Institutionalizing Modular Adaptable Ship Technologies

ASNE Tysons-Carderock Chapter Technical Dinner Presentation
July 19, 2011

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Observations

- Combat System Development vs. Ship Design and Construction

Attribute	Combat Systems	Ship Design & Construction
Timeline	Short	Long
Expertise required	Electronics, software	HM&E, Hardware
Configuration	Volatile	Stable
Effect on *Design* Ship Service Life	Little influence	Strong driver
Effect on *Actual* Ship Service Life	Strong driver – can't cost effectively update	Moderate driver – Ships decommissioned early

- Affordability will become increasingly important.

MODULAR ADAPTABLE SHIP TECHNOLOGIES ENABLE SHIPS TO AFFORDABLY REMAIN OPERATIONALLY RELEVANT OVER THEIR SERVICE LIFE

MODULAR ADAPTABLE SHIP TECHNOLOGIES ARE NOT YET AN INSTUTIONAL PART OF OUR DESIGN AND MODERNIZATION PROCESSES

Agenda

- Criteria for Modular Adaptable Ship (MAS) Technology Maturity
- MAS Technology Developments
- Criteria for MAS Process Maturity
- MAS Engineering and Acquisition Process Developments
- Modular Adaptable Ship Applications

EVALUATE READINESS TO TRANSITION MODULAR ADAPTABLE SHIP TECHNOLOGIES AND PROCESSES TO A SHIP DESIGN

IDENTIFY WORK NEEDED TO INSTITUTIONALIZE MODULAR ADAPTABLE SHIP TECHNOLOGY

Criteria for MAS Technical Maturity: Ready for Integration into a ship

- TRL 7 achieved (TRL7)
  - Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
- Industrial Base ready to produce the product (Industry)
- Approved Specifications / Standard Drawings exist (Specs)
- Approved Design Guidance / Handbooks exist (HDBK)
- Ability to accurately and promptly predict work and costs (by Government and Shipyards) (Cost)
- Ability to accurately and promptly evaluate Value and Cost Benefit over the life of a ship including an understanding of impact of changing requirements (Value)

THESE ACCOMPLISHMENTS ARE NEEDED TO INSTITUTIONALIZE MODULAR ADAPTABLE SHIP TECHNOLOGY

MAS Technology Developments

- "Modular Hull Ship" (bow, stern, variable Parallel Mid-Body)
- "Mission Bay" (like LCS)
- Container Stacks/Slots/Interfaces
- Weapon/Electronics Modules / zones
- Aperture Station
- Aircraft, boats, UUV, UAV, USV
- Electronic Modular Enclosures (EME)
- Flexible Infrastructure

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

Done
Working
Not Started

Modular Hull Ship

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Pre-engineered bow and stern section to accommodate variable length Parallel Midbody..

Why:

Eliminate rework in bow and stern design to accommodate need for additional displacement or volume for new combat systems. Facilitates rapid insertion of new disruptive technologies (Rail gun, FEL)

Enable prefabrication and testing of parallel midbody sections for relatively rapid insertion during ship modernization availabilities.

Facilitate preservation of industrial base by allowing different shipyards to construct and test bow, stern, and parallel midbody.

Status:

Basic concept at sea today with the Sigma Design Concept by Schelde Naval Shipbuilding

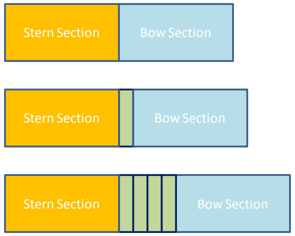
General technical concept understood.

Need Specifications to detail interface between "modules"

Need Design Data Sheet or Handbook to guide development of a future ship design. (BA4)

Need better cost estimation methods. (BA 3 – BA 4)

Need method to value the Modular Hull Ship (BA 1 – BA 4)



Bow = 4 x Beam
Stern = 4 x Beam
PMB = 0 to 2 x Beam

"Van Ameijden says Schelde is "very much aware" of the "90:10 rule" of shipbuilding: Changing 10% of the ship requires changes to 90% of the drawings. This, he adds, is not necessary with the Sigma concept because of the high degree of standardization."

Schelde Naval Shipbuilding: Sigma Design Concept

Mission Bay

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Large open interior area in ship to accommodate multiple elements of a mission module. Generally has access to the exterior for vehicle launch and recovery and for loading/unloading mission modules.

Can be combined with the Helicopter Hangar.

Why:

Enable customization of the ship's combat systems for each deployment

Enables development and testing of a mission module independent of the ship.

Status:

At sea today with LCS and with Spanish *Buque de Acción Marítima (BAM)* Offshore Patrol Vessels.

JHSV under construction

General technical concept understood.

