Flexible Adaptable Electric Warship

Electric Ship Technology Symposium
April 22-24, 2013
Arlington, VA

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Approved for Public Release

Agenda

- The Fleet Today
- Opportunities
- Observations
- Modularity and Flexibility – Modular Adaptable Ship

Status of the U.S. Navy

- **Navy Personnel**
  - **Active Duty:** 317,464
    - 52,450 Officers
    - 260,581 Enlisted
    - 4,433 Midshipmen
  - **Ready Reserve:** 109,596 [Feb 2013]
    - 4,241 currently mobilized [Mar 2013]
- **283 Ships and Submarines**
  - **Deployed: 94 (33% of total)**
  - **Underway for Local Ops / Training: 30 (10% of total)**
- **3700+ Aircraft**

SOURCE: www.navy.ml on April 2, 2013

Battle Force Composition

10 Aircraft Carriers

14 Ballistic Missile Submarines

4 Guided Missile Submarines

54 Attack Submarines

100 Surface Combatants

34 Combat Logistics Ships

30 Amphibious Warfare Ships

32 Support / Mine Warfare Ships

5 Naval Reserve Force, Active (NRFA) Ships

SOURCE: www.nvr.navy.mil on April 2, 2013

Maritime Strategy

- **Forward Presence**
- **Deterrence**
- **Sea Control**
- **Power Projection**
- **Maritime Security**
- **Humanitarian Assistance and Disaster Response**

Focus on Littorals and Anti-Access / Area-Denial (A2/AD)

Evolving and very different threats / environments

Challenges of Warship Acquisition

Very low quantities, high unit cost, long lives

No prototypes, first ship(s) must be fully operational

Combat / weapons systems developed concurrently

Government assumes responsibility for meeting requirements

Extremely high parts count (in the order of 10 million)

Minimal commercial shipbuilding industrial base

Intense Congressional/OSD oversight

Opportunities

Forward-Fit

Table ES-1. FY2013-2042 Long-Range Naval Vessel Construction Plan

Fiscal Year	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Aircraft Carrier	1					1					1					1					1					1				
Large Surface Combatant	2	1	2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	2	2	2	2	3	3	3	3	3	3	3
Small Surface Combatant	4	4	4	2	2	3	3	3	3	3	3	3	3	3				1		1		1	1	2	3	4	4	4	4	2
Attack Submarines	2	1	2	2	2	2	2	3	2	3	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2
Ballistic Missile Submarines									1			1		1	1	1	1	1	1	1	1	1	1							
Amphibious Warfare Ships					1	1		1		1		2		1		2	1	1	1	2				1				2		1
Combat Logistics Force				1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
Support Vessels	1	1		2		1	1	2		2	3	2	1			1	1	2	2	3	2	2								
Total New Construction Plan	10	7	8	9	7	11	8	12	9	12	13	12	10	9	6	9	8	9	8	11	8	8	5	7	7	10	8	11	8	8

Back-Fit

Table ES-2. FY2013-2042 Naval Battle Force Inventory

Fiscal Year	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Aircraft Carrier	10	10	11	11	11	11	11	11	11	12	11	11	11	11	12	11	11	11	11	11	11	11	11	11	11	11	11	10	10	10
Large Surface Combatant	80	78	78	80	82	84	86	87	88	87	89	89	88	89	90	89	87	85	81	80	79	78	80	82	84	86	88	88	89	88
Small Surface Combatant	35	30	26	30	32	35	39	37	38	40	39	41	43	46	49	52	55	55	55	55	55	55	55	55	55	55	55	55	55	55
Attack Submarines	55	55	54	53	50	51	51	48	48	47	47	46	45	45	44	43	43	43	45	45	46	47	48	49	50	48	49	49	48	49
Cruise Missile Submarines	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1															
Ballistic Missile Submarines	14	14	14	14	14	14	14	14	14	14	14	14	14	14	13	12	11	11	11	10	10	10	10	10	10	10	10	10	11	12
Amphibious Warfare Ships	31	29	28	29	30	31	31	31	31	32	32	34	34	34	33	34	33	33	32	32	33	34	33	33	33	32	32	31	32	31
Combat Logistics Force	32	32	31	31	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Support Vessels	24	27	30	32	33	33	35	34	33	33	35	35	33	32	33	33	33	33	33	33	33	33	33	33	33	34	33	33	33	33
Total Naval Force Inventory	285	279	276	284	285	292	300	296	296	298	300	303	301	302	304	303	302	300	297	295	296	297	299	302	305	305	307	306	307	307

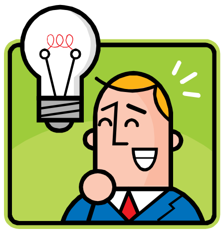
Annual Report to Congress on Long-Range Plan for Construction of Naval Vessels for FY2013, April 2012

