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Realizing Flexible Ships:
Flexibility Cost Savings Estimate for U.S. Navy

ASNE Modular Adaptable Ships Symposium
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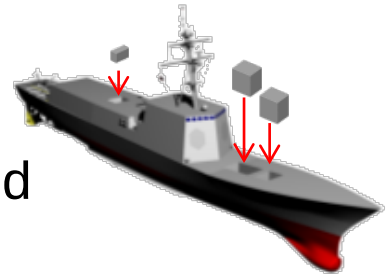
Agenda

- Introduction to “Flexibility” and Navy Cost Estimate Model
  - 1) Using Flexible Design Features for Production & Modernization Cost Estimates
  - 2) Process-Based Life Cycle Savings Estimates
  - 3) Streamlining Ship Operating Cost Estimates Using Commercial Models
- Recommendations

Introduction: Flexibility and Ship Cost

- Flexibility is defined as:
  - "The ability of a ship to adapt to universal or alternate solutions with the benefit of increased capability, reduced cost or both."



Attribute	Description per **NAVSEA Flexible Ships Roadmap 2014**
Adaptability	Ships built with the ability to accept systems/equipment that can be removed and replaced according to specified time/cost objectives to adapt a ship's capabilities to a given mission.
Modularity	Ships built with standardized interfaces and modular components that reduce the complexity of producing/integrating systems and modernizing capabilities.
Scalability	The ability of hardware/software combinations to be increased/decreased to match capability requirements of different sized ship platforms without sacrificing performance.
Payload Commonality	Payload systems developed independently of ship platforms using standardized design specifications allowing the same systems to be applied across multiple platforms.

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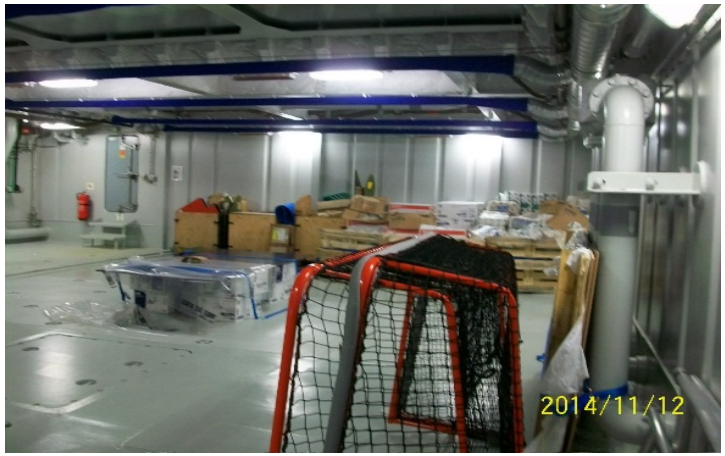
1) Flexible Design Features

- Three Biggest Cost Drivers for Surface Combatants
  - Ship Construction, Modernization, and Maintenance
- Our Approach on Flexible Design Features
  - Identification – Literature review, find representatives and philosophies
  - Organization – Link features to SWBS & SSCS with subset of items
  - Ship Impact – Influence on Weight, Area/Volume, Capability, etc.
  - Cost Impact – Trends for Acquisition/O&S Cost Increase or Reduction
- Results: Flexible Features Library and Summary
  - A presentation of Flexible Feature Groups and their cost trends
  - Databases for AoA for Cost Estimating Models

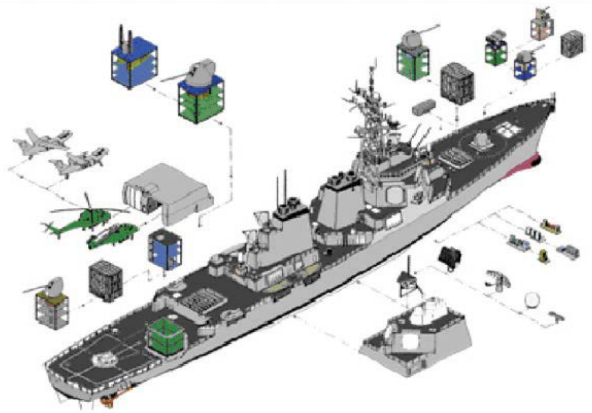
Flexible Ship Architecture (FSA) Examples

