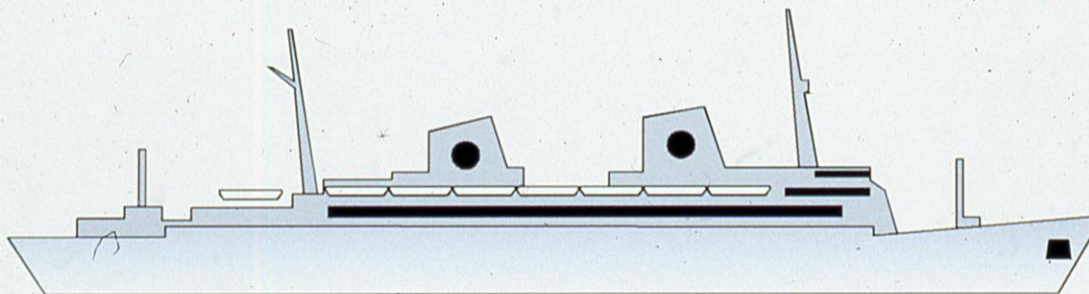
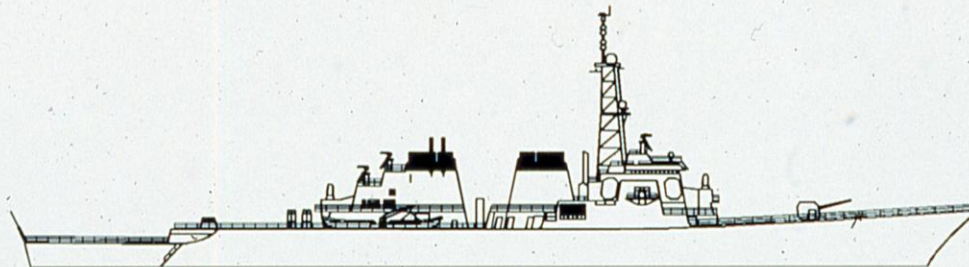


INTEGRATED POWER SYSTEM FOR MARINE APPLICATIONS

April 28, 1994



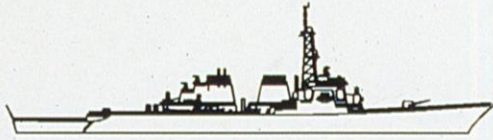
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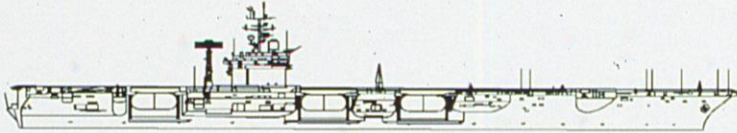
INTEGRATED POWER SYSTEM (IPS)

- **Power System Architecture for**
 - Electrical Power Generation, Distribution, Conversion, Storage and Control.
 - Propulsion Motors. (Integrated Electric Drive)
 - Other Electrical Loads.
- **Family of Modules**
 - “Building Blocks” for designing, procuring, and supporting marine power systems.
 - Applicable across a broad range of ship types.

IPS Range of Application



Surface Combatants



Tactical Aviation Platforms



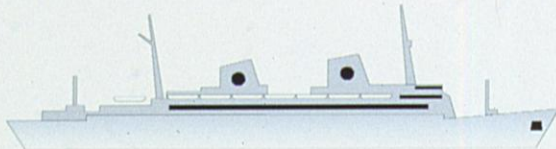
Submarines



Amphibious Ships



Sea Lift Ships



Commercial Marine

IPS GOAL

A Power System **Architecture** and Family of **Modules** which significantly reduce acquisition and life cycle **costs** in commercial marine and naval applications while meeting all **performance** requirements.

IPS Affordability Initiatives

1. Extend Architectural Advantage
2. Exploit Producibility
3. Reduce Component Cost
4. Reduce Energy Cost
5. Promote Commonality
6. Reduce Infrastructure
7. Reduce Manning
8. Reduce Combat System Cost

MUST ATTACK COST FROM ALL DIRECTIONS

IPS Approach

- Use common prime movers to generate **electricity** for both **propulsion** and **ship service power**.
- Use and exploit **zonal** architectures.
- Use common, pre-tested, pre-outfitted, and individually procured **modules**.
- Use **common** submodules and components.
- Use **dual-use** components, modules, and architectures.
- Exploit new **technology**.
- Maximize **engineering re-use**.

