



Institutionalizing Modular Adaptable Ship Technologies

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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 <i>Design</i> Ship Service Life	Little influence	Strong driver
Effect on <i>Actual</i> 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 INSTITUTIONAL 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

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
- Mission Bay
- Container Stacks
- Weapon Modules
- Aperture Station
- Off-Board Vehicles
- 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

Need better cost estimation methods

Need method to value the Modular Hull Ship



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



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)

Need a method to value different sizes of Mission Bay

GENERAL DYNAMICS Littoral Combat Ship

Maximum Warfighting Capability Per Dollar



Container Stacks

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

ARAPAHO system of 1970's and 80's provided ASW helicopter capability to container ships using ISO Containers

SS Wright (T-AVB 3) and SS Curtiss (T-AVB 4) provide modular aviation maintenance

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 specifications for apertures and weapons launchers / magazines

Need to specify human access and distributed system connections

Need better cost estimation methods

Need a Design Data Sheet or Handbook to guide future ship design

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Doerry



Chinese Ship 865.
(China-Defense-Mashup.com)



SS Curtiss (T-AVB 4)



RFA Reliant with ARAPAHO
(RFA Nostalgia)

Weapons Modules

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:

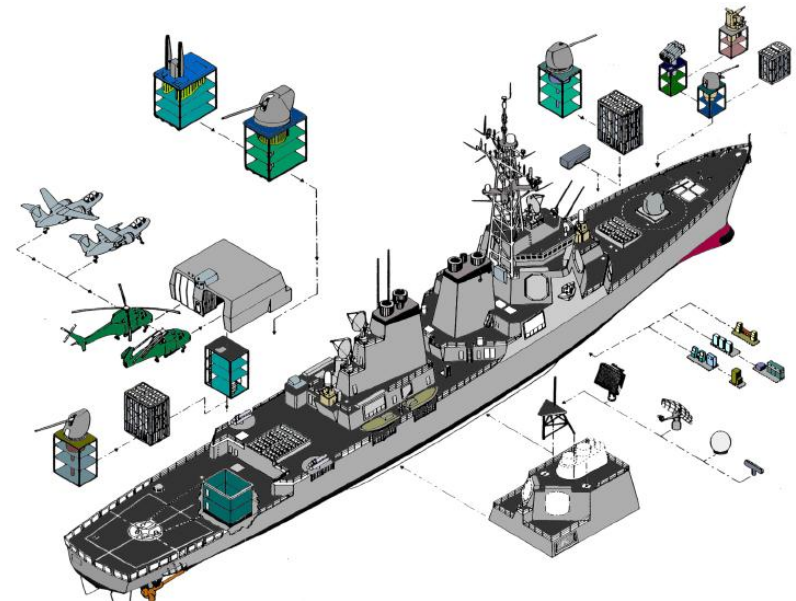
Guides exist, but not formalized

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

Need Specifications and Standards development

Need Cost Estimation methods

Need method to value Weapons Modules / Zones needed



Aperture Stations

TRL 7
INDUSTRY
SPECS
HDBK
COST
VALUE

What:

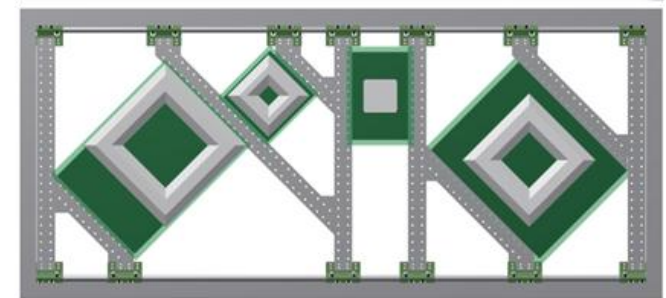
Standardized ship-aperture interfaces in the topside design of the ship to enable upgrading of transmit and receive modules
Integrated into the ship in a manner to minimize co-site / EMI issues.

Why:

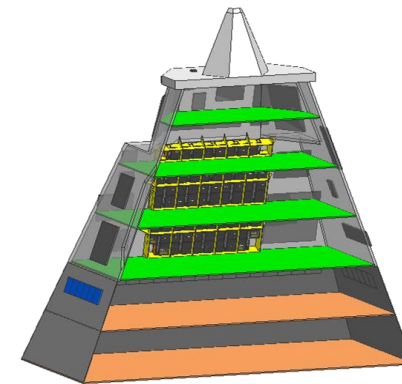
Decouple transmit / receive module design from the ship design
Enable combat systems design to be concurrent with detail design and construction of the ship.
Enable upgrading of apertures during the ship's lifecycle

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



Modular Mechanical Architecture concept for INTOP antenna subsystem (Courtesy ONR)