Ways to get a new product on a ship

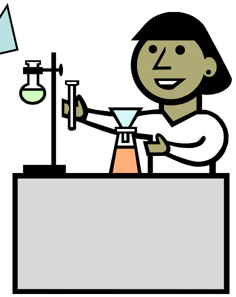
- In Service
  - Ship Change Document (Planned configuration change)
  - Alteration Equivalent to Repair (AER)
  - Fit Form Function replacement of a repair part
    - Via Stock System
  - Alteration during Depot Maintenance
  - “Requirements” for consumables (Maintenance Requirements Cards, Technical Manuals, etc.)
- New Construction
  - Written into Ship Specifications
  - Engineering Change Proposal
  - Written into Component Specification / Standard

New Technology to the Fleet

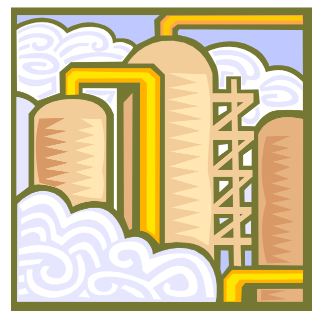
ONR, Academia
& Labs (Gov't & Industry)



Great Idea!

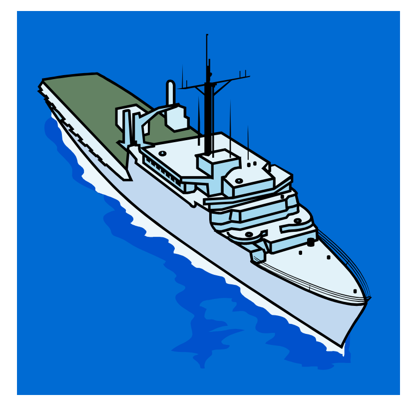


Technology Development
"Create Knowledge"



PEO/SYSCOM
& Industry

Product Development
"Integrate Technologies
to meet requirements"



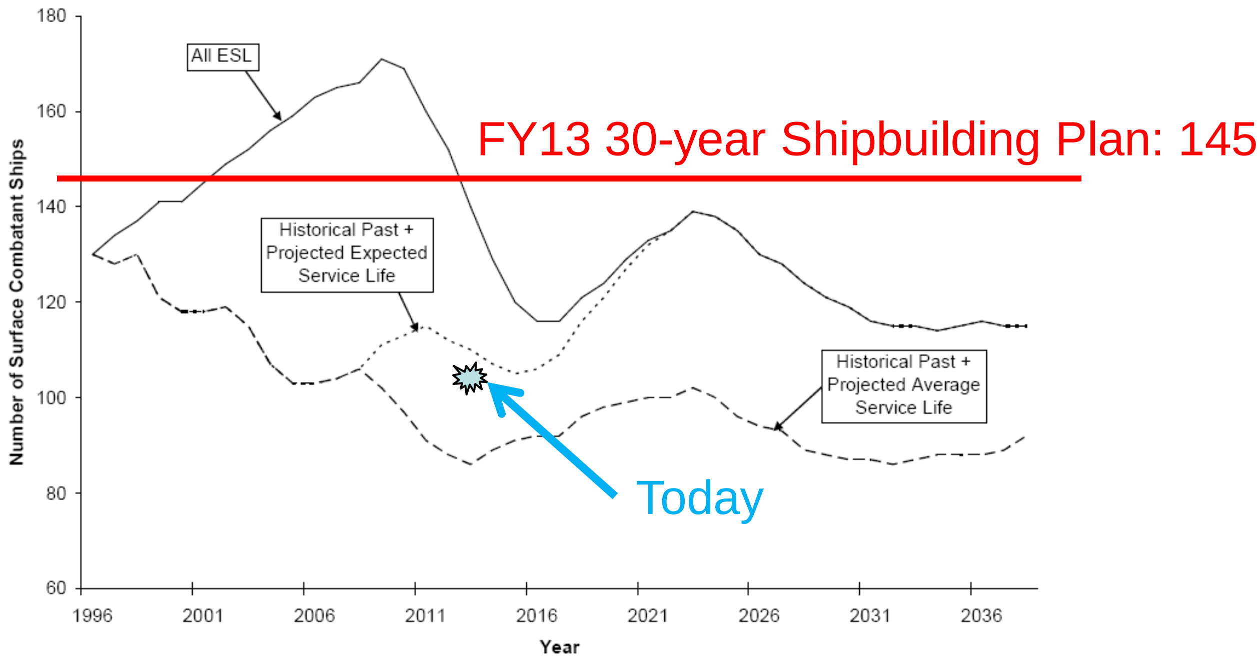
Qualify for Naval Use /
Specification & Standards /
Forward-Fit & Back-Fit
"Institutionalize"