Need a Design Data Sheet or Handbook to guide development of a future ship design (Reflect Lessons Learned from LCS) (BA 4)

Need a method to value different sizes of Mission Bay. (BA 1 – 4)

Container Stacks / Slots / Interface

TRL 7
INDUSTRY SPECS HDBK COST VALUE

What:

Develop a shipboard interface for standard ISO containers that enable COTS equipment within the container to survive in a naval environment.

Entire mission functionality contained in the containers

Differs from a Mission Bay in the environmental protection (shock, vibration) and the closer packing of modules

Why:

Enable complete combat systems to be tested independent of the ship.

Could manage combat systems suites independent of the hull – integrate combat systems into the hull shortly before a deployment. (Treat Combat Systems like an Air Wing)

Hull replacement and Combat Systems replacement do not have to be aligned in time.

Status:

Structural details well defined for containers and container stacks for commercial applications

DARPA Tactical Expandable Maritime Platform (TEMP) is examining concept for giving commercial container ships some military capabilities. Early work of TEMP is concentrating on Humanitarian Assistance and Disaster Relief.

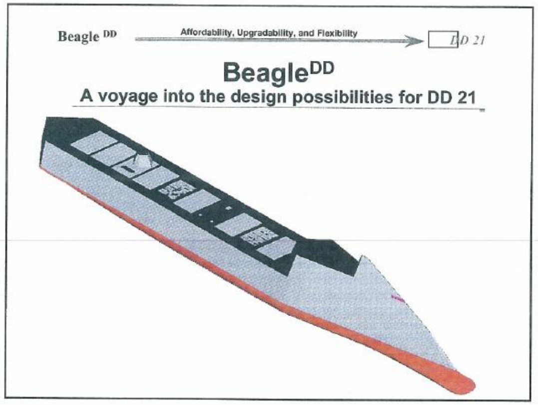
Need to develop methods to implement apertures and weapons launchers / magazines (BA 3 – BA 4)

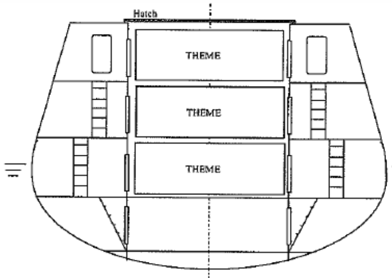
Need to develop methods to specify human access and distributed system connections. (BA 3 – BA 4)

Need better cost estimation methods. (BA 3 – BA 4)

Need a Design Data Sheet or Handbook to guide development of a future ship design. (BA 4)

Chinese Ship 865.
Credit: China-Defense-Mashup.com





Weapons/Electronics Modules / zones

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Predefined and standardized physical, structural, and distributed system interfaces for weapons modules.

Why:

Facilitate upgrading of combat systems elements

Facilitate reuse of combat system elements across ship classes.

Works well for elements that require both internal to the ship and external access.

Status:

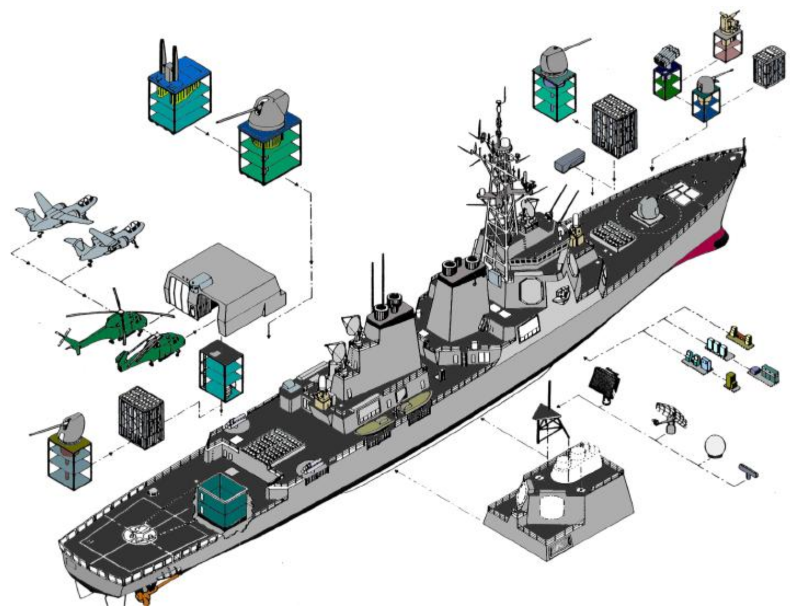
Guides Exist

Specifications from original modularity efforts of 80's exist as a baseline

Need Specifications and Standards development (BA 4)

Need Cost Estimation methods (BA 3 – BA 4)

Need method to value Weapons Modules / Zones needed (BA 1 – BA 4)



Aperture Stations

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Standardized ship-aperture interfaces in the topside design of the ship to enable upgrading of transmit and receive modules

Integrated into the ship in a manner to minimize co-site / EMI issues.