Flexible Infrastructure (FI)
(NNS photo on NMC website)

Large Passageway & Cable Trays
(StanFlex Frigate Visit in Nov 2014)

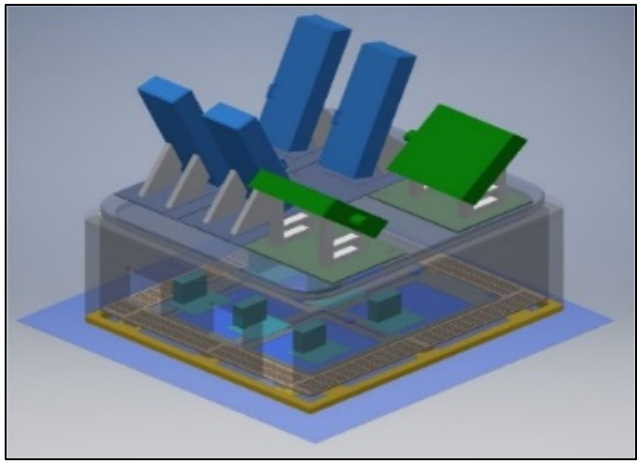


Payload Zones/Module Stations
(StanFlex Midship Container Storage Area)



Payload Zones/Module Stations
(US Navy Modular DDG concept)

Flexible Payload Module (FPM) Examples



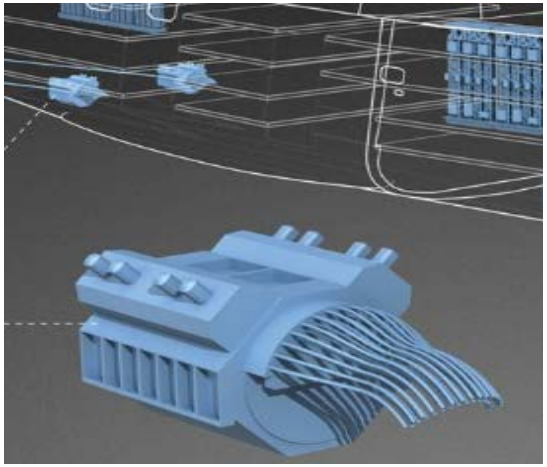
Weapon Module
(Common Launcher Concept by AOC)

Mission Support Equipment Module
(Mobile Fuel Storage Unit by AOC)

Weapon/Payload Modules
(StanFlex Modular VLS, Photo by AOC)

Weapon/Payload Modules
(StanFlex Reuses Modules, Photo by AOC)

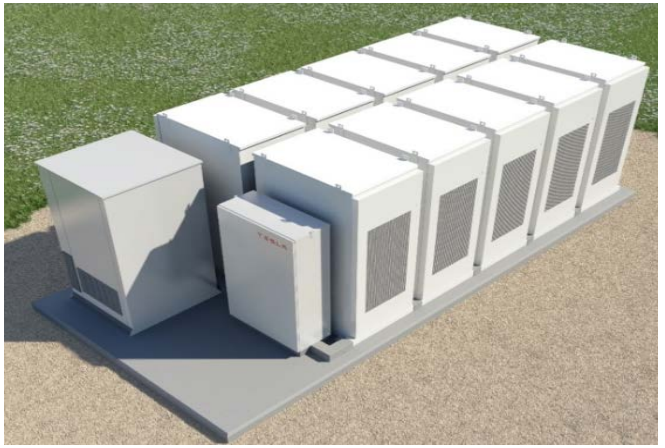
Flexible Ship Technology (FST) Examples



Integrated Power System
(DDG-1000 IPS on IEEE Spectrum)

Container Mover
(Mobicon on LCS)

Direct Energy Weapon
(Naval Laser Gun, Photo by CNN)



Energy Storage Modules
(TESLA on Energy Storage News)