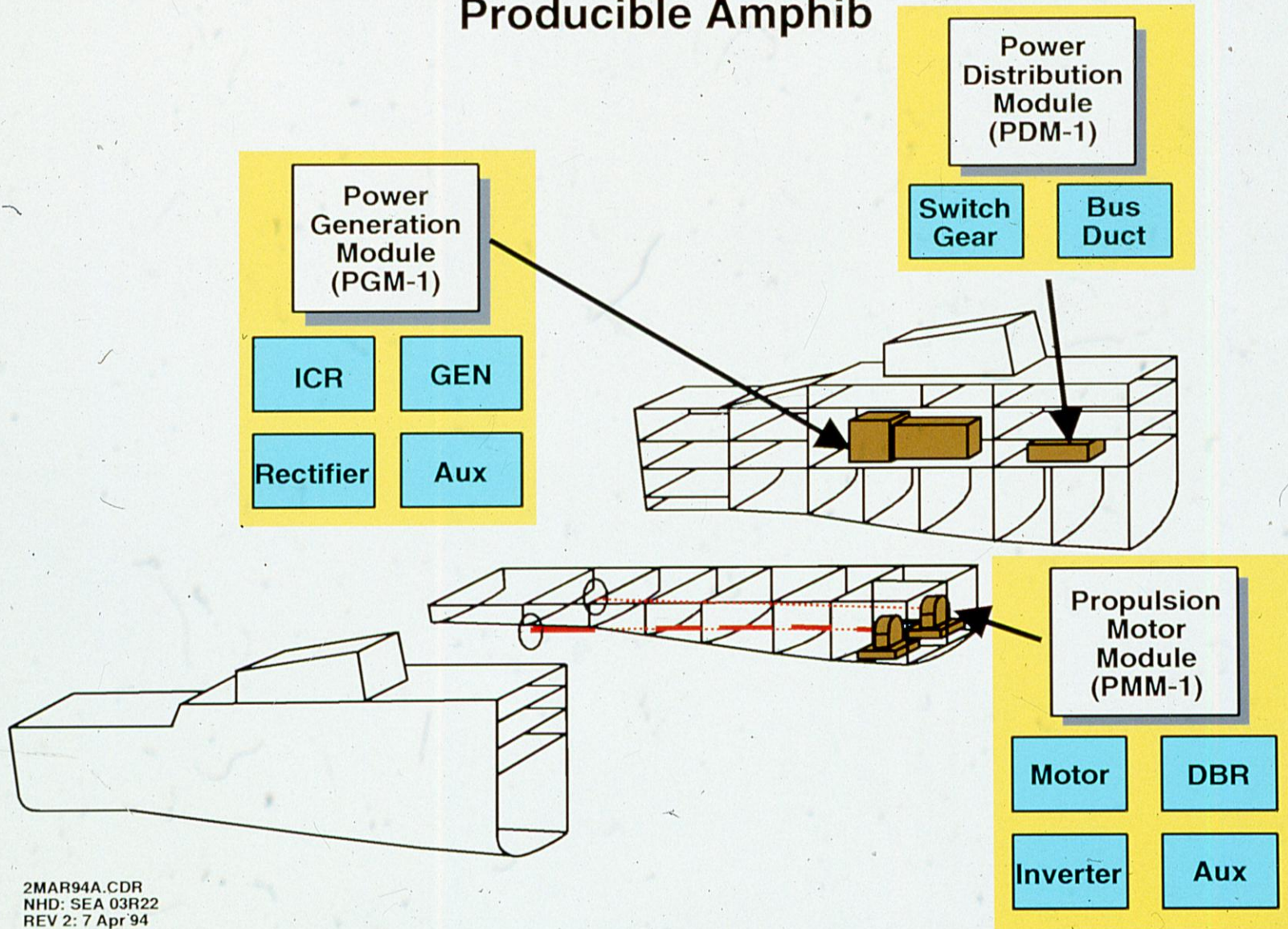
WHY ELECTRIC DRIVE?

- **Extends Architectural Advantage**
 - Flexibility in locating prime movers.
 - Potential to reduce volume for intakes/exhaust.
- **Exploits Producibility**
 - Short shafts.
 - Vertical integration of propulsion equipment.
- **Reduces Component Cost**
 - Eliminate prime movers.
- **Reduces Energy Cost**
 - “Power Station” concept.
 - Use the most efficient prime movers for existing operational conditions.

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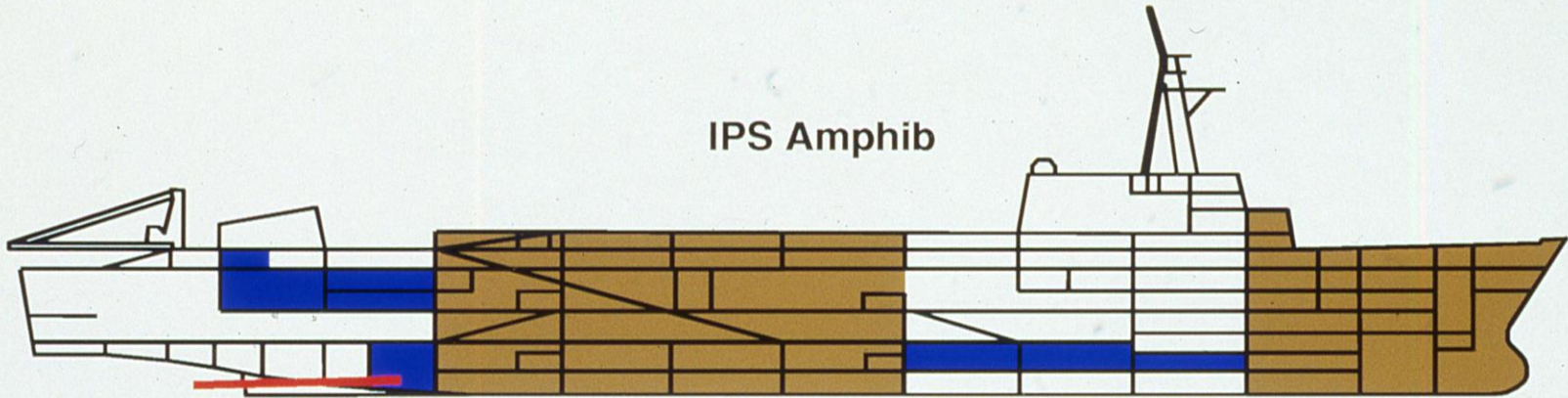
Extend Architectural Advantage

