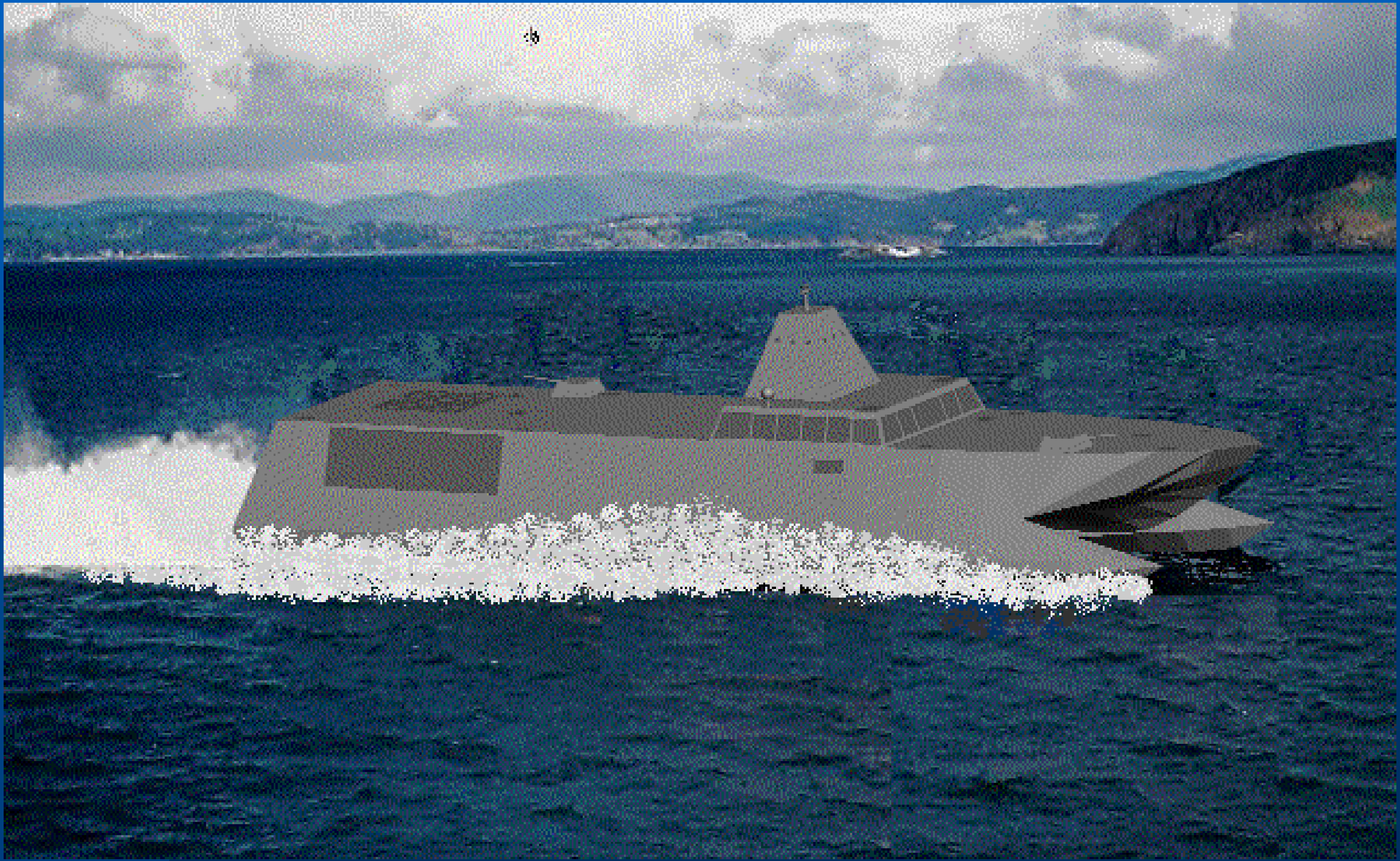
Total Ship Systems Engineering Program (TSSE)

