NAVSEA
NAVAL SEA SYSTEMS COMMAND

“Ship as a Truck”

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ASNE – SNAME SD-8 Navy Ships Panel Meeting

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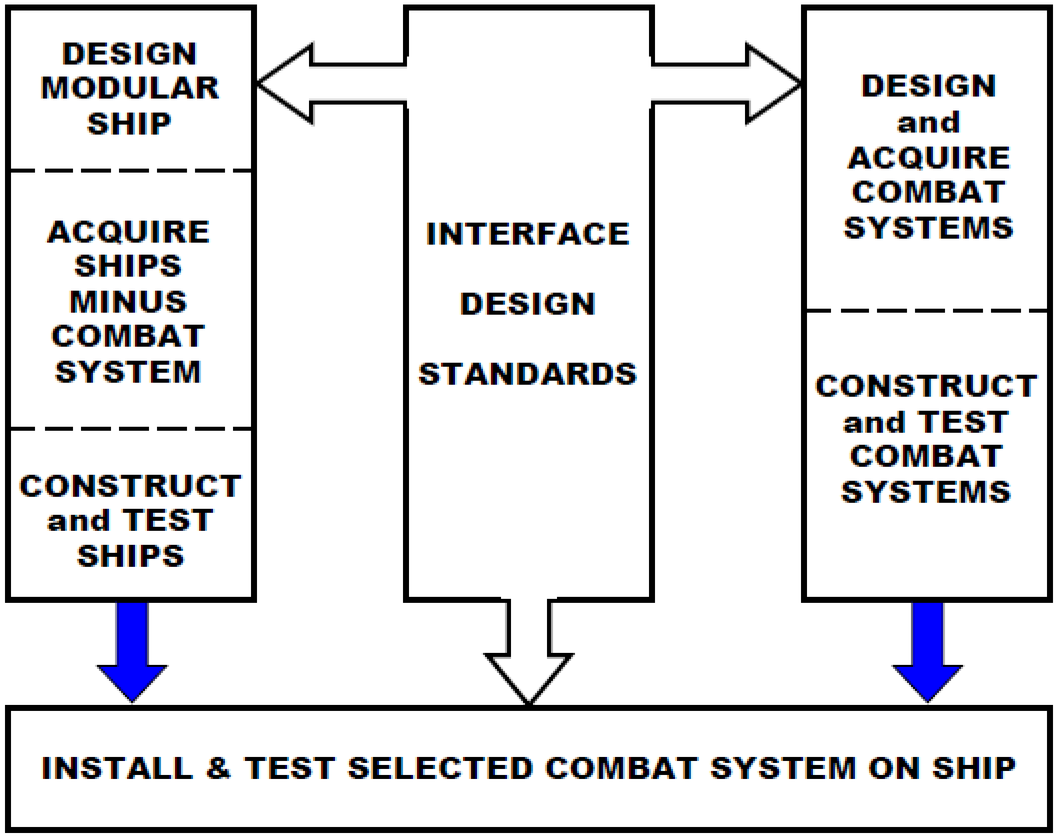
Today’s Objectives

- Develop a list of potential obstacles in the design, acquisition, construction, testing, and in-service support of a surface ship that has a strong decoupling of the combat systems from the host ship “truck.”
- Explore ways to overcome the potential obstacles.

This isn’t a new idea

SSES: Ship System Engineering Standards – circa 1980-1985



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

Ship Design Process Workshop #5 November 17-18, 2010

- Working Group Objectives
  - Develop a List of potential obstacles in the design, acquisition, construction, testing and in-service support of surface ship that has a strong decoupling of the combat systems from the host ship “truck”.
  - Identify ways to overcome the potential obstacles.
- 20 Participants
  - Government
  - Academia
  - Industry

Overall Take-aways from Ship Design Process Workshop #5

- The "Ship as a Truck" surface combatant will likely incorporate a number of different types of modularity
  - No one type will likely provide the flexibility and adaptability needed to decouple combat systems from the "truck" design.
- A fundamental issue is developing an analytically rigorous process to determine how much of each different type of modularity should be incorporated.
  - Should be based on an examination of multiple alternate futures
  - Should be based on establishing the value in $ for each form of modularity through a method such as Real Options Theory
  - Should also apply to other types of ships (auxiliaries, amphibious warfare, etc.)
- Many of the obstacles are not technical –technical approaches won't necessarily overcome the obstacles.
  - Acquisition
  - Organizational
  - Requirements

Types of Modularity

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

Modular Hull Ship

What:

Pre-engineered bow and stern section to accommodate variable length Parallel Midbody. Possibly treat parts of the superstructure as another modular element.