Why:

Decouple transmit / receive module design from the ship design

Enable combat systems design to be concurrent with detail design and construction of the ship.

Enable upgrading of apertures during the ship's lifecycle

Status:

ONR InTop INP is demonstrating how to use same array to meet multiple missions.

ONR Aperstructures programs demonstrating integrated apertures with OA structural integration ICDs

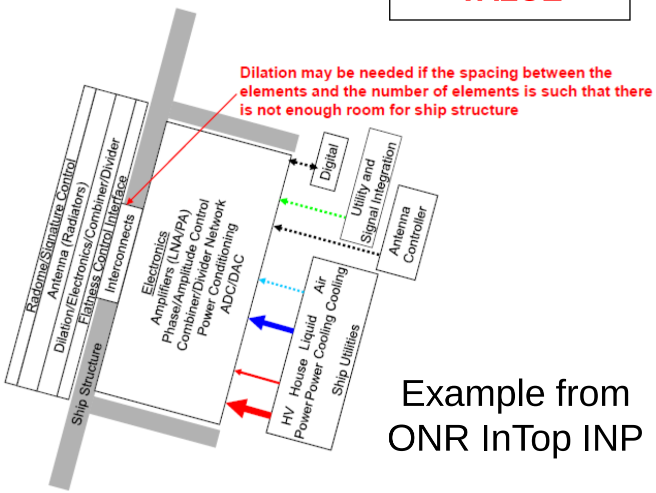
Need to demonstrate that the array design facilitates modular upgrading over the service life of ship.

Need to develop an industrial capacity

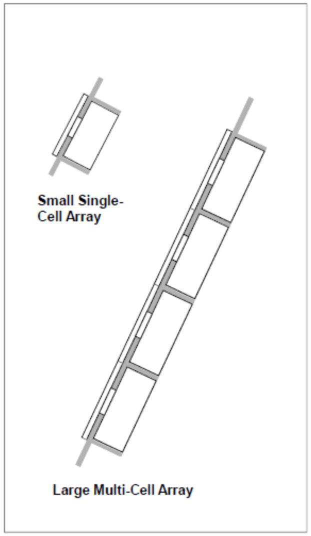
Need to develop specifications, standard drawings, and handbooks

Need to develop cost estimating relationships

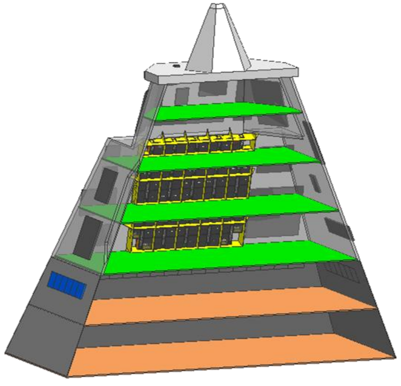
Need to develop methods to value Aperture Stations



Example from ONR InTop INP



Aperstructures



NAVSEA
NAVAL SEA SYSTEMS COMMAND

Aircraft, Boats, UUV, UAV, USV

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Support for multiple types of aircraft, boats, unmanned underwater vehicles, unmanned air vehicles, and unmanned surface vehicles.

- Vehicle Handling
  - Boat Davits and Helo Deck
  - UUV / USV handling gear
  - UAV launch and recovery
- Vehicle Stowage, Communications, Command and Control, Maintenance

Why:

Extend the offboard reach of sensors and weapons.

Enable independent development of the ship and the embarked vehicles.

Status:

Well Established methods for integrating manned aircraft and craft

Need to mature systems and methods for integrated unmanned systems (BA 2 – BA 4)

Need to develop methods to value different combinations and numbers of craft (BA 1 – BA 4)

Electronic Modular Enclosures (EME)

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

Encapsulation of Commercial Off the Shelf (COTS) electronics in a modular enclosure to enable equipment survival in a naval combatant environment.

Why:

Allow COTS equipment to be used on a naval combatant.

Provide standardized equipment racks to enable rapid reconfiguration of the electronics.

Status:

Will be installed on DDG 1000 based on DBPS section 681 and ICDS

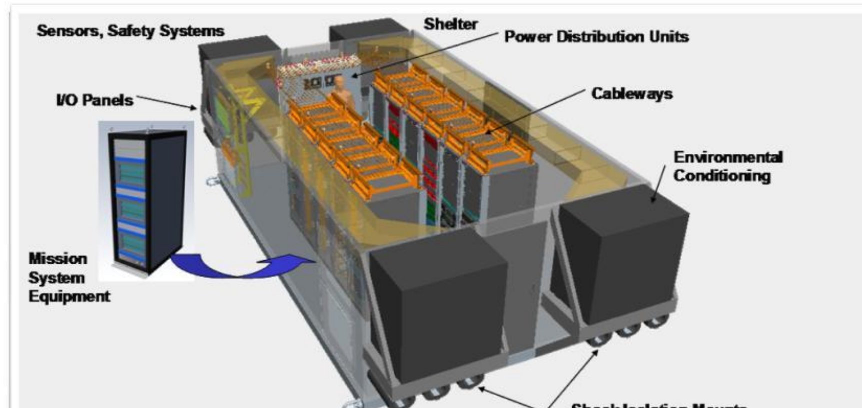
EME Design Criteria Manual Exists for specific DDG 1000 application (BA 4)