Benefits of Flexibility over Life Cycle

Flexible Enablers	Production Modularity	SWAP-C (Growth Margins)	Modular Payloads & Stations	Flexible Mission Space (Mission Bay)	Open Infrastructure	Commonality	Open Standards
Production							
Schedule	Reduced Build Schedule & Schedule Risk	Reduced Integration Risks	Reduced Build Schedule & Schedule Risk	NC	Reduced Design Time	Reduced Design Time	Reduced Procurement Lead Times
Cost	Reduced Labor	Increased Material Costs	Reduced Labor	NC	Reduced Unit Costs	Reduced Unit Costs	Reduced Unit Costs
Pre & Post Deployment							
Maint & Training	NC	Reduced Maintenance Time	Reduced Training & Reduced Maintenance Time	NC	Reduced Training	Reduced Training	Reduced Training
Deployment							
Availability	NC	Increased Ao - (Reduced Maintenance Time)	Increased Ao - (Reduced Maintenance Time)	NC	NC	Increased Ao - Common Spares/ Redundancy	NC
Overhaul & Repair							
Maint & Training	*Reduced Maintenace Time	Reduced Maintenance Time	Reduced Training & Reduced Maintenance Time	NC	Reduced Training	Reduced Training	Reduced Training
Cost	*Reduced Labor	Reduced Labor	Reduced Labor	More Flexibility per Ship	Reduced Labor	Reduced Unit Costs (Quantity Buy)	Reduced Unit Costs (Spares)
Technology Upgrades							
Maint & Training	*Reduced Maintenace Time	Reduced Maintenance Time	Reduced Training & Reduced Maintenance Time	NC	Reduced Training	Reduced Training	Reduced Training
Cost	*Reduced Labor	Reduced Integration Time	Reduced Integration Time	Reduced Integration Time	Reduced Integration Time	Reduced Unit Costs	Reduced Unit Costs
Integration Risks	*Reduced Risks	Reduced Risks	Reduced Risks	Reduced Risks	Reduced Risks	NC	NC
Disposal							
Cost	*Reuse of Modularized Equipment	NC	Reuse of Payloads / Reduced Labor	NC	NC	Resue of Common Hardware	NC

Flexible Ships Applications for Future U.S. Navy Surface Combatants (Abbott 2015)

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Sample ICD Station Layout

- Station Name:
  - Name of the Individual station.
- Station Notes:
  - Information about this station relevant to the Shipbuilder.
- Station Requirements:
  - Contains singular requirements with a unique ID, based on the station name
- Mission Package Guidance:
  - Information about this station relevant to the Mission Package
- Table of Interfaces:
  - Specific interfaces that are associated with the station
- Optional Figure to Illustrate Interfaces and Clearances

2) Process-Based Life Cycle Savings Estimates

4000-ton Frigate/Cutter Dockside Modernization example:

- **Replacing 7 electronics cabinets (1000 lbs. ea) in 4 compartments on 02 deck**
- **Traditional approach (used currently):**
  - Large pierside crane rental required
  - Interior foundation installation requires hotwork
  - Rigging through the BERP access hatch at deckhouse
- **The Flexibility-enabled cost estimate incorporates the major features from:**
  - Process-Based cost estimates based on USCG/Army /Commercial Shipyard repair experience
  - Flexibility features in the ship design:
  - Flexible Infrastructure, - Large Access Openings, - Elevator,
  - Vehicle Ramp, and - ICD Standard Interfaces including SWAP-C

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Electronic Cabinet Installation SWBS Impacts Comparison

Swap without Flexible Features	SWBS (in Traditional Approach)
Traditional installation: - no FI - no dedicated access routes	900 Ship Assembly & Support Services 150 Deck House Structure 180 Foundations 184 Command & Surveillance Foundations 186 Outfit & Furnishings Foundations 410 Command & Control Systems
Swap using Flexible Features	**SWBS (in Flexible Approach)**
Adequate: - passageways - wide doors - elevator or ramps - FI	900 Ship Assembly & Support Services 180 Foundations 184 Command & Surveillance Foundations 186 Outfit & Furnishings Foundations 410 Command & Control Systems