Capstone Design Project

Naval Postgraduate School
Team 2000

SEA LANCE



Presentation Outline

- Introduction
- TSSE Program
- Operational Scenario
- Requirements Documents
- Alternative Architectures
- Measures Of Effectiveness
- Analysis Of Alternatives
- Design Drivers
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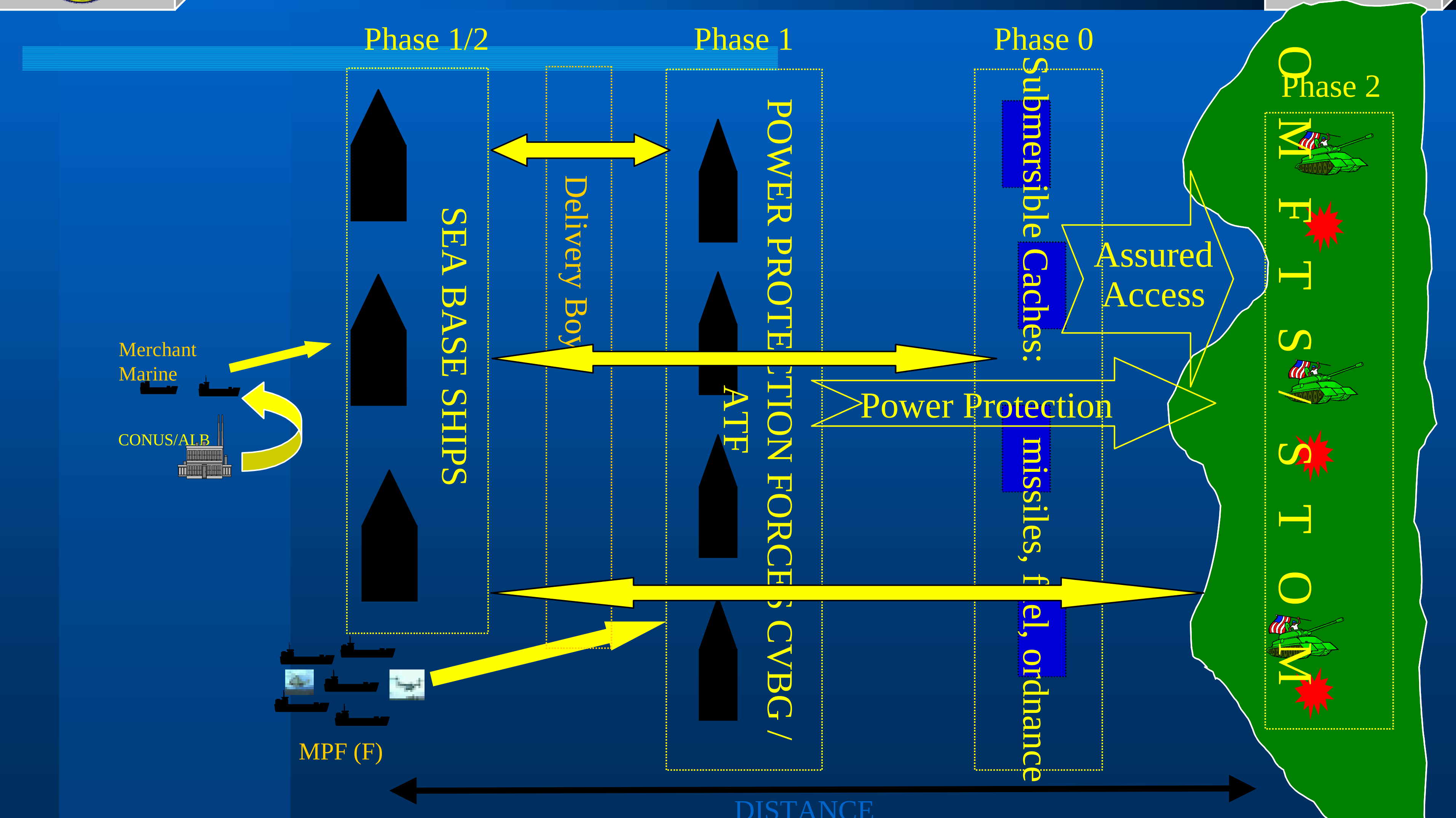
- Summary

Navy After Next Potential CONOPS



Who We Are

- TSSE Staff
  - Prof. Charles Calvano
  - Prof. Dave Byers
  - Prof. Robert Harney
  - Prof. Fotis Papoulias
  - Prof. John Ciezki
- Other NPS Staff
  - Prof. Wayne Hughes
  - Prof. Phil Depoy

- 2000 Design Team
  - LT Howard Markle
  - LT Karl Eimers
  - LT Rick Trevisan
  - LT Tim Barney
  - LTjg Ahmet Altekin
  - LT Chris Nash
  - LCDR Garrett Farman
  - LT Ricardo Kompatzki