Observations

- Surface Combatants & Amphibious Warfare Ships
  - Modularity and Flexibility
    - Variable electric load
  - Growth in radar loads
  - Future growth in electric weapons
  - Continued progression of electric drive / hybrid electric drive
- Auxiliaries
  - The standard practice for all but high speed vessels is now integrated diesel electric

AFFORDABILITY WILL CONTINUE TO BE A KEY DRIVER

Modular Adaptable Ship: Motivation



Koenig, Dr. Philip, Don Nalchajian, and John Hootman,"Ship Service Life and Naval Force Structure," ASNE ETS 2008, 23-25 Sept 2008

Our ships must remain militarily relevant (affordably) over their Expected Service Life for the Navy to achieve Force Level Requirements

Building an Affordable Future Fleet in an Evolving World

- Face uncertain times
  - The threat is evolving
  - Our technology is evolving
  - Lean times ahead
- Ships and their systems must be robust, flexible and adaptable
- Systems Engineering must anticipate uncertain and changing requirements

The Electrical Infrastructure
must be robust, flexible, and adaptable

NAVSEA NAVAL SEA SYSTEMS COMMAND

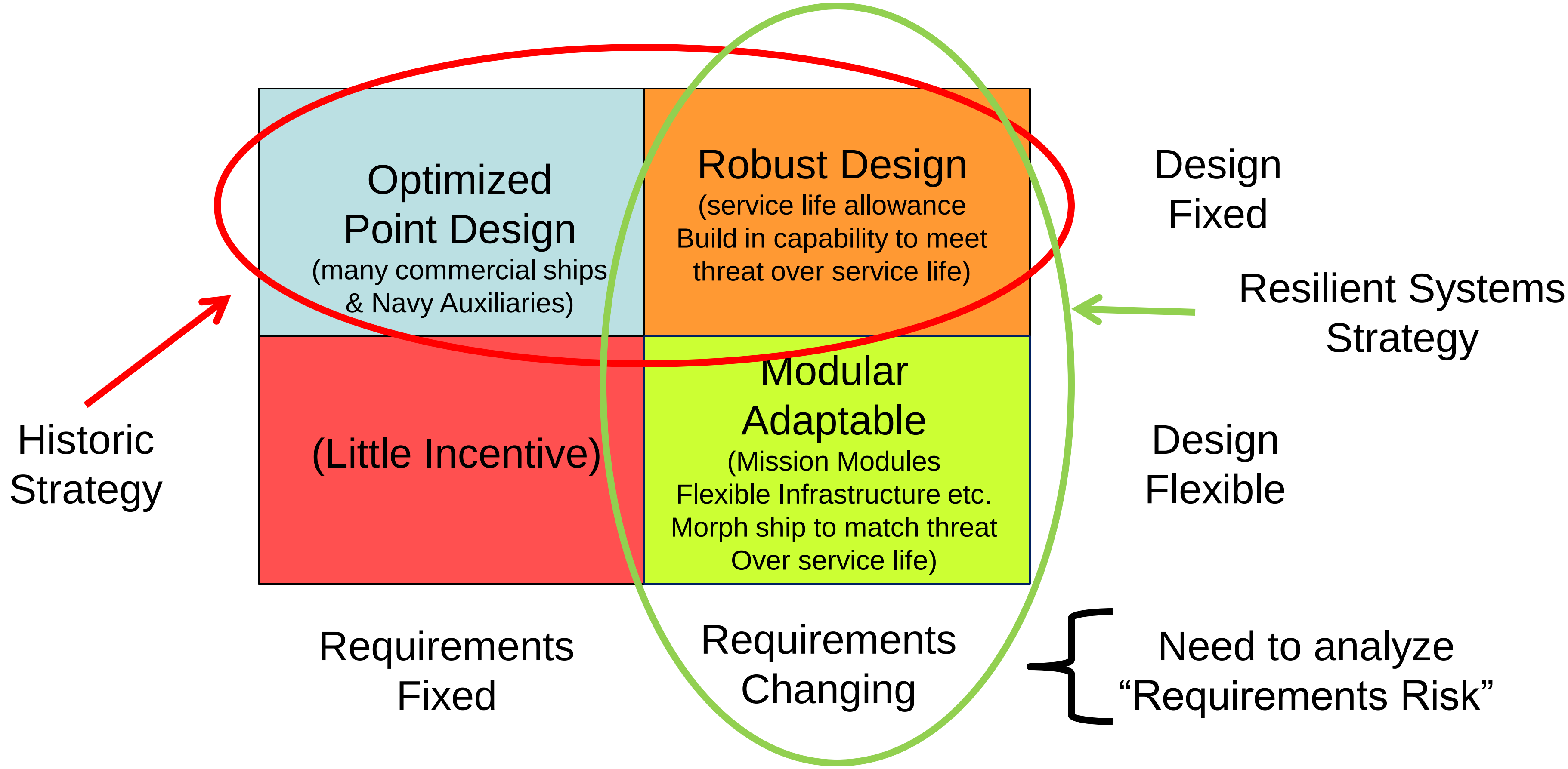
Design Strategies

	Requirements Fixed	Requirements Changing
Design Fixed	Optimized Point Design (many commercial ships & Navy Auxiliaries)	Robust Design (service life allowance Build in capability to meet threat over service life)
Design Flexible	(Little Incentive)	Modular Adaptable (Mission Modules Flexible Infrastructure etc. Morph ship to match threat Over service life)

Need to analyze "Requirements Risk"

A combination of strategies is likely optimal

Design Strategies