Producible Amphib



Exploit Producibility

IPS Amphib

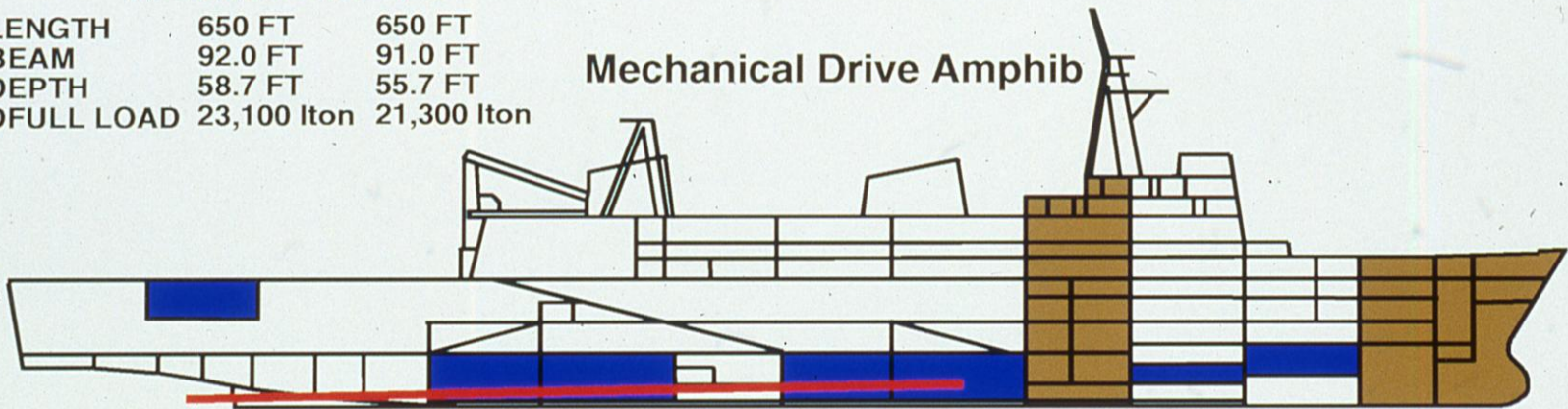


CHARACTERISTICS

Mechanical Drive IPS

LENGTH	650 FT	650 FT
BEAM	92.0 FT	91.0 FT
DEPTH	58.7 FT	55.7 FT
DFULL LOAD	23,100 lton	21,300 lton

Mechanical Drive Amphib

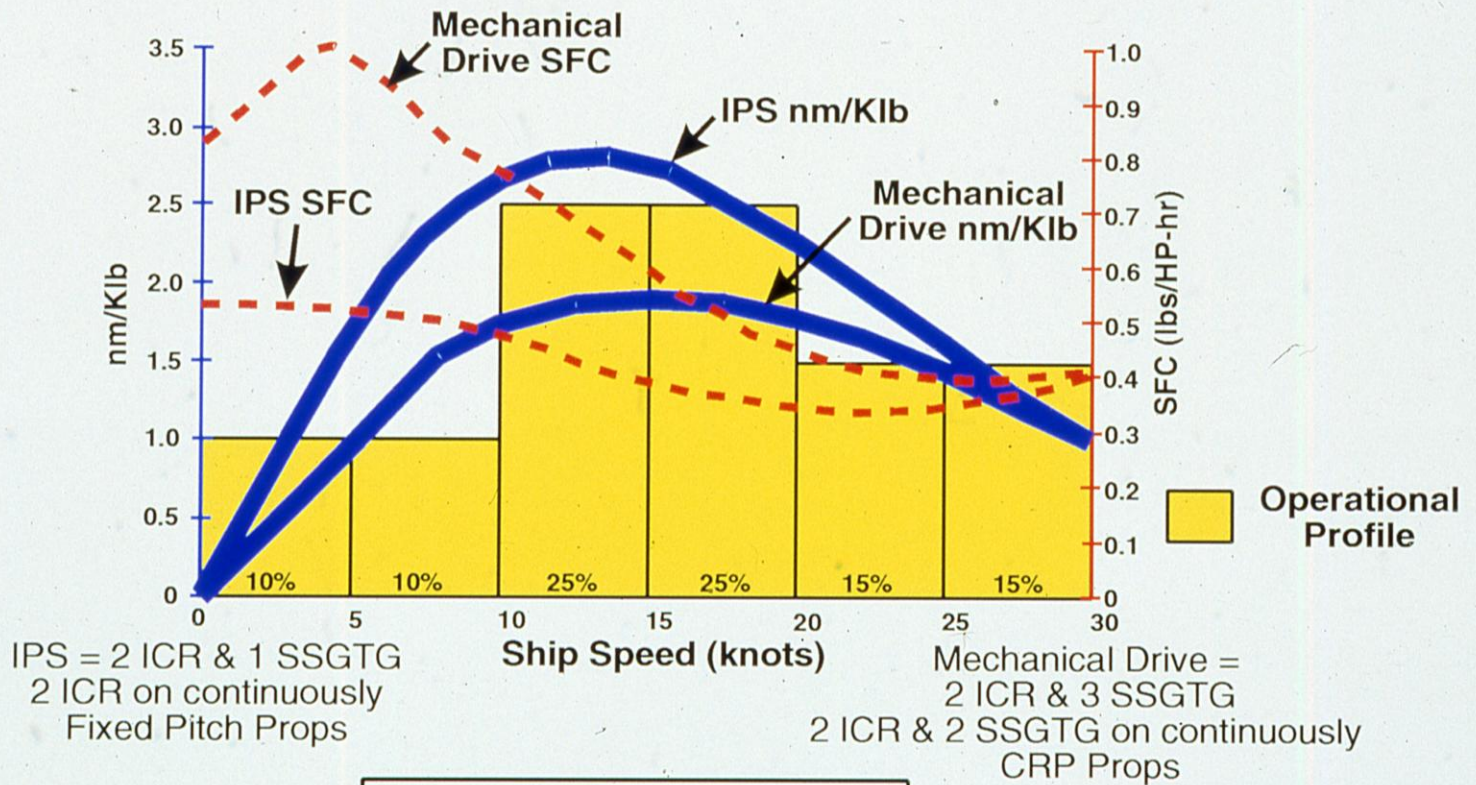


**Short Shaft Lines
Vertical Integration**