May be beneficial to convert DBPS section 681 to a MIL-PRF (BA 4)

Need improved Cost Estimation methods (BA 3 – BA 4)

Need method to Value EME (BA 1 – BA 4)

Electronic Modular Enclosures



	Length	Width	Height
Mini	18 ft	7 ft	7.45 ft
Small	25 ft	11.8 ft	7.45 ft
Medium	30 ft	11.8 ft	7.45 ft
Large	35 ft	11.8 ft	7.45 ft

- Specialized shelter provides environment for Commercial Off The Shelf (COTS) Hardware
- 16 shelters house 236 cabinets
- Shock, Thermal, EMI, Security, & Noise Reduction
- Power Distribution and Control
- Enables Integration of electronics in factory

Flexible Infrastructure

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

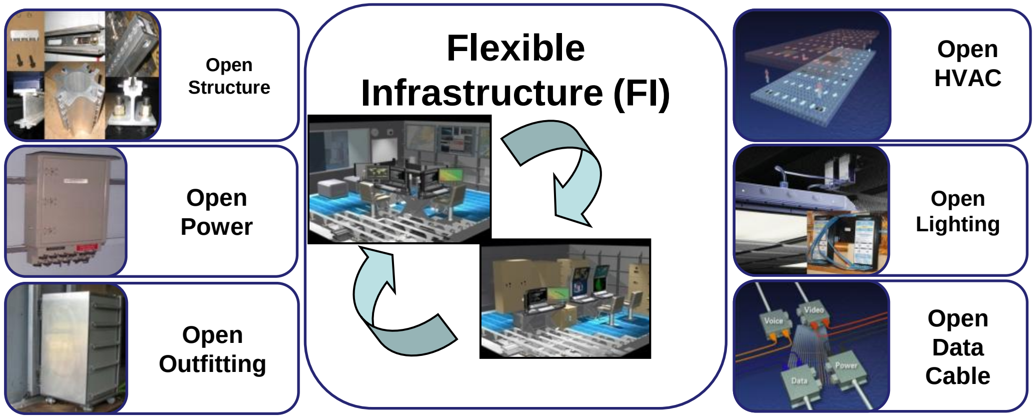
What:

Infrastructure for an interior space to enable rapid reconfiguration without welding or other labor intensive activities.

Why:

Facilitate rapid adaptation of spaces likely to change often during the service life of a ship.

Works well for command and control spaces and electronics intensive spaces



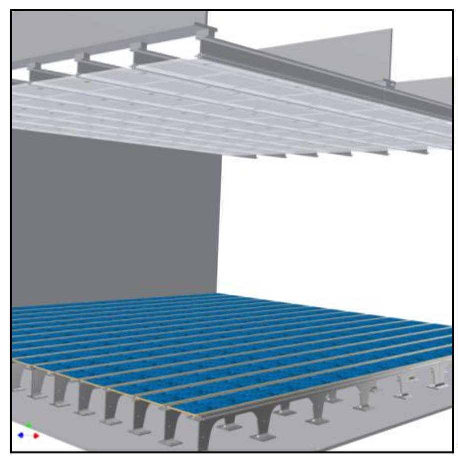
Status:

Demonstrated on ships

Standard Drawings in approval process

Handbook in approval process

Cost Data Exists, but not yet incorporated into cost models.



Need to develop method to Value Flexible Infrastructure (BA1 – BA4)

Criteria for MAS Process Maturity: Ready for a ship acquisition program

- Process defined in a handbook or guide (HDBK)
- Workforce trained and ready to implement process (TRAINING)
- Process Tools exist, are ready and available to the workforce (TOOLS)
- Valid Data required by the process is available to the workforce (DATA)

HDBK
TRAINING
TOOLS
DATA

Done
Working
Not Started

MAS Engineering and Acquisition Process Developments

- Cost Estimation of Modular Adaptable Ships.
- Valuing Modularity and Flexibility.
  - Forecasting evolving requirement ranges through Alternate Future considerations
  - Real Option Theory
  - Control Theory analog
- Optimization of each type of MAS technology.
  - Control Theory analog
- Optimization of Acquisition, Maintenance, and Modernization Strategies.
  - Control Theory analog