Why:

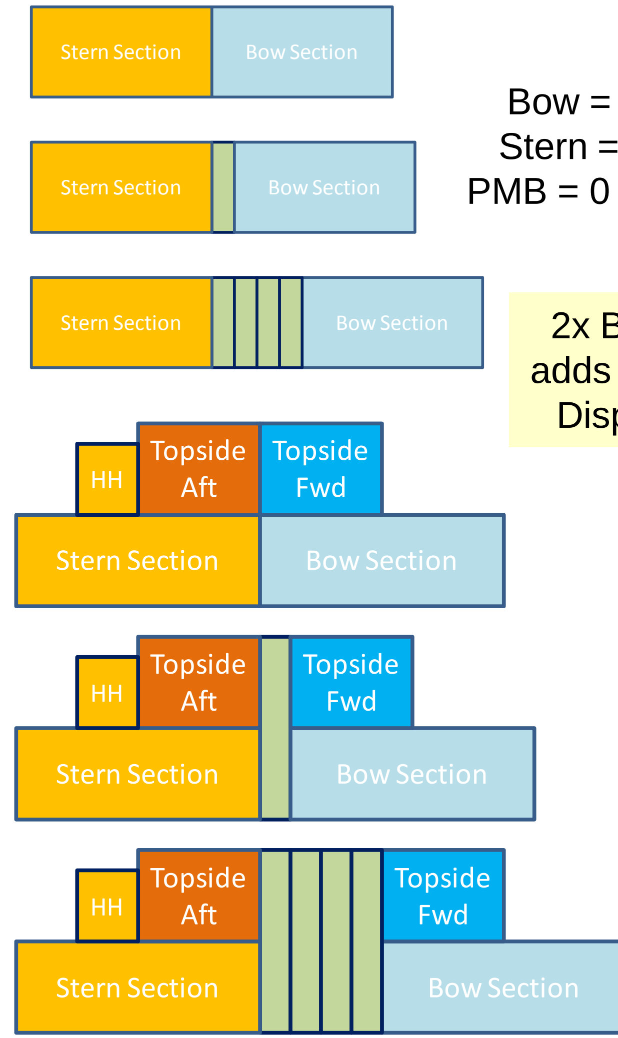
Eliminate rework in bow and stern design to accommodate need for additional displacement or volume for new combat systems. Facilitates rapid insertion of new disruptive technologies (Rail gun, FEL)

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.

Limitations:

Generally can only be exploited during initial construction and major modernization availabilities



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

2x Beam PMB adds about 30% Displacement

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.

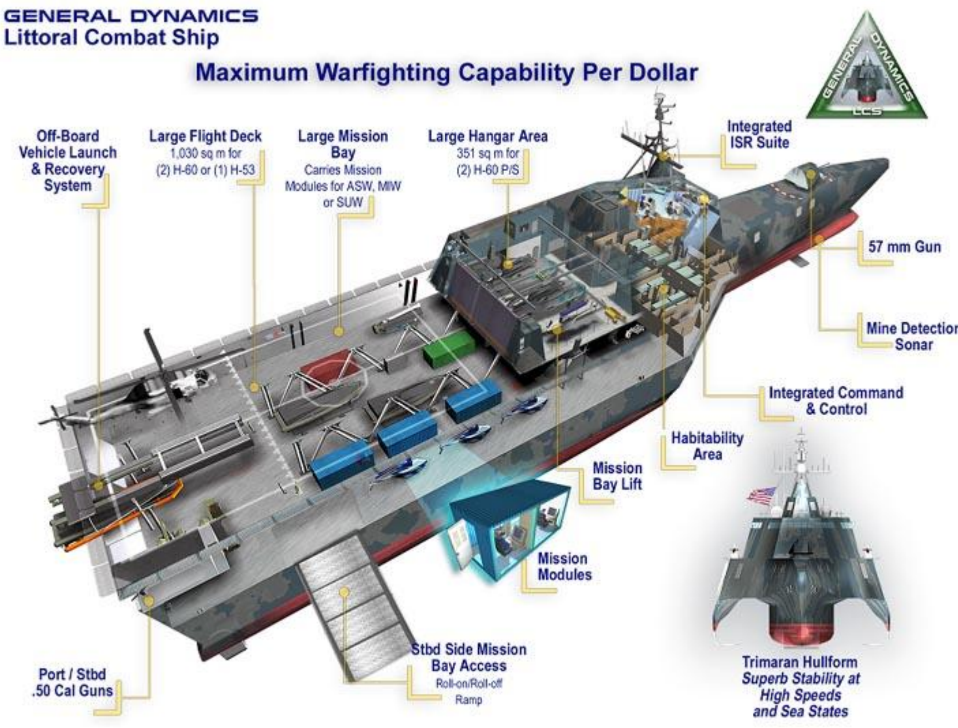
Why:

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

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

Limitations:

Not suitable for weapons systems that need topside exposure such as apertures and weapons



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.

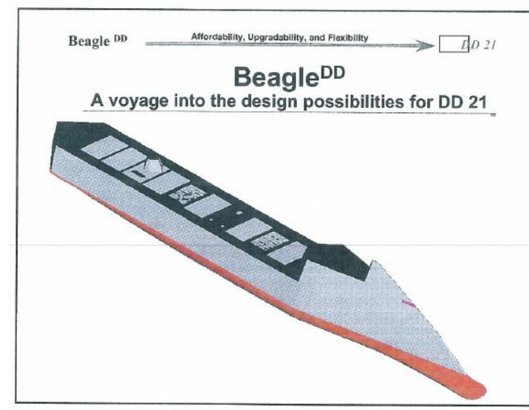
Could manage combat systems suites independent of the hull – integrate combat systems into the hull shortly before a deployment. (Treat Combat Systems like an Air Wing)

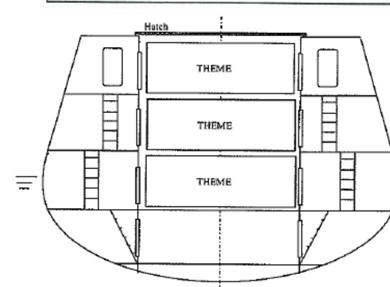
Hull replacement and Combat Systems replacement do not have to be aligned in time.

Limitations:

Unclear how to implement apertures and weapons launchers with this concept.

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





Weapons Modules / zones

What:

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

Why:

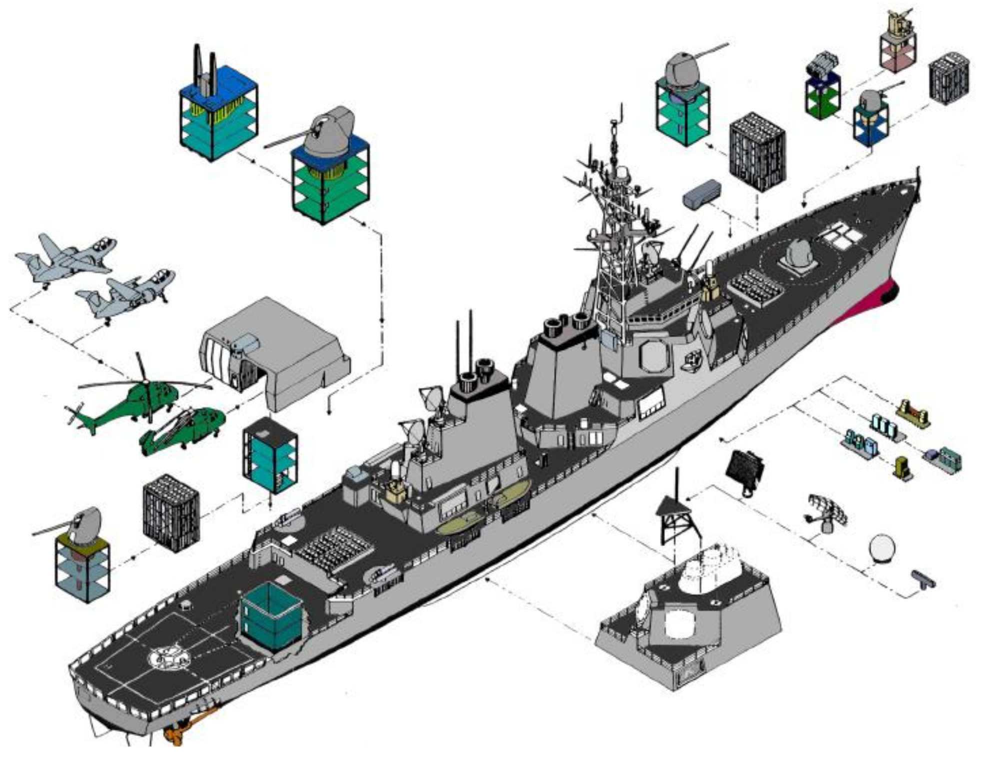
Facilitate upgrading of combat systems elements

Facilitate reuse of combat system elements across ship classes.