- Zones without machinery spaces
- Machinery Space
- Shaft Line

REDUCE ENERGY COST

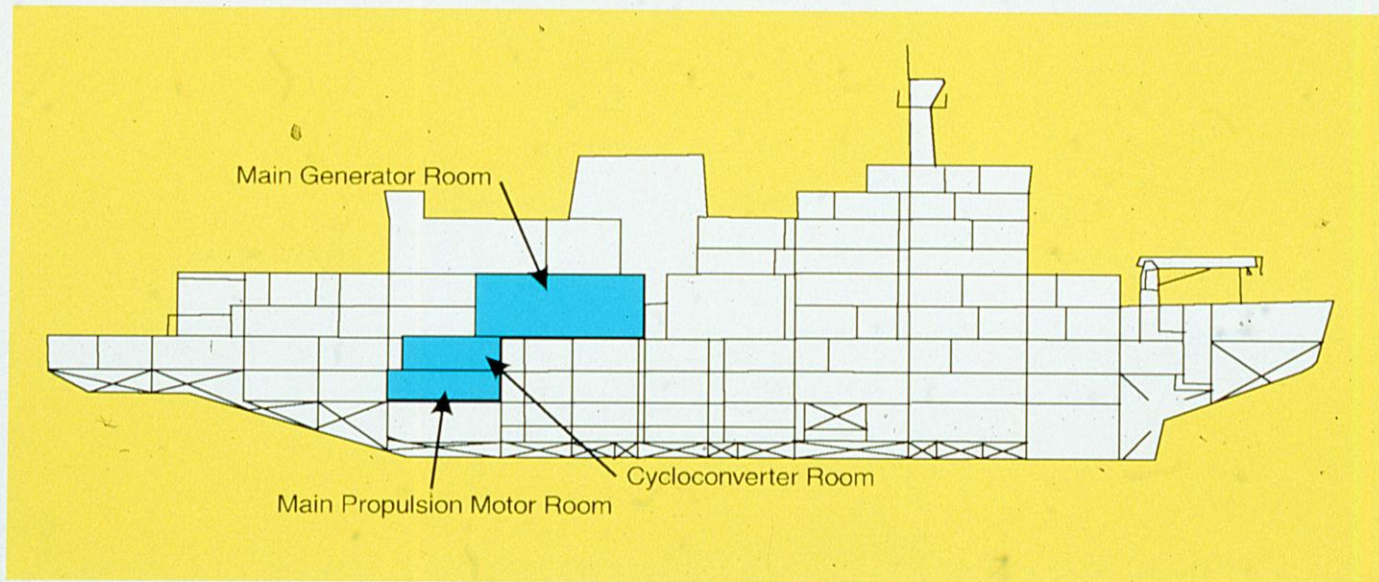
IPS vs. Mechanical Drive



18% Fuel Savings

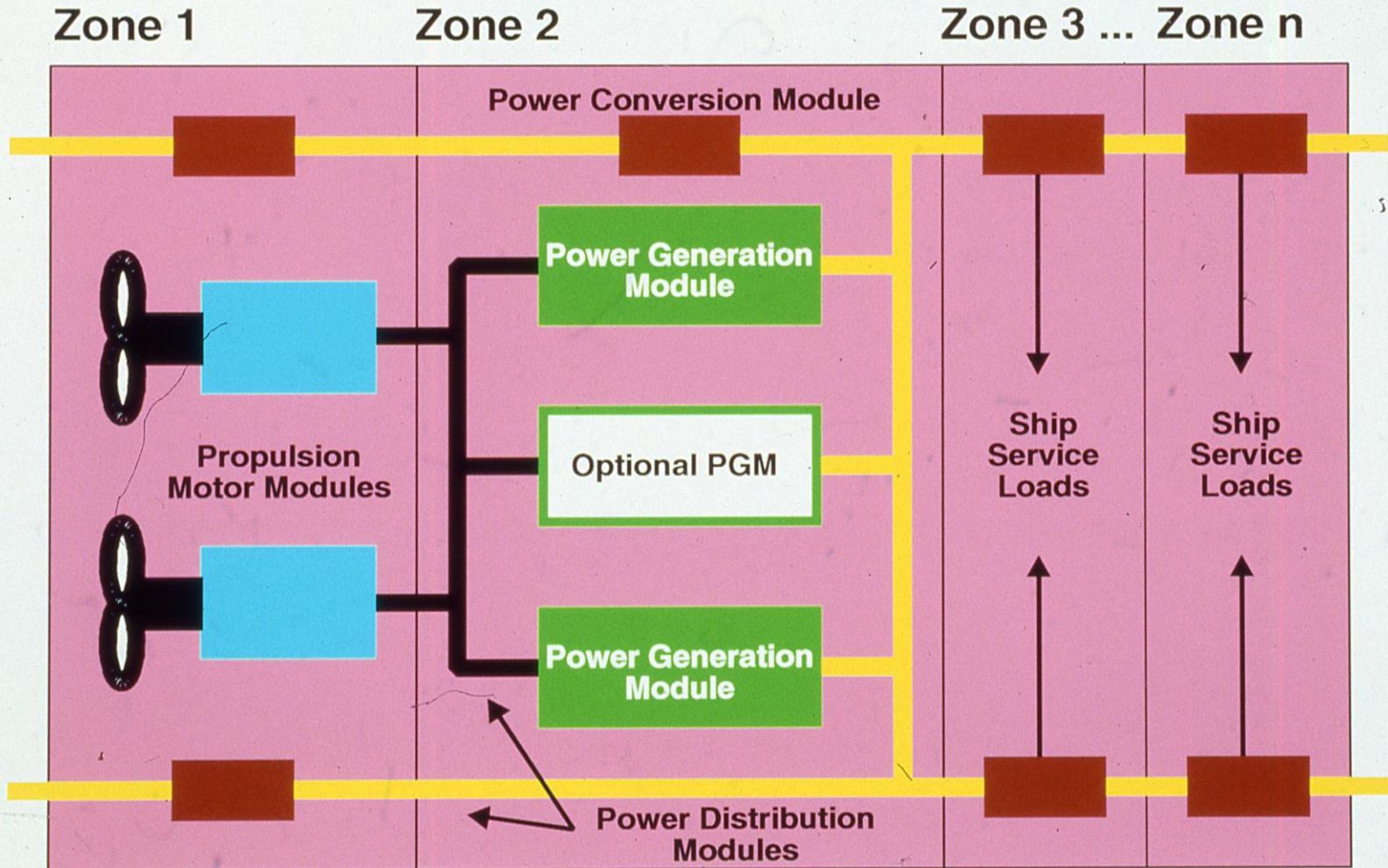
Naval Architecture Flexibility

WAGB-20 Polar Ice Breaker



Exploiting Electric Drive Flexibility is not new.

