Institutionalizing Modular Adaptable Ship Technologies

ASNE Tysons-Carderock Chapter Technical Dinner Presentation

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Observations

- Combat System Development vs. Ship Design and Construction

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Combat Systems</th>
<th>Ship Design &amp; Construction</th>
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</thead>
<tbody>
<tr>
<td>Timeline</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Expertise required</td>
<td>Electronics, software</td>
<td>HM&amp;E, Hardware</td>
</tr>
<tr>
<td>Configuration</td>
<td>Volatile</td>
<td>Stable</td>
</tr>
<tr>
<td>Effect on Design Ship Service Life</td>
<td>Little influence</td>
<td>Strong driver</td>
</tr>
<tr>
<td>Effect on Actual Ship Service Life</td>
<td>Strong driver – can't cost effectively update</td>
<td>Moderate driver – Ships decommissioned early</td>
</tr>
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</table>

- 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
• 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

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Modular Hull Ship

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)

“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.”

http://www.aviationweek.com

Schelde Naval Shipbuilding: Sigma Design Concept

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Mission Bay

**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)**

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Container Stacks / Slots / Interface

**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)

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**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

**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
Aircraft, Boats, UUV, UAV, USV

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)
**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)
**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)
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

- 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

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

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
• 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
Modular Adaptable Ship Applications

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

SSNs 21 & 22
SSN 23
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

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DDG 1000

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

### ELECTRONIC MODULE ENCLOSURES

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<tr>
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<th>Length</th>
<th>Width</th>
<th>Height</th>
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<tr>
<td>Mini</td>
<td>18 ft</td>
<td>7 ft</td>
<td>7.45 ft</td>
</tr>
<tr>
<td>Small</td>
<td>25 ft</td>
<td>11.8 ft</td>
<td>7.45 ft</td>
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<tr>
<td>Medium</td>
<td>30 ft</td>
<td>11.8 ft</td>
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<tr>
<td>Large</td>
<td>35 ft</td>
<td>11.8 ft</td>
<td>7.45 ft</td>
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</table>
Blohm & Voss MEKO

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

Determine Mission requirements
- SELECT STANDARD PLATFORM
- SELECT WEAPONS
- SELECT ELECTRONICS

http://www.nps.edu/Academics/Institutes/Meyer/docs/April%202006%20History%20of%20Modular%20Payload%20ships.pdf
• Modular Adaptable Ship Technologies
  – Weapons Modules / Zones

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

http://navy-matters.beedall.com/mhpc.htm
Schelde Naval Shipbuilding SIGMA

- Modular Adaptable Ship Technologies
  - Modular Hull Ship

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

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

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## Conclusions

### TECHNOLOGIES

<table>
<thead>
<tr>
<th></th>
<th>TRL 7</th>
<th>Industry</th>
<th>Specs</th>
<th>Handbook</th>
<th>Cost</th>
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<td>Modular Hull Ship</td>
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<tr>
<td>Mission Bay</td>
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<td>Container Stacks/Slots/Interface</td>
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<td>Weapon Modules / Zones</td>
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<tr>
<td>Aperture Station</td>
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<tr>
<td>Vehicles</td>
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<tr>
<td>Electronic Modular Enclosures</td>
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<tr>
<td>Flexible Infrastructure</td>
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WORK REMAINS TO INSTITUTIONALIZE MODULAR ADAPTABLE SHIP TECHNOLOGY

### PROCESSES

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<tr>
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<th>Handbook</th>
<th>Training</th>
<th>Tools</th>
<th>Data</th>
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<tbody>
<tr>
<td>Cost Estimation</td>
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<tr>
<td>Valuing Modularity &amp; Flexibility</td>
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<tr>
<td>Optimization of MAS Technology</td>
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<tr>
<td>Optimization of Acquisition, Maintenance and Modernization Strategies</td>
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