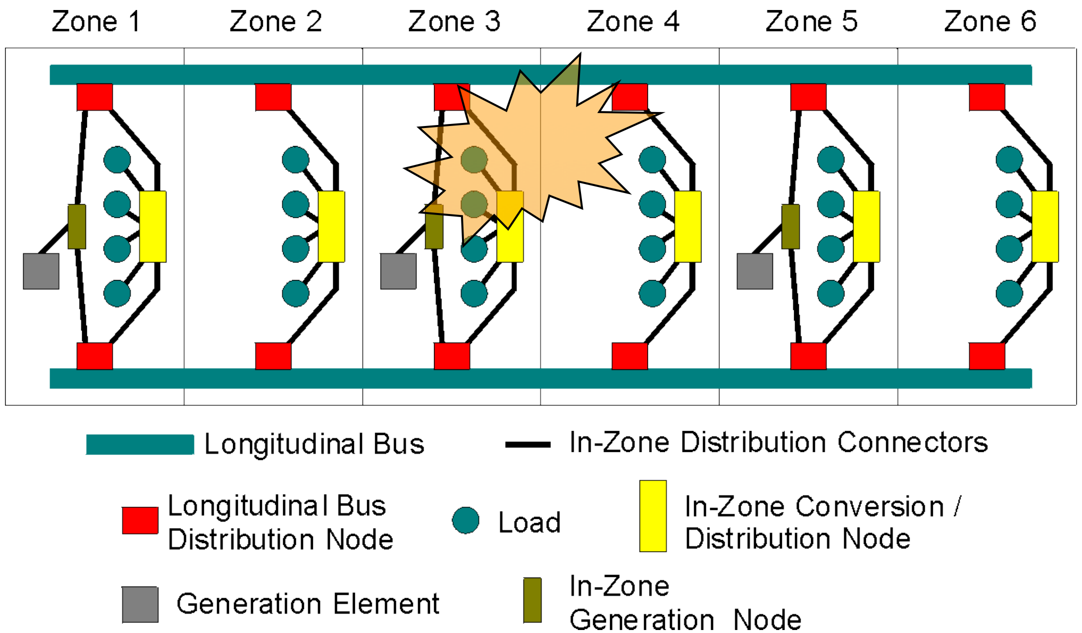
http://www.mhi.co.jp/ship/english/htm/crp01.htm

General Arrangements Flexibility Improve Ship Producibility

- Vertical Stacking of Propulsion Components
- Pods
- Athwart ship Engine Mounting
- Horizontal Engine Foundation
- Engines in Superstructure
- Distributed Propulsion
- Small Engineering Spaces



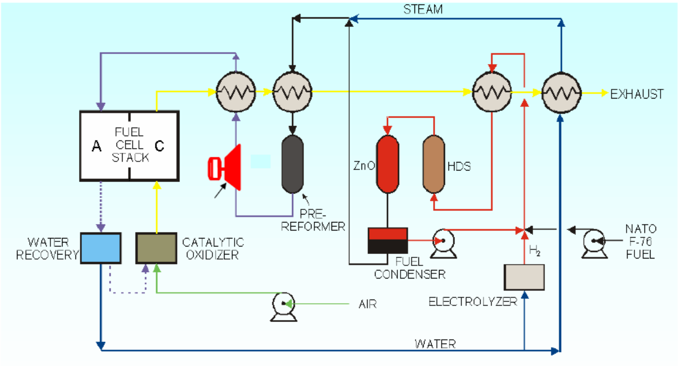
Support Zonal Survivability

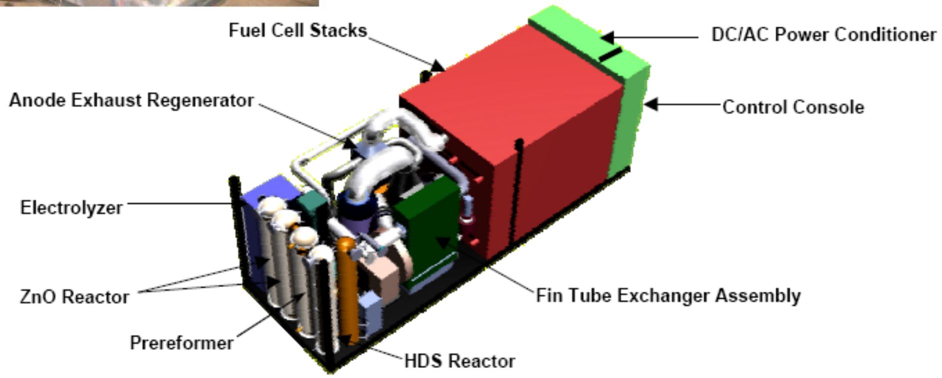


- Zonal Survivability is the ability of a distributed system, when experiencing internal faults, to ensure loads in undamaged zones do not experience a service interruption.
  - Sometimes applied to only Vital Loads.
  - Usually requires one longitudinal bus to survive damage.
- Limits damage propagation to the fewest number of zones.
  - Enables concentration of Damage Control / Recoverability Efforts.

Facilitate Fuel Cell Integration

- Many Advantages
  - Highly Efficient (35-60%)
  - No Dedicated intakes-uptakes; use ventilation
- Challenges
  - Reforming Fuel into Hydrogen – Onboard Chemical Plant.
  - Eliminating Sulfur from fuels.
  - Slow Dynamic Response – Requires Energy storage to balance generation and load
  - Slow Startup – Best used for base-loads





FuelCell Energy 625kW 450V, 3ϕ, 60 HZ, MC SSFC Power System

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