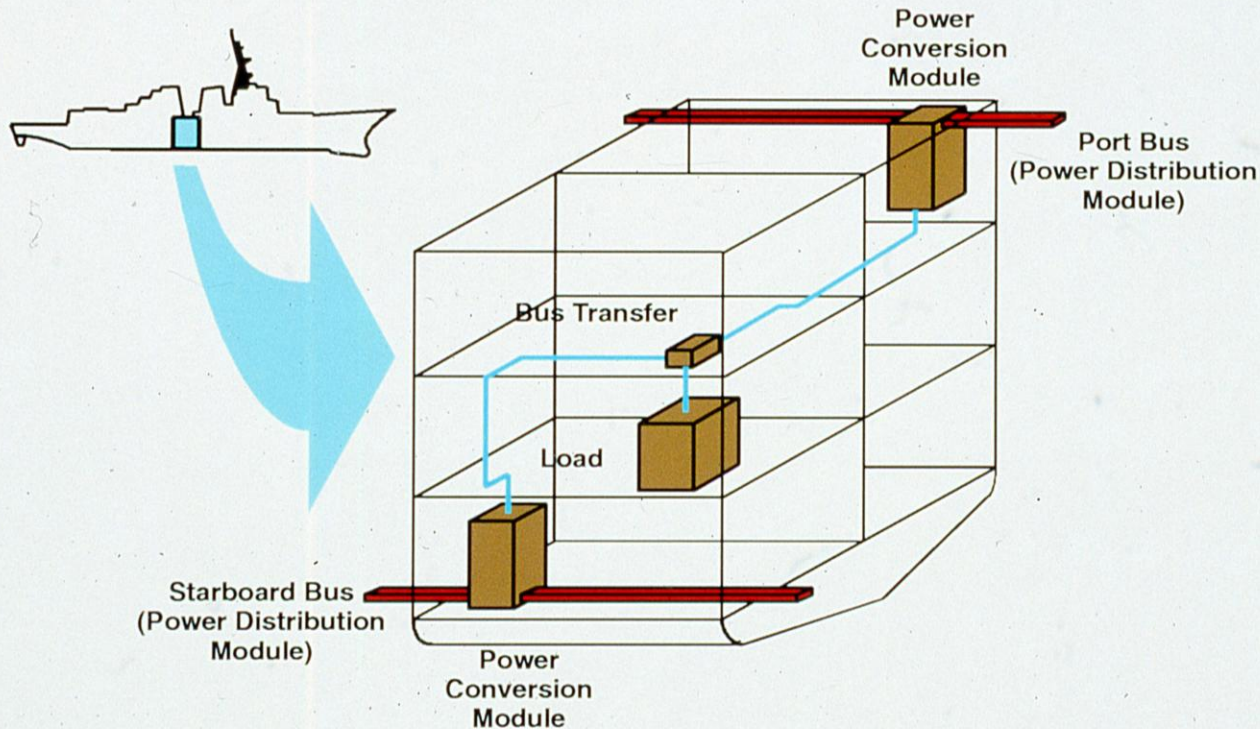
IPS Building Blocks



Flexible & Scalable Power System

Zonal Electrical Distribution

Within Zone Distribution



**Reduce / Simplify Distributed Systems
Crossing Ship Construction Boundaries**

MODULE DEFINITION

- A set of equipment and/or software fulfilling one of the following functions:
 - Power Generation
 - Power Distribution
 - Power Conversion
 - Energy Storage
 - Power Load
 - » Includes Propulsion Motors
 - System Control
- Composed of:
 - Submodules: Equipment mounted on a sub-base
 - Packages: Equipment not mounted on a sub-base.

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Common Modules vs Packaging

There is a difference between:

- (a) Packaging what is out there into modules.

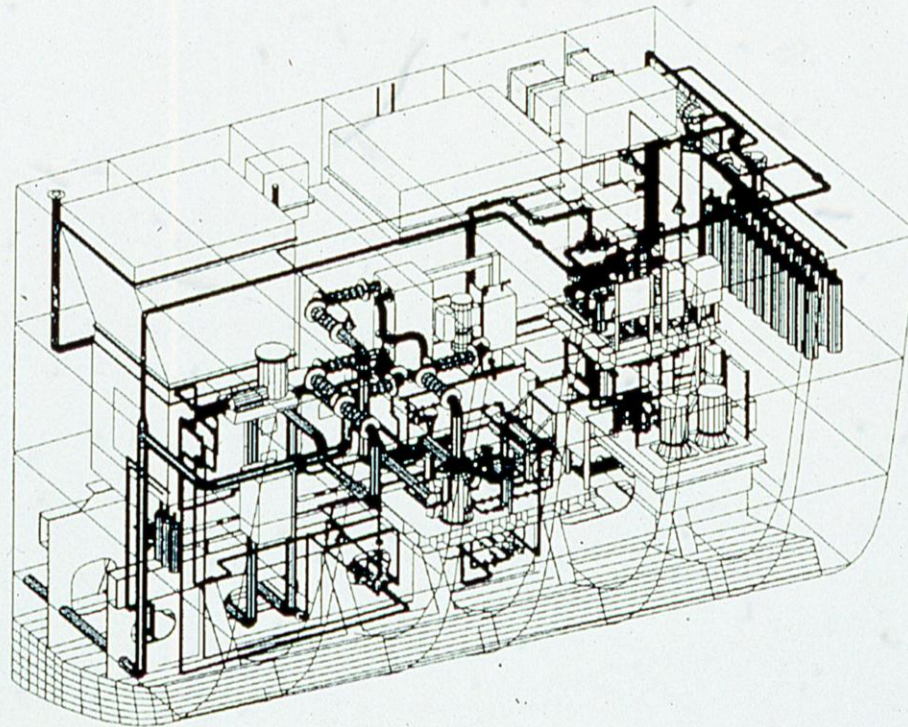
- (b) Creating a standard set of common modules that could be used by all shipyards on all ships.

IPS uses common modules.