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Program Content

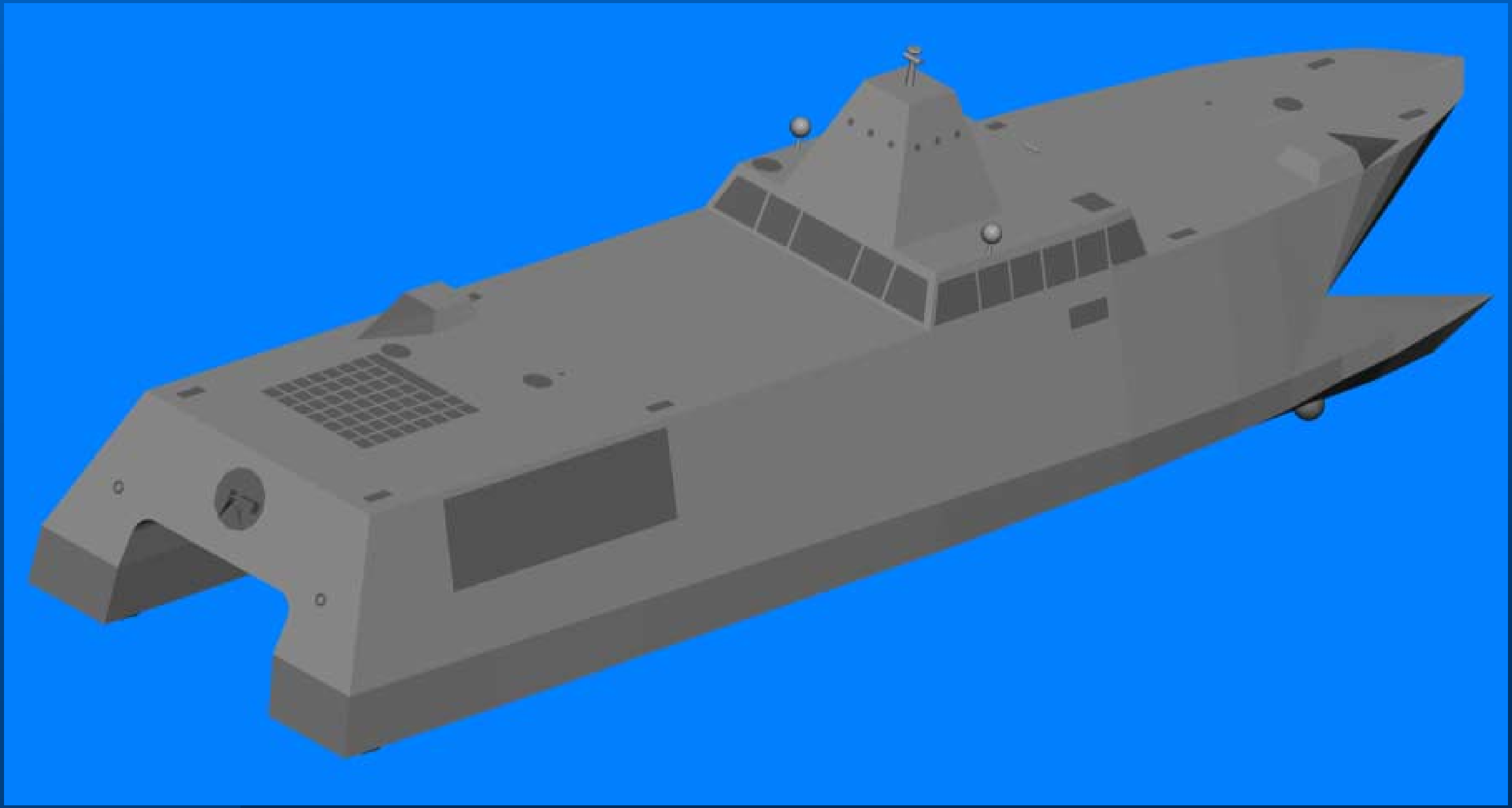
- In addition to other degree requirements, including thesis, the TSSE students take the following eight core courses, which are "the program".