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

Limitations:

Places constraints on combat system element design.



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:

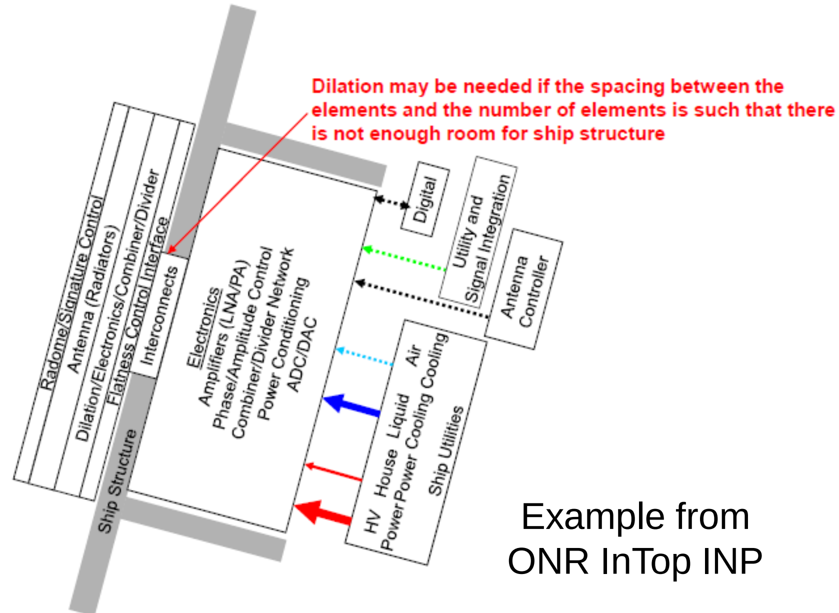
Decouple transmit / receive module design from the ship design

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

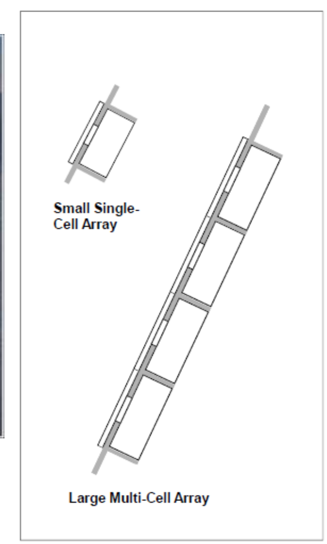
Enable upgrading of apertures during the ship's lifecycle

Limitations:

Only applies to the topside design.



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.

Why:

Extend the offboard reach of sensors and weapons.

Enable independent development of the ship and the embarked vehicles.

Limitations:

Launch and recovery operations limit the speed of deployment / retrieval of systems

Energy storage capacities of the vehicles can limit vehicle endurance.

Generally require a considerable amount of ship volume.

Electronic Module Enclosures (EME)

What:

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

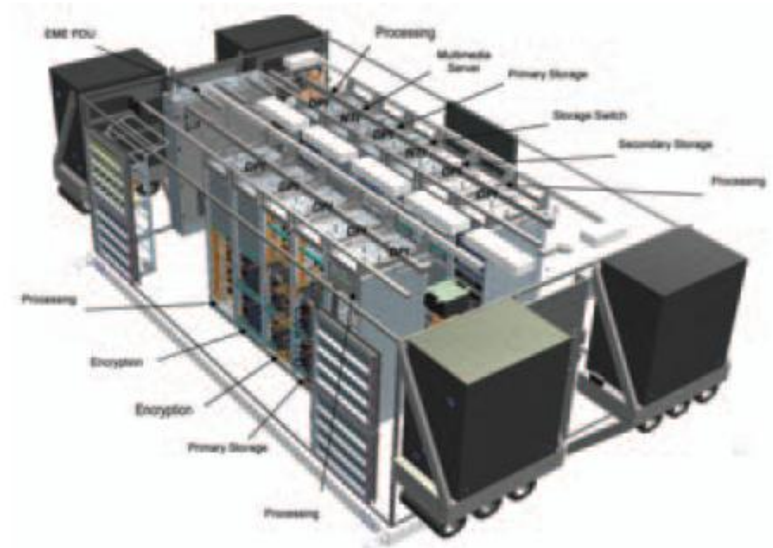
Why:

Allow COTS equipment to be used on a naval combatant.