Cost Estimation of Modular Adaptable Ships

HDBK
TRAINING
TOOLS
DATA

- Current Cost Estimation techniques are largely insensitive to the potential cost savings associated with Modular Adaptable technologies
- Need to develop and document in a handbook tailored cost estimation approaches that can help predict the impact of Modular Adaptable technologies on ship acquisition and lifecycle cost (BA 2-4)
- Need to update the "CARD" inputs produced by the ship designers to provide the information needed for the new estimating approaches (BA 2-4)
- Need to develop tools and produce data for the new estimating process (BA 2-4)
- Need to provide continuous training for the cost estimating workforce

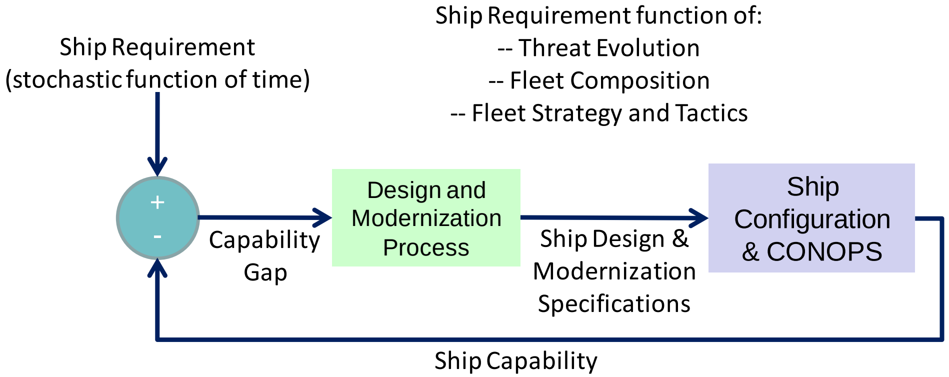
Figure 1. PODAC Cost Model Modules

Trumbule, John, et al., "Product Oriented Design and Construction Cost Mode I – An Update," 1999 Ship Production Symposium, Arlington, VA

Valuing Modularity and Flexibility

HDBK
TRAINING
TOOLS
DATA

- To determine the cost benefit of Modular Adaptable Ship technologies, need to understand:
  - How Requirements are likely to change over the life of the ship
  - How capability gaps are measured and addressed in the Design and Modernization process
  - How the individual Modular Adaptable Ship technologies and associated CONOPS facilitate adaptation to changing requirements
  - How to compare cost with the ability to adapt to changing requirements in performing a Cost Benefit Analysis
    - Possibly use Real Options Theory

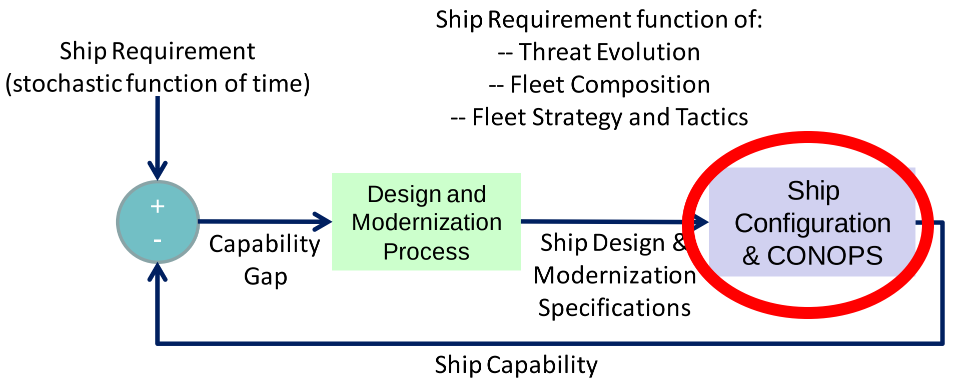


Flexibility Goal: Minimize Acquisition and Modernization Cost while also minimizing positive Capability Gap during the design service life.

Consider the Design and Modernization Process as a MIMO controller for the Ship Configuration & CONOPS. The latter must provide sufficient "control authority" or "control bandwidth" to provide acceptable performance.

Optimization of each type of MAS technology

- Need to understand how to:
  - Determine the optimal amount of each type of MAS technology to ….
  - Provide sufficient adaptability for the Design and Modernization process to adequately address Capability Gaps ….
  - While minimizing Cost



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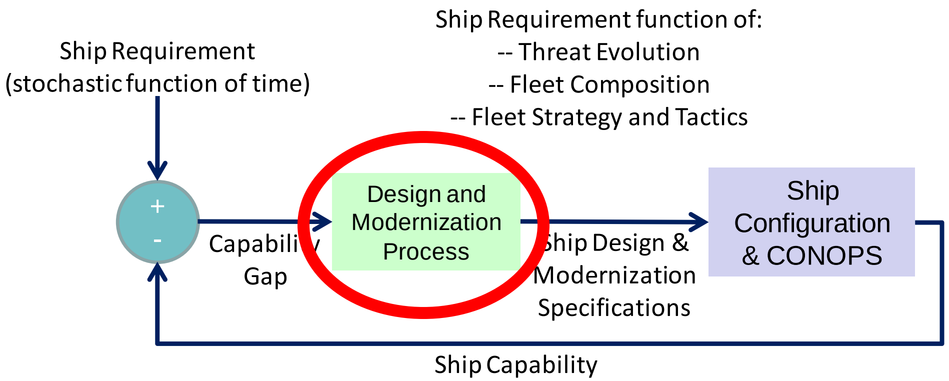
Optimization of Acquisition, Maintenance, and Modernization Strategies