Aperstructures

Off-Board Vehicles

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

Need to develop methods to value different combinations and numbers of craft



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

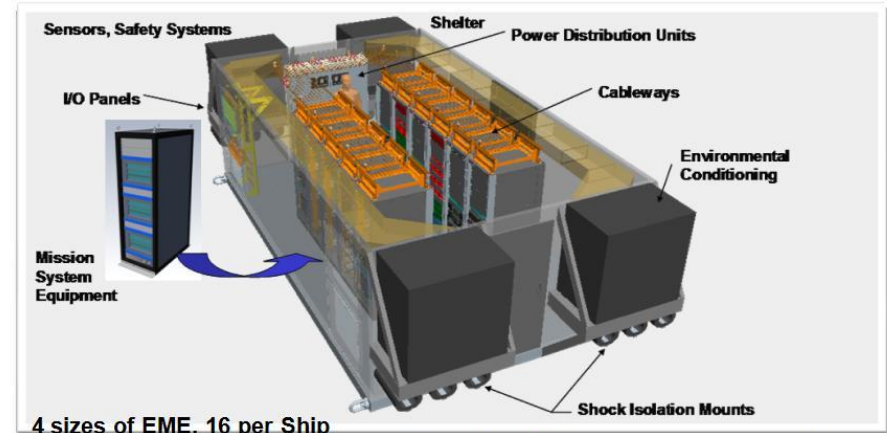
EME Design Criteria Manual Exists for specific DDG 1000 application

May be beneficial to convert DBPS section 681 to a MIL-PRF

Need improved Cost Estimation methods

Need method to Value EME

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:

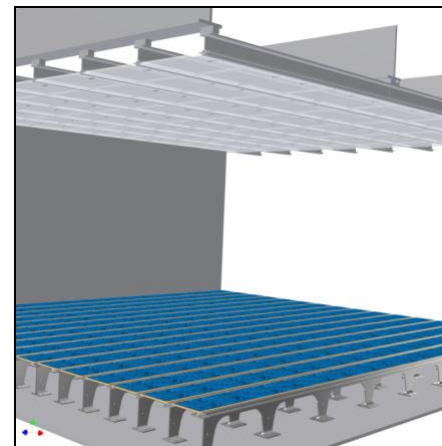
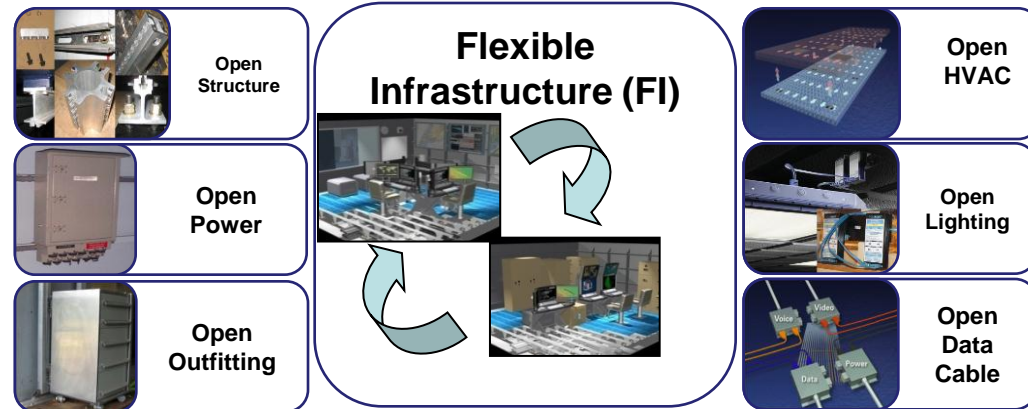
Demonstrated on ships

Standard Drawings in development

Handbook in development

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

Need to develop method to Value Flexible Infrastructure





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

- Estimating cost.
- Valuing modularity and flexibility.
- Optimizing acquisition, maintenance, and modernization strategies.
- Optimizing ship configuration.

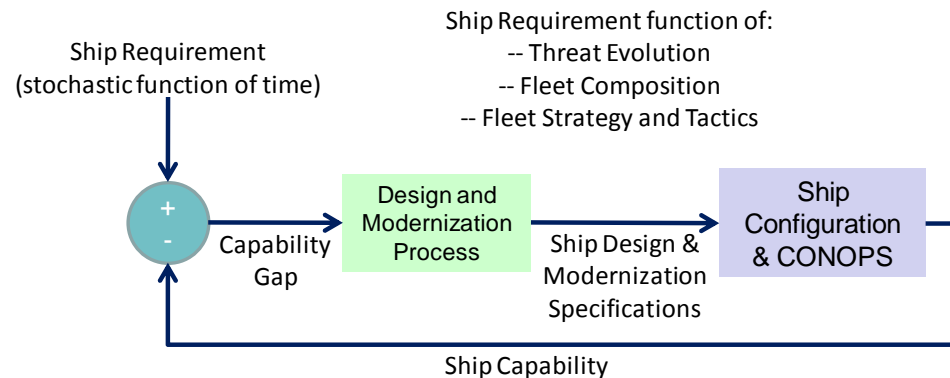
- Current Cost Estimation techniques are largely insensitive to the potential cost savings associated with Modular Adaptable technologies
- Need to develop and document in a handbook tailored cost estimation approaches that can help predict the impact of Modular Adaptable technologies on ship acquisition and lifecycle cost
- Need to update the cost estimation inputs produced by the ship designers to provide the information needed for the new estimating approaches
- Need to develop tools and produce data for the new estimating process
- 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 1 – An Update," 1999 Ship Production Symposium, Arlington, VA