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Flexibility Savings Example on a Frigate: Existing vs. Flexible Process-Based Approach

tj	4000-ton Frigate/Cutter								
	FY-11 DockSide@Pac Coast Yard								
	420' x 55' x 39'D @ 15'draft			Mtl	S/C	ODC	Unit	Tot.	Tot
Item	DESCRIPTION	QTY	U/M	Cost	Cost	Cost	Price	Price	HRS
	Existing: BERP Vertical Hatch at Deckhousetop, Typical Horizontal P-way & Door Width								
Now-1-900	Temp Services, Dockside Homeport (Req.)	10	wk	$3,650	$2,278	$18,900	6235	$62,348	536
Now-2-150	Opening and Closing of the BERP (Shared)	475	lbs	$3,450	$0	$1,338	77.84	$36,974	460
Now-3-184	F&I ADNS Equip Fndns at MPC Annex (1ea)	316	lbs	$1,427	$300	$494	44.73	$14,119	170
Now-4-180	F&I other Equip Fndns at MPC, etc. (6ea)	1896	lbs	$8,562	$1,800	$2,964	44.69	$84,726	1020
Now-5-410	Rig, Lift & Mtl Handling Support on 7 Electronic Cabinets (to 4 spaces)	6085	lbs	$1,070	$4,000	$3,059	3.94	$23,991	227
	Grand Total All Items			$18,159	$8,378	$26,755		$222,158	2413
	Built-in Flex Features: Elevator, Flex Infrastruct., Side Vehicle Ramp, optional IWS CSER Bkhd Hatch, ICD Std interfaces								
Flex-1-900	Temp Services, Dockside Homeport (Opt.)	1	wk	$1,060	$639	$920	7603	$7,603	71
Flex-2-150	~~150 Opening and Closing of the BERP [N/A]~~	0	lbs	$0	$0	$0		$0	0
Flex-3-184	~~184 F&I ADNS Equip Fndns at Annex [N/A]~~	0	lbs	$0	$0	$0		$0	0
Flex-4-180	~~F&I other Equip Fndns (6ea) [N/A]~~	0	lbs	$0	$0	$0		$0	0
Flex-5-410	Rig, Lift & Mtl Handling Support on 7 Electronic Cabinets (to 4 spaces)	6085	lbs	$1,070	$0	$659	2.89	$17,591	227
	Grand Total All Items			$2,130	$639	$1,579		$25,194	298

3) Streamlining the Ship Cost Estimates Using Commercial Models

- **Construction Cost Estimating**
  - Optimization of Hull form
  - Accurate Price Lists
  - Manages the Center of Gravity
  - Cost input variables of crew size, days underway, lightship displacement, & fuel Costs

NSMV (by Herbert)

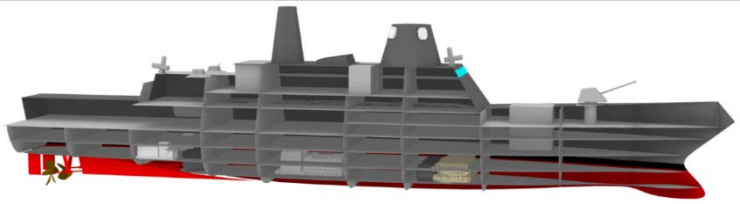
- **Examples of ship construction using software for Fixed Price contracts:**
  - Danish StanFlex Frigates ($340M each)
  - U.S. MARAD National Security Multi-Mission Vessel (NSMV) ($300M each)

3) Streamlining the Ship Cost Estimates Using Commercial Models

- **O&S Estimating Using Commercial Models**
  - How a Modular Warship is Similar to a Modular Containership
    - Maximizes the number of days available “at-sea”
    - Treats combat systems as modular payloads
    - Calculates and tracks fuel usage, crew salaries, readiness levels, and available “at-sea” days.

Recommendations

Flexibility Features Impacts on Cost Estimating:



Conceptual Frigate Source: AOC

1. **Incorporating the Flexibility Enablers**
   - Reduces installation time and damage to electronic equipment
   - Using an ICD manages interfaces and contributes to standardized modules
2. **Developing Process-based Life Cycle Savings Cost model**
   - Shows savings achieved in the SWBS 900 category
   - Shows time savings achieved during equipment upgrades
3. **Using Commercial Software Tools to Improve Estimates on New Construction and Operation & Support Costs**
   - Assists with accuracy of near-term Fixed Price contracts
   - Provides data for analyzing operating costs

These methods supplementing traditional weight-based cost estimating will provide insight to the true cost savings of using flexible features, payload modules, and technologies.

Questions?

Conceptual Trimaran by AOC

Thank You