- Need to understand how to:
  - Optimize the Design and Modernization Process to …
  - Take advantage of the MAS technologies to …
  - Minimize Capability Gaps over the ship's service life …
  - While Minimizing cost



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Modular Adaptable Ship Applications

- Aircraft Carriers & Amphibious Warfare Ships
- LCS
- DDG 1000
- MEKO
- STANFLEX
- SIGMA

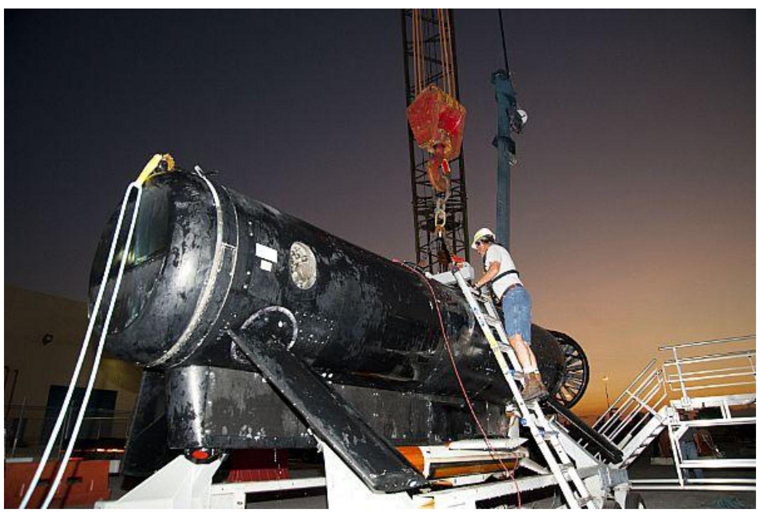
Aircraft Carriers & Amphibious Warfare Ships

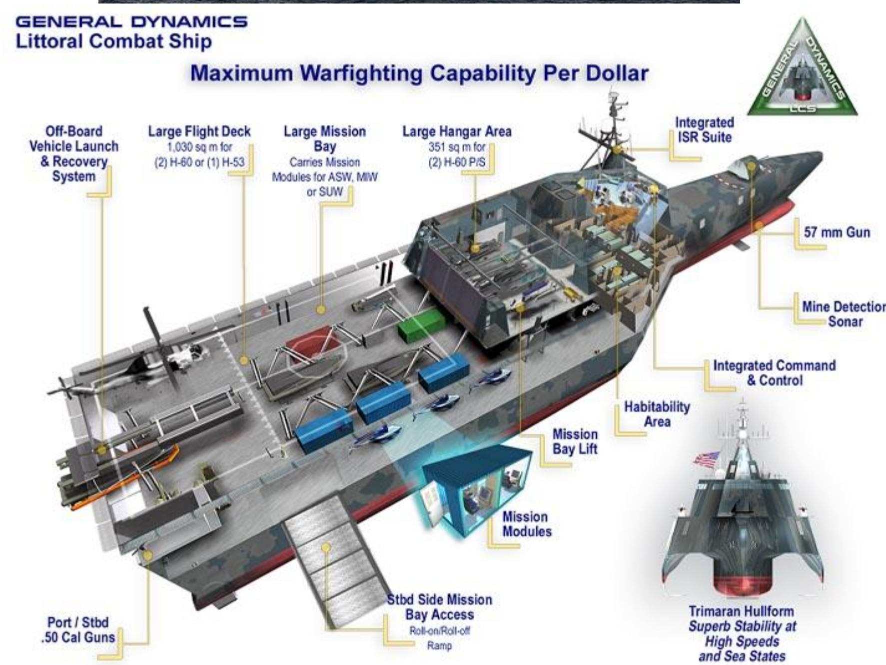
- Modular Adaptable Ship Technologies
  - Aircraft and boats
  - Flexible Infrastructure




Littoral Combat Ship (LCS)