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

Limitations:

Only applies to electronic equipment.



Flexible Infrastructure

What:

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

Why:

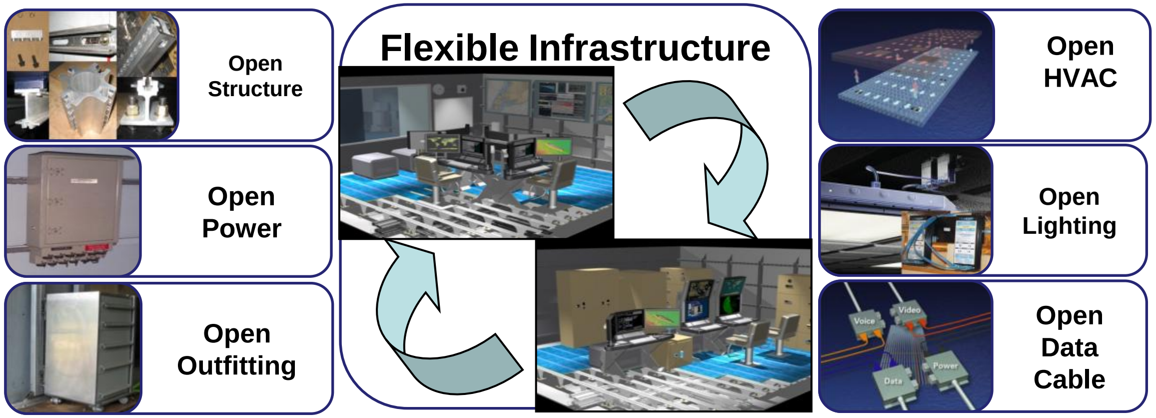
Facilitate rapid adaptation of spaces likely to change often during the service life of a ship.

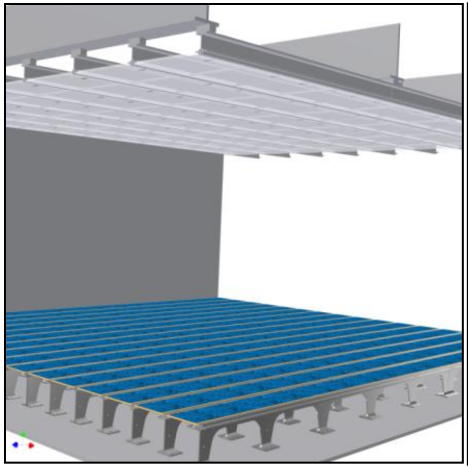
Works well for command and control spaces and electronics intensive spaces

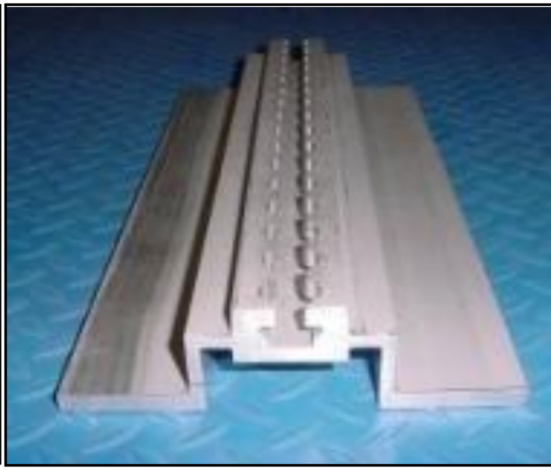
Limitations:

Only applies to interior spaces

Generally does not work well for spaces with heavy machinery or equipment with very high power or cooling requirements.