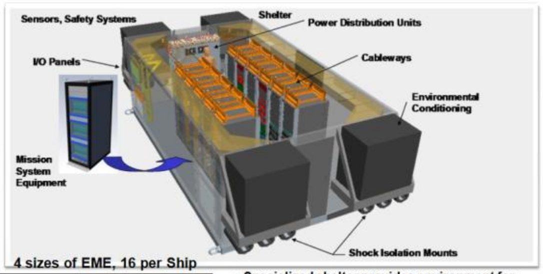


Keep Robust Design, but shift to Modular Adaptable Design

Modular Adaptable Ship Technology Examples

- "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

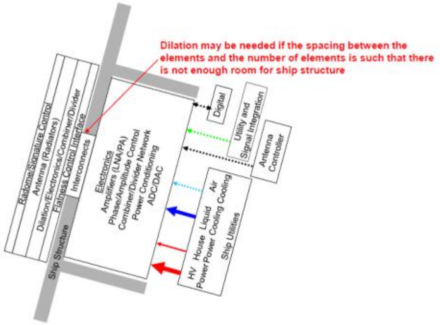
Electronic Modular Enclosures

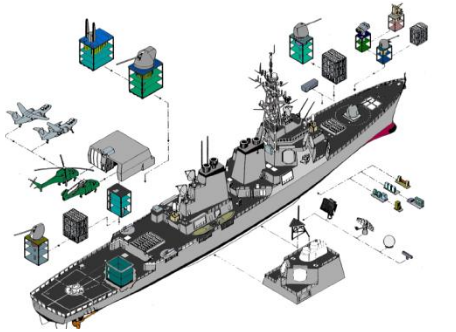


4 sizes of EME, 16 per Ship

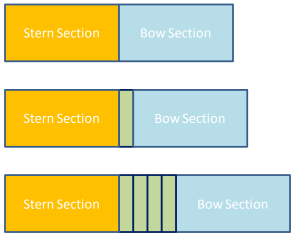
	Length	Width	Height
Mini	18 ft	7 ft	7.45 ft
Small	25 ft	11.8 ft	7.45 ft
Medium	30 ft	11.8 ft	7.45 ft
Large	35 ft	11.8 ft	7.45 ft

- 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

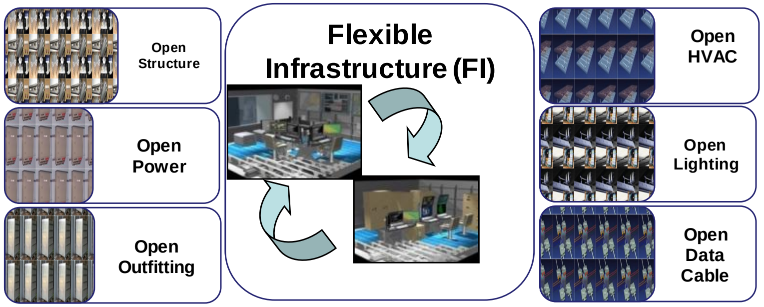




All impact electrical power system design



Schelde Naval Shipbuilding: Sigma Design Concept



Challenges

- How should flexibility be valued?
- Incorporate how much of what type of flexibility?
  - Return on investment calculations are not easy
    - future requirements are uncertain
    - future investment is uncertain
    - future return on the investment is uncertain
  - Net Present Value analysis is not ideal
    - Alternatives generally not equal in performance.
    - Does not value delaying decisions until more information is known about requirements.

"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.

Conclusion

- The Navy is continuing on the path to the Electric Warship.
  – Its more than just Electric Drive
- There are plenty of opportunities to influence future ship designs as well as back-fits into the existing fleet.
- Affordability will continue to be a major driver.
- Our community should spend time and resources on understanding how to best design power systems for future “Modular Adaptable Ships.”