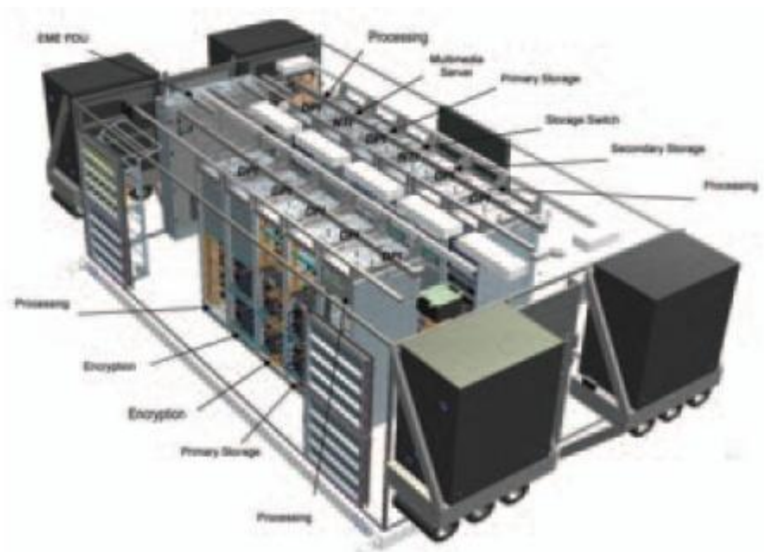
- Modular Adaptable Ship Technologies:
  - Mission Bay
  - Weapon Modules
  - Aircraft, boats, UUV, UAV, USV





DDG 1000

- Modular Adaptable Ship Technologies
  - Aircraft and Boats
  - Electronic Modular Enclosures



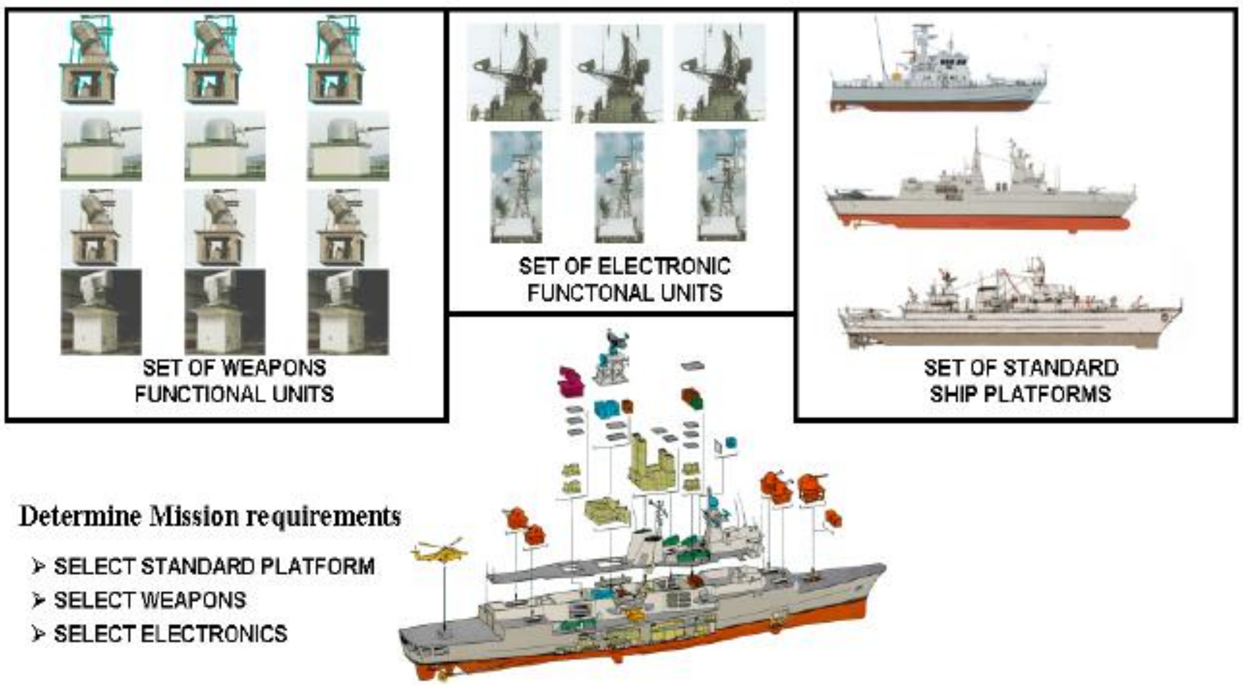
ELECTRONIC MODULE ENCLOSURES

	Length	Width	Height
Mini	18 ft	7 ft	7.45 ft
Small	25 ft	11.8 ft	7.45 ft
Medium	30 ft	11.8 ft	7.45 ft
Large	35 ft	11.8 ft	7.45 ft