- TS3000 Shipboard Electrical Power Systems
- TS3001 Fundamental Principles of Naval Architecture
- TS3002 Principles of Ship Design and Systems Engineering
- TS3003 Naval Combat Systems Elements
- TS4000 Naval Combat Systems Engineering
- TS4001 Design of Naval Engineering Systems
- TS4002 Ship Systems Integration
- TS4003 Total Ship Systems Engineering

Design Project History

TEAM	DESIGN PROJECT	TEAM COMPOSITION
AY92	Regional Deterrence Ship	4 USN
AY93	Large Missile Carrier	5 USN
	("Arsenal" Ship)	
AY94	Littoral Warfare "Mother Ship"	6 USN
AY95	Combined (USN/USCG)	5 USN, 3 USCG
	Patrol Corvette	
AY96	Arsenal Ship	10 USN, 4 USCG, 1 USMC
AY97	S-CVX	6 USN, 1 CIV
AY98	MPF Ships for 2010	6 USN
AY99	Surf. Warfare Test Ship	4 USN, 1 Hellenic Navy
AY00	Small Fast Networked combatant	6 USN, 1 Chilean, 1 Turkish

Sea Lance



TSSE Knowledge Scheme

TS3000,
3001, 3003

TS4002,4003

Capstone Design Project

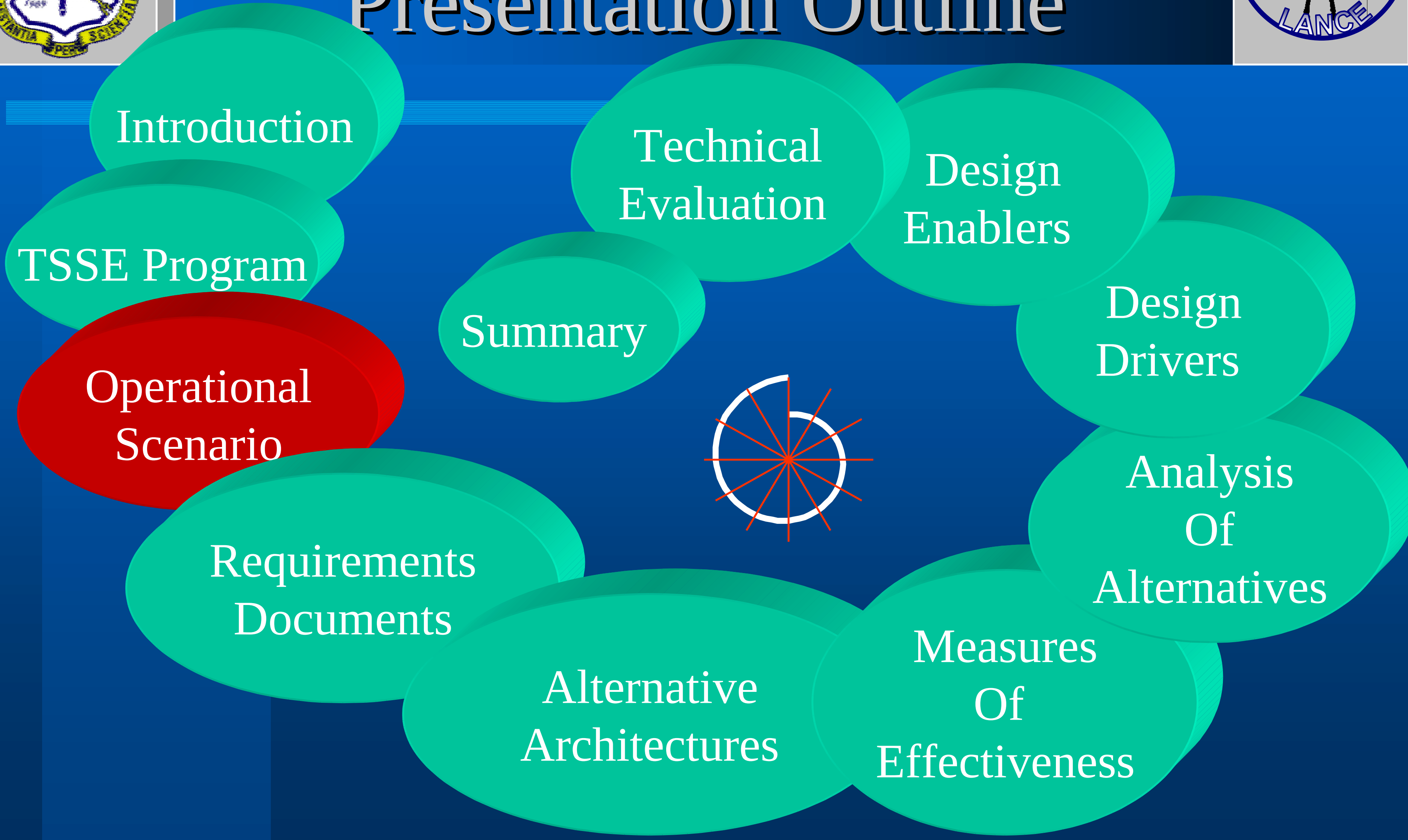
Realistic, Team-based Application

TS3002, 4000,
4001

TSSE Courses
Systems Engineering Principles and Process
Integration Processes and Techniques