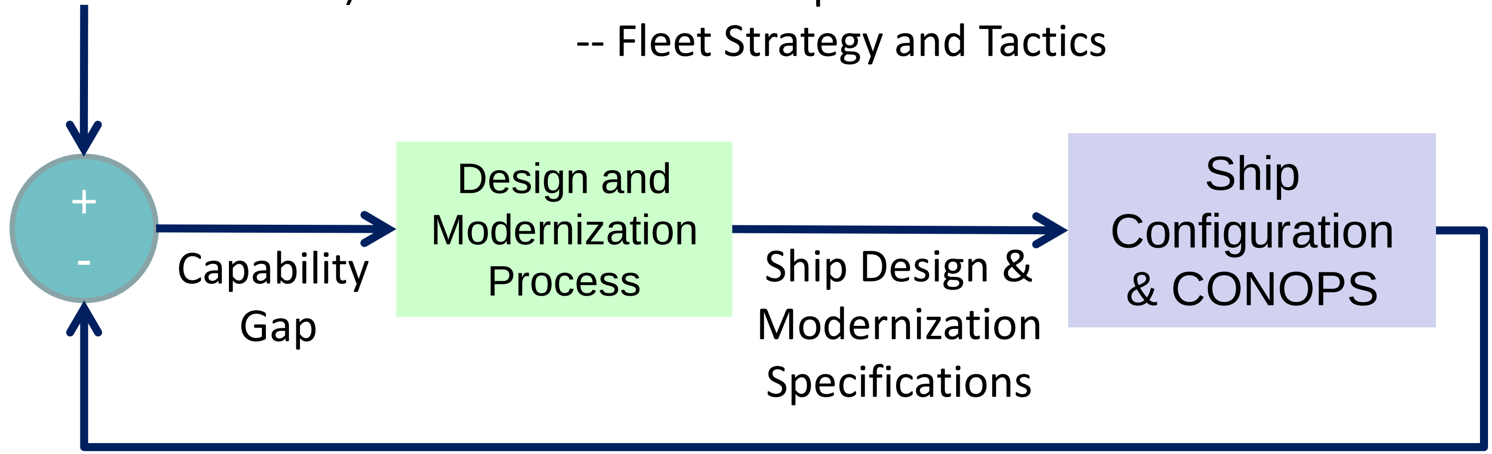




The challenge of how much flexibility

Ship Requirement function of:
-- Threat Evolution
-- Fleet Composition
-- Fleet Strategy and Tactics

Ship Requirement
(stochastic function of time)