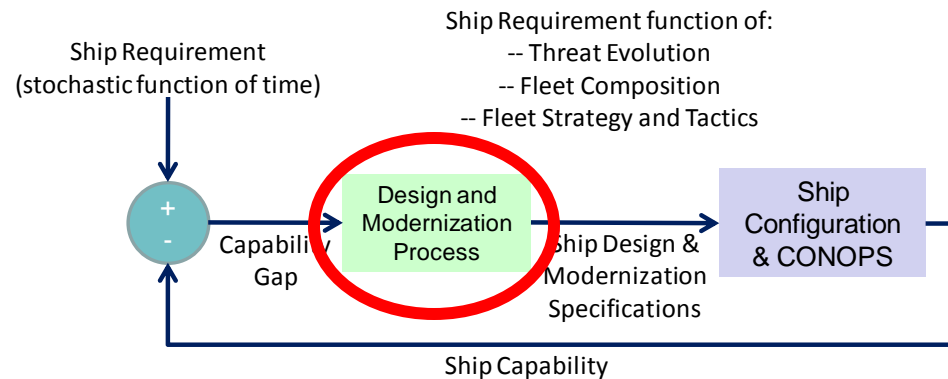
- To determine the cost benefit of Modular Adaptable Ship technologies, need to understand:
 - How Requirements are likely to change over the life of the ship
 - How capability gaps are measured and addressed in the Design and Modernization process
 - How the individual Modular Adaptable Ship technologies 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
 - 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.

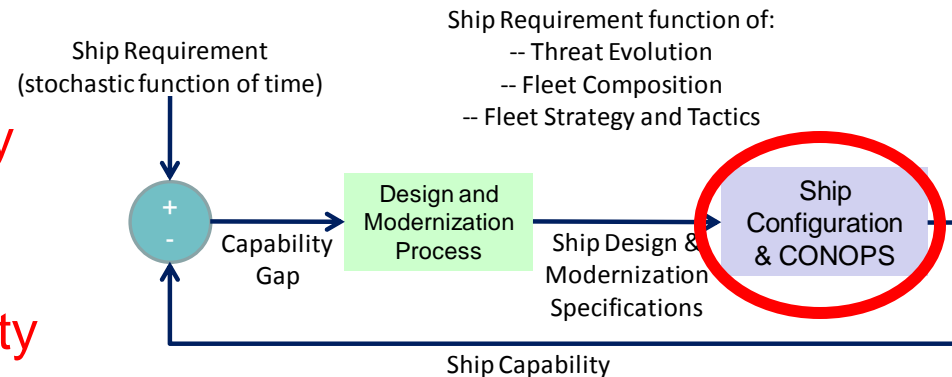
- Need to understand how to:
 - Optimize the Design and Modernization Process to ...
 - Take advantage of the MAS technologies to ...
 - Minimize Capability Gaps over the ship's service life ...
 - While Minimizing cost



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

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- 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



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.

Conclusions

TECHNOLOGIES	TRL 7	Industry	Specs	Handbook	Cost	Value
Modular Hull Ship	Green	Green	Red	Red	Red	Red
Mission Bay	Green	Green	Yellow	Red	Green	Red
Container Stacks	Green	Yellow	Yellow	Yellow	Red	Red
Weapon Modules	Green	Green	Yellow	Yellow	Red	Red
Aperture Station	Yellow	Yellow	Red	Red	Red	Red
Off-Board Vehicles	Yellow	Yellow	Yellow	Yellow	Yellow	Red
Electronic Modular Enclosures	Green	Green	Yellow	Yellow	Red	Red
Flexible Infrastructure	Green	Green	Yellow	Yellow	Yellow	Red

PROCESSES	Handbook	Training	Tools	Data
Cost Estimation	Red	Red	Red	Red
Valuing Modularity & Flexibility	Red	Red	Red	Red
Optimizing Acquisition, Maintenance and Modernization Strategies	Red	Red	Red	Red
Optimizing Ship Configuration	Red	Red	Red	Red

WORK REMAINS TO INSTITUTIONALIZE MODULAR ADAPTABLE SHIP TECHNOLOGY