Blohm & Voss MEKO

- Modular Adaptable Ship Technologies
  - Weapons/Electronics Modules / Zones


http://en.wikipedia.org/wiki/File:Fregatte_Mecklenburg-Vorpommern_F218.jpg

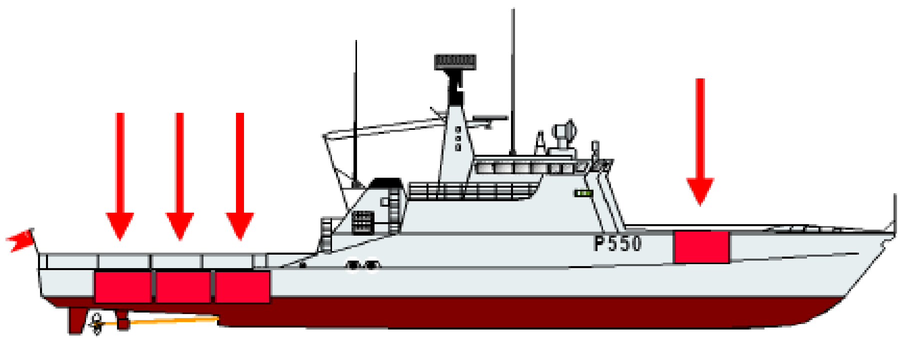



http://bolozer21.blogspot.com/2010/10/meko-class-corvettes-frigates-germany.html

http://www.nps.edu/Academics/Institutes/Meyer/docs/April%2027%202006%20History%20of%20Modular%20Payload%20ships.pdf

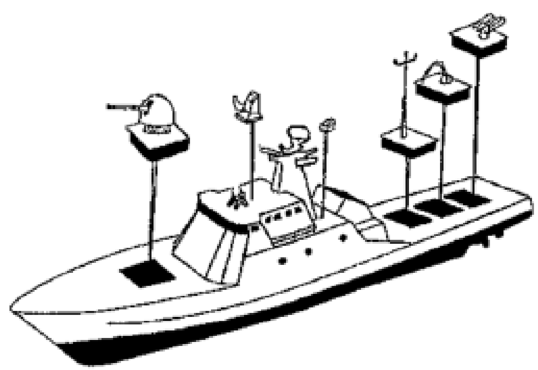
STANFLEX

- Modular Adaptable Ship Technologies
  - Weapons Modules / Zones



http://navy-matters.beedall.com/mhpc.htm

Standard displacement	=	320 tonnes
Length	=	54 m
Beam	=	9 m
Container positions	=	4
Hull material	=	GRP



http://www.nps.edu/Academics/Institutes/Meyer/docs/April%2027%202006%20History%20of%20Modular%20Payload%20ships.pdf

Schelde Naval Shipbuilding SIGMA

- Modular Adaptable Ship Technologies
  - Modular Hull Ship

KRI *Diponegoro*

Specifications	Sigma 9113	Sigma 9813	Sigma 10513	Sigma 10514
Ordered by	Indonesian Navy	Royal Moroccan Navy	Royal Moroccan Navy	Indonesian Navy
Length	90.01 meters	97.91 meters	105.11 meters	105.14 meters
Beam	13.02 meters	13.02 meters	13.02 meters	13.02 meters
Draft	3.60 meters	3.75 meters	3.75 meters	3.75 meters
Displacement	1,692 tons	2,075 tons	2,335 tons	2,400 tons
Main machinery	2 x 8910 kW	2 x 8910 kW	2 x 8910 kW	2 x 9240 kW
Speed (cruising)	18 knots	18 knots	18 knots	18 knots
Speed (maximum)	28 knots	28 knots	28 knots	30 knots
Endurance	4,000 nm	4,000 nm	4,000 nm	4,000 nm
Primary sensors	Thales MW08	Thales SMART-S MK2	Thales SMART-S MK2	Thales SMART-S MK2

Ship **I**ntegrated **G**eometrical **M**odularity **A**pproach.

http://en.wikipedia.org/wiki/Sigma_class_corvette

Conclusions

TECHNOLOGIES	TRL 7	Industry	Specs	Handbook	Cost	Value
Modular Hull Ship	Green	Green	Red	Red	Red	Red
Mission Bay	Green	Green	Green	Red	Green	Red
Container Stacks/ Slots/Interface	Red	Red	Red	Red	Red	Red
Weapon Modules / Zones	Green	Green	Amber	Green	Red	Red
Aperture Station	Red	Amber	Red	Red	Red	Red
Vehicles	Amber	Amber	Amber	Amber	Amber	Red
Electronic Modular Enclosures	Green	Green	Amber	Amber	Red	Red
Flexible Infrastructure	Green	Green	Amber	Amber	Amber	Red

PROCESSES	Handbook	Training	Tools	Data
Cost Estimation	Red	Red	Red	Red
Valuing Modularity & Flexibility	Red	Red	Red	Red
Optimization of MAS Technology	Red	Red	Red	Red
Optimization of Acquisition, Maintenance and Modernization Strategies	Red	Red	Red	Red

WORK REMAINS TO INSTITUTIONALIZE MODULAR ADAPTABLE SHIP TECHNOLOGY