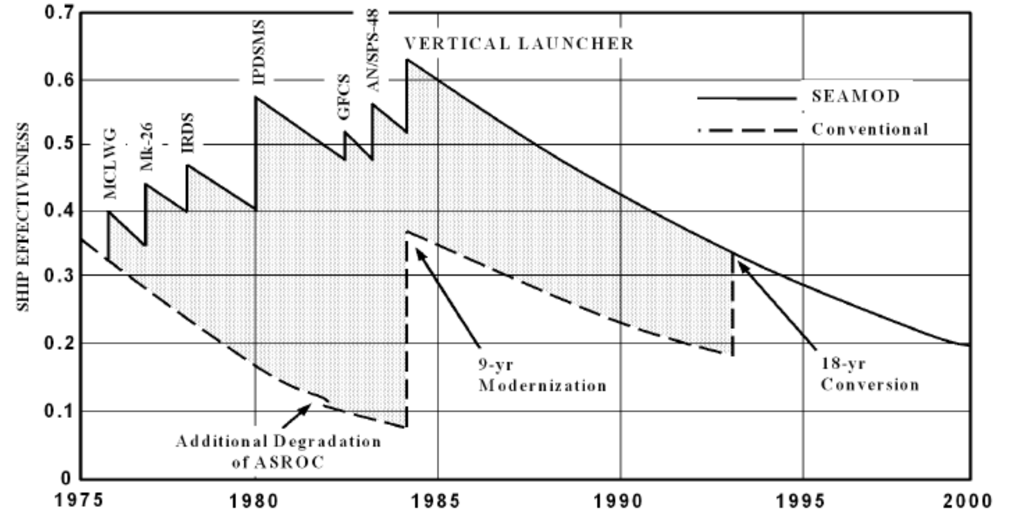
Ship Capability

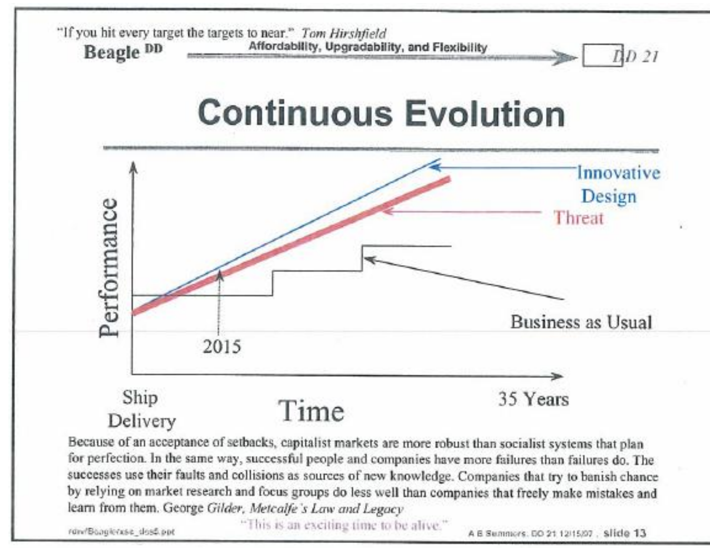
Flexibility Goal: Minimize Acquisition and Modernization Cost while also minimizing positive Capability Gap during the design service life.

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.

Effectiveness (value) over time

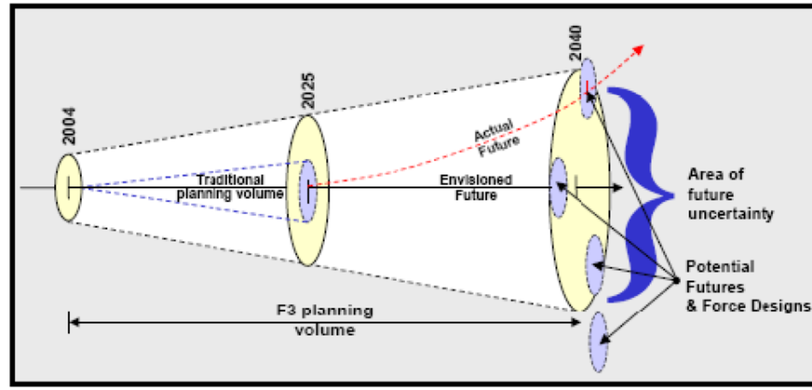
- Threat evolves over time.
  - Usually threats become harder to counter.
  - But sometimes not.
- Typically, effectiveness of a ship decreases with time unless ships are modernized or tactics change.
  - Performance must continually improve to stay equally effective
  - Each choice to modernize is an option.
- Fleet design and fleet tactics influence the level of effectiveness needed for a given ship.
  - Function of time and fleet composition
- Maintenance/training funding/ practices also influence ship effectiveness.





Alternate Futures

- Cannot predict with any reliability more than 10 years into the future.
  - Ship designs can impact the fleet for 50+ years.
- Need to consider multiple alternate futures to determine where flexibility adds value.
  - “orthogonal”
  - Sufficient span



“Current valuations in naval ship design tend to focus on valuing a point designed product. Although there have been efforts to more completely explore the design space for the optimal solution, the optimal solution is based on a fixed set of requirements and preferences. In addition, optimization infers certainty. There is no way in the current system to value adding flexibility to the design, **since under certainty, flexibility has no value**.”

Gregor, Jeffrey Allen. 2003. *Real options for naval ship design and acquisition: A method for valuing flexibility under uncertainty*. M.S. thesis, Ocean Engineering, MIT.