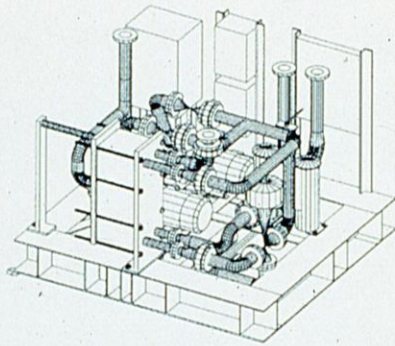
Power Generation Module

Intercooled Recuperated (ICR) Gas Turbine

22 MW Permanent Magnet (PM) Generator

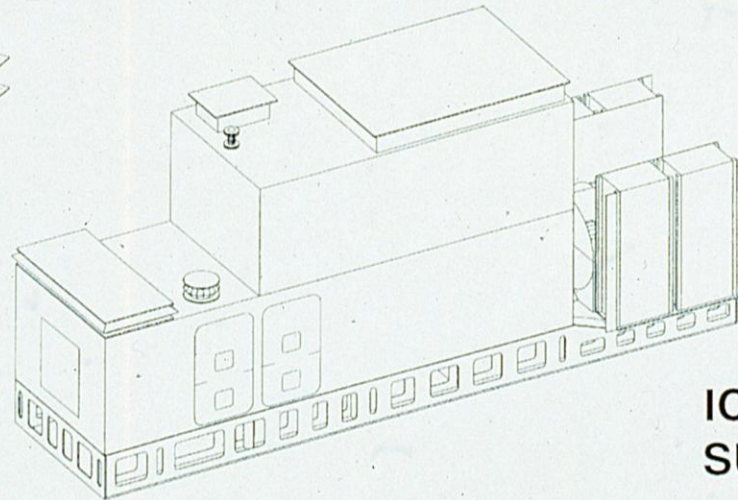
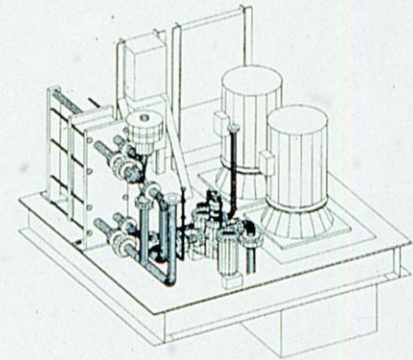