MS Degree (ME/Physics/ECE) — Foundation
Engineering Understanding of Major Elements

Presentation Outline



SEA LANCE

- **S**eaborne
- **E**xpeditionary
- **A**ssets for

- **L**ittoral
- **A**ccess
- **N**ecessary in
- **C**ontested
- **E**nvironments

Expeditionary Grid Gaming

Sea Surface Units

Floating Weapons Buoy Canisters - Strike 2

TLAM:

Primary Function: Long-range subsonic cruise missile for attacking land targets.

Contractor: Hughes Missile Systems Co., Tucson, Ariz.

Power Plant: Cruise turbo-fan engine; solid-fuel booster

Length: 18 feet 3 inches (5.56 meters); with booster: 20 feet 6 inches (6.25 meters)

Weight: 2,650 pounds (1192.5 kg); 3,200 pounds (1440 kg) with booster, 3800 pounds in capsule

Diameter: 20.4 inches (51.81 cm)

Wing Span: 8 feet 9 inches (2.67 meters)

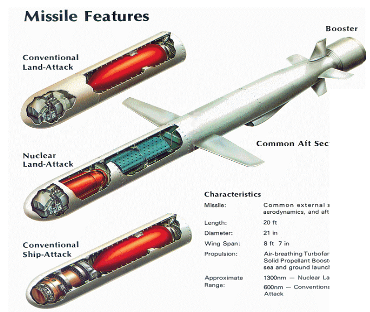
Range: Land attack, conventional warhead: 600 nautical miles (690 statute miles, 1104 km)

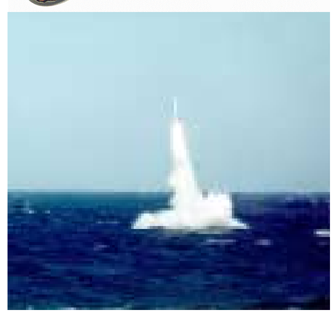
Speed: Subsonic - about 550 mph (880 km/h)

Guidance System: Inertial, TERCOM, and GPS

Warheads: Conventional: 1,000 pounds Bullpup, or Conventional submunitions dispenser with combined effect bomblets, or WDU-36 warhead w/ PBXN-107 explosive & FMU-148 fuze

Plays as: Regular Thawk with characteristics noted above; launched from standalone capsule vice platform.





Ref: FAS Web Site

99-NUWC/0594U.M4

CM Radar Picket

Antenna: Array of 6 dipoles @ 150 Mhz VHF

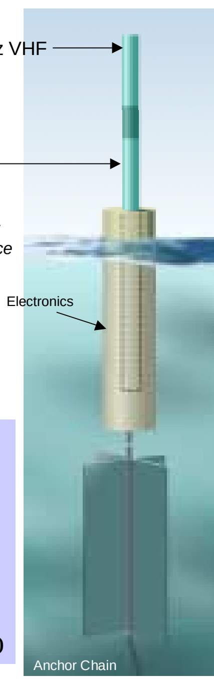
Height of 6 meters

Diameter of 6 to 12 inches

This section 4 to 6 meters

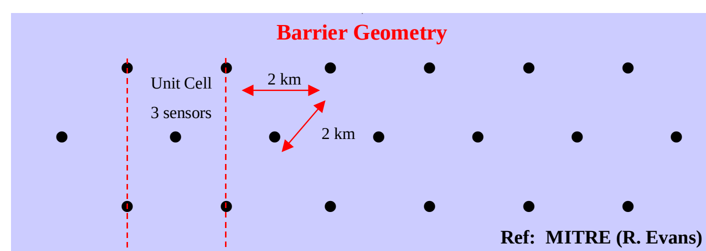
Water Surface

Electronics



Antenna covers 360° (omni-azimuth). Therefore, no angle info from a single sensor.

However, range and Doppler info on a target can be ascertained through an appropriate spacing of multiple sensors in a barrier configuration. The normal spacing between sensors would be