Options Theory

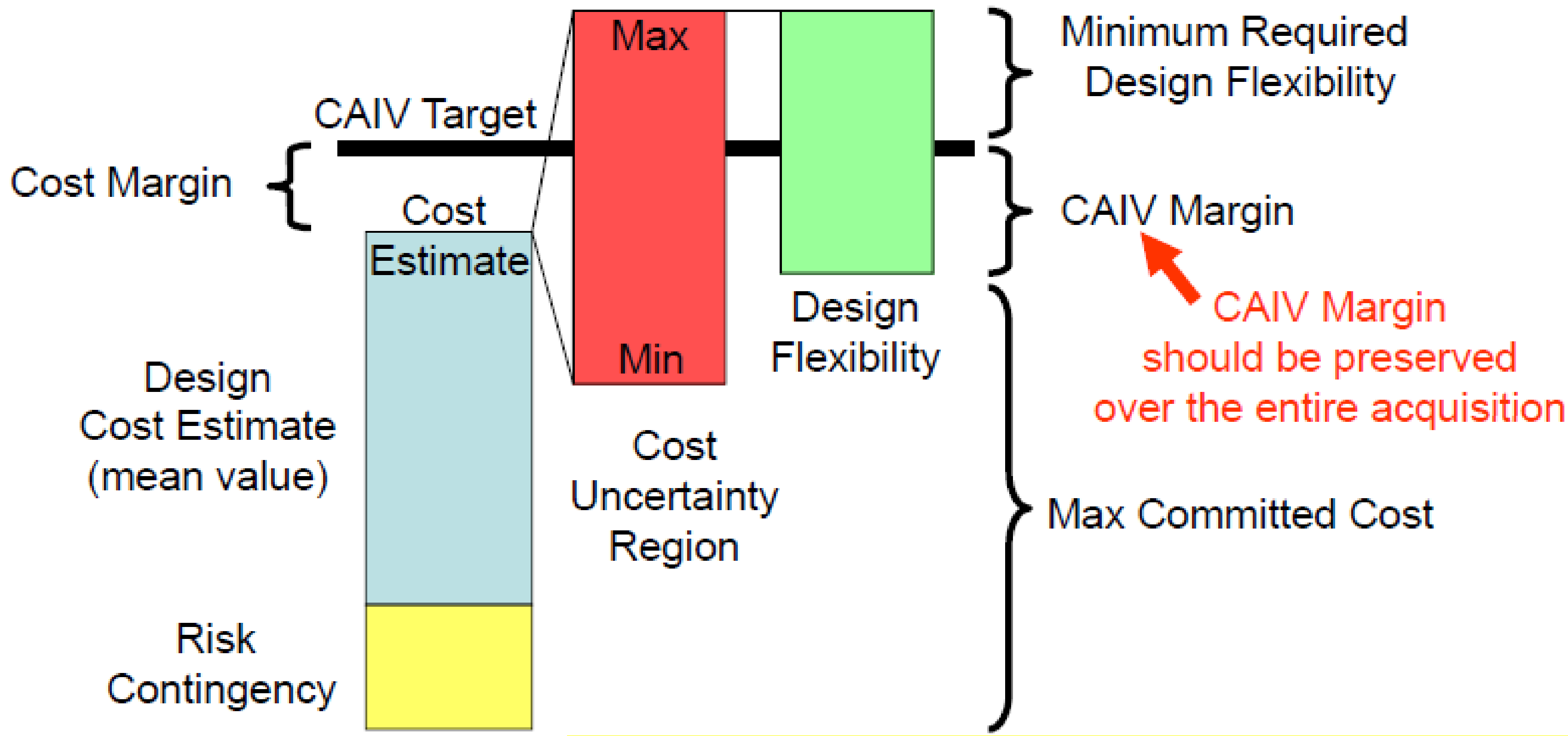
Financial Options

- Option Price
  - Listed on Financial markets
- Current Value of stock
  - Listed on Financial markets
- Striking Price
  - Contractually Specified
- Value of Stock at Expiration

Real Options – Ship Design

- Real Option Price
  - Price of Flexibility Feature
- Effectiveness Price
  - Price to achieve effectiveness at the time of expiration with the delivered ship (without flexibility feature)
- Striking Price
  - Price to achieve effectiveness at the time of expiration exploiting the flexibility feature.
- Effectiveness Price at expiration
  - Price to achieve effectiveness at the time of expiration for a ship that does not have the Flexibility Feature.

Design Flexibility can help implement CAIV during acquisition



Separating the Ship from the Mission System can reduce **cost uncertainty, risk contingency** and **design flexibility** for the acquisition of the ship

Opening List of issues

- Design
  - Sizing the Hull / Topside arrangements
  - Predicting technology needs / trends for the future
  - Distributed system sizing
  - Volume / Area requirements
  - Ship – Combat System interface development and maintenance
  - Manpower implications
  - Margin and Service Life Allowance policy
- Organizational
  - Design / Modernization Process definition
  - Budgeting and Funding
  - Risk Management
  - Program Management relationship among Gov't Program Managers and Industry Program Managers

Workshop Product

- Power Point Out Brief
  – Develop a list of potential obstacles in the design, acquisition, construction, testing, and in-service support of a surface ship that has a strong decoupling of the combat systems from the host ship “truck.”
  – Explore ways to overcome the potential obstacles.
- White Paper input to Workshop Report