SUBMODULES



**FUEL OIL
SUBMODULE**

**LUBE OIL
SUBMODULE**

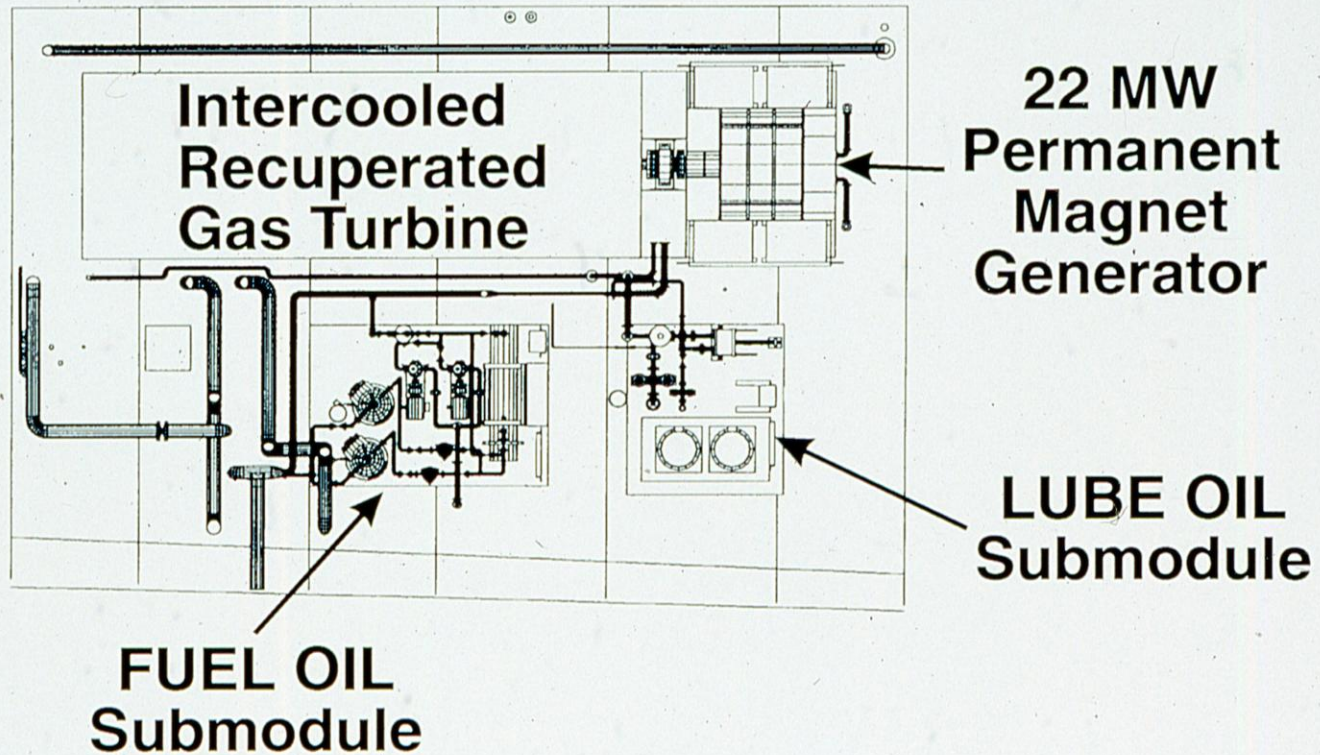


**ICR GENSET
SUBMODULE**

**EQUIPMENT MOUNTED
ON A COMMON SUB-BASE**

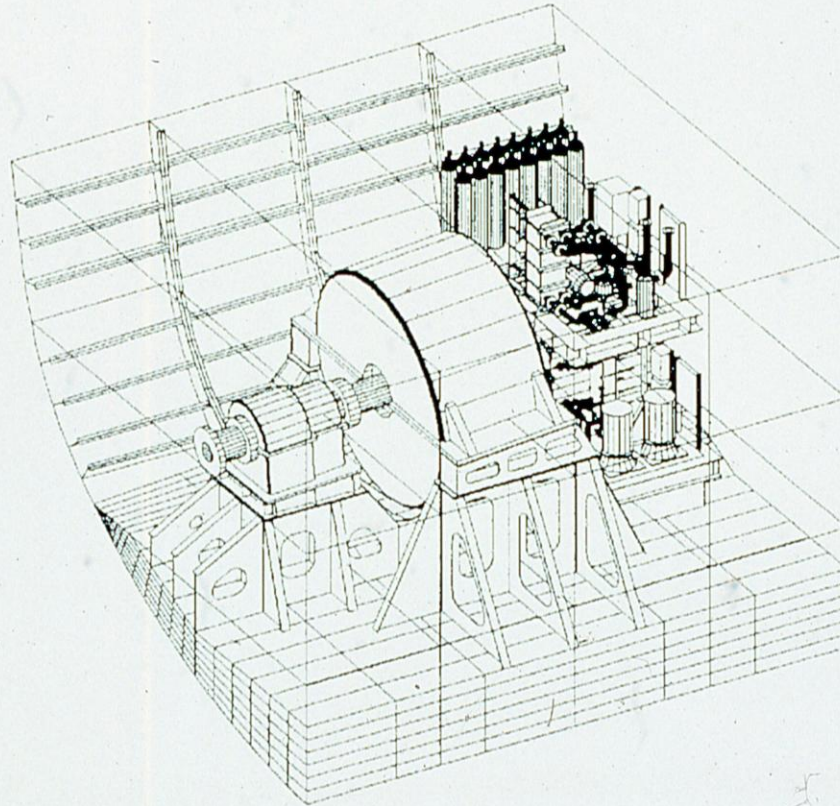
POWER GENERATION MODULE

INTERMEDIATE LEVEL -- PLAN VIEW



Propulsion Motor Module

30 MW 150 RPM Permanent Magnet Motor



Module Interface Standards

- **Interface Types**

- Module to Module interfaces.
- Module to External System interfaces.
- Module to Human Operator.

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- **Interface Properties**

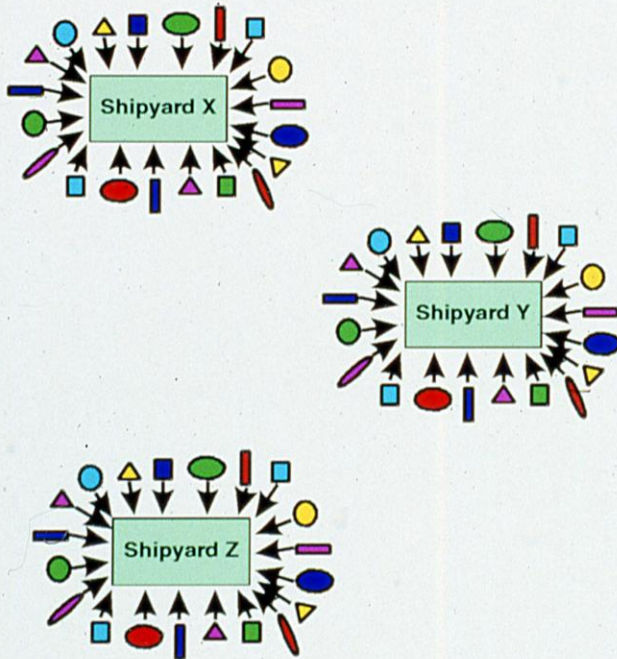
- Emphasis on Power and Control System interfaces.
- Technology independent.
- Reflect an Open Architecture.

- **Why?**

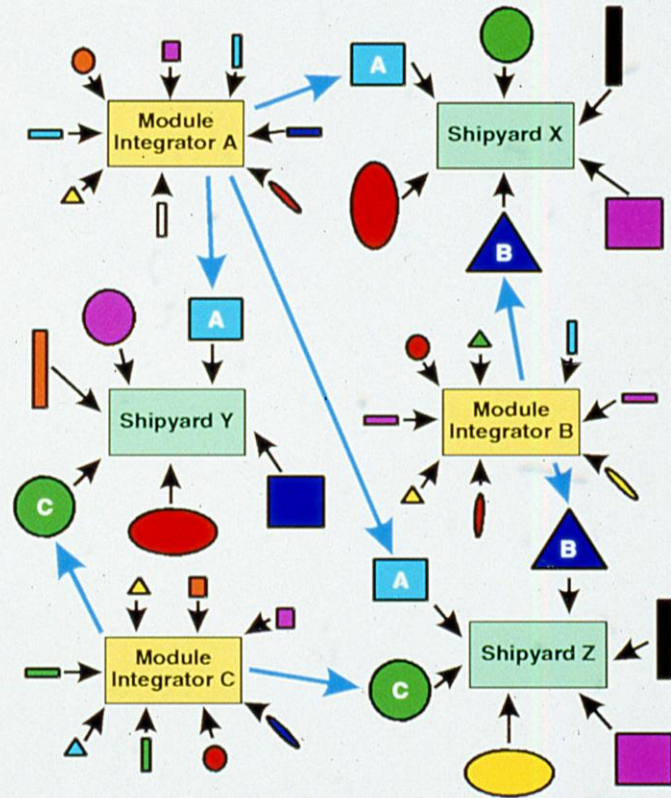
- Divorce module design from system/ship design.
- Facilitate competition by enabling modules from multiple vendors to work together.
- Reduce system impact of new technology insertion.

MODULE / SHIP INTEGRATION

TODAY



IPS



COMMON MODULES USE COMMON PROCESS LANES

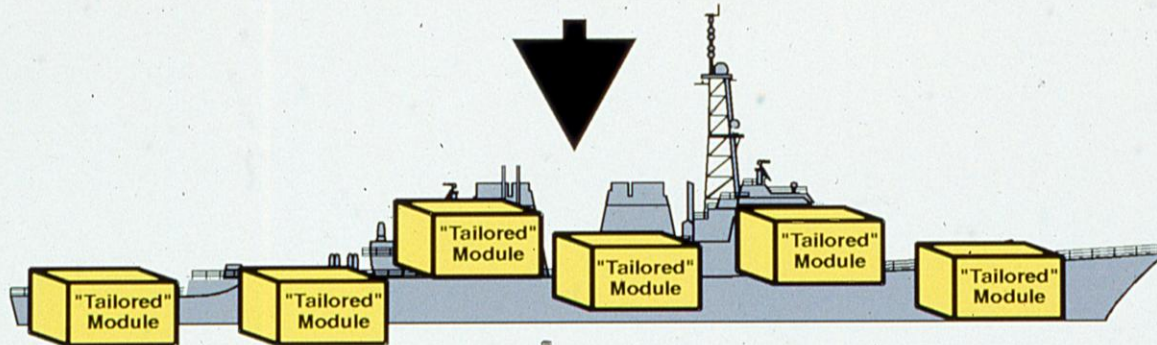
IPS SYSTEMS INTEGRATION

- Vessel Hull Form
- Rated Speed
- Endurance
- Ship Service Loads
- Special Loads
- Shock Requirements
- Acoustic Requirements

REQUIREMENTS

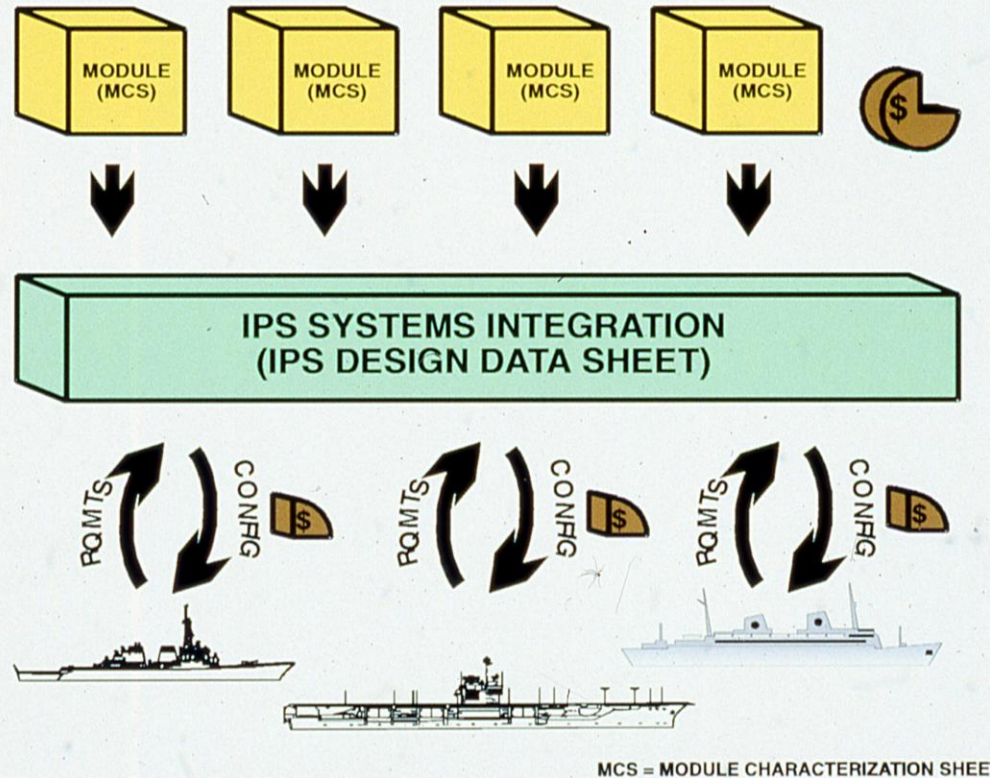
1. Extend Architectural Advantage
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SYSTEMS INTEGRATION



"Tailoring" ensures Performance Requirements are met

ENGINEERING RE-USE



**Reduce Ship Design Systems Engineering
Re-use Module Systems Engineering**

IPS Affordability

- **Small Combatant Cost Study**
 - Cost Delta model comparing Mechanical Drive small combatant with IPS combatant
 - **Mechanical Drive**
 - » 2 ICR Gas Turbines
 - » 3 Ship Service Gas Turbine Generator (SSGTG) sets
 - » CRP propellers
 - **IPS**
 - » 2 ICR/PM Power Generation Modules
 - » 1 SSGTG based Power Generation Module
 - » Fixed Pitch propellers

\$20-26M Acquisition Cost Savings
\$.85M Operating & Support Cost Savings

Acquisition Cost Savings

- **Component Cost: \$2.4 M Savings**
 - Largely resulted from burdened cost of Ship Service Gas Turbine Generator sets.
 - \$8.7 M savings possible with use of advanced power semi-conductor devices (MCTs)
- **Ship Impact Cost: \$10.4 M Savings**
 - Calculated from ASSET Generated SWBS weights and Cost Estimation Relationships (CERs)
- **Ship Producibility Cost: \$7.0 M Savings**
 - Calculated as percentage of Ship End Cost based on projections by several shipyards.

\$20 to 26 M Savings for each ship

Operating and Support Cost Savings

- **Manning Cost: \$0.25 M Annual Savings**
 - Reduce Engineering Department manning from 52 to 45.
- **Fuel Cost: \$0.60 M Annual Savings**
- **Maintenance Cost**
 - Savings probable with reduction of Ship Service Gas Turbine Generator sets.
- **Training**
 - Savings probable when IPS is used across multiple ship classes.

\$0.85M Annual savings for each ship

AFFORDABILITY REPORT CARD

1. Extend Architectural Advantage
 - \$10.4M Ship impact acquisition cost savings per ship.
2. Exploit Producibility
 - \$7.0M Acquisition cost savings per ship.
3. Reduce Component Cost
 - \$2.4M acquisition cost savings per ship.
4. Reduce Energy Cost
 - \$0.60M Annual savings per ship.
5. Promote Commonality
 - TBD
6. Reduce Infrastructure
 - TBD
7. Reduce Manning
 - \$0.25M Annual savings per ship.
8. Reduce Combat System Cost
 - TBD

CONCLUSION

IPS =
AFFORDABLE
MARINE
POWER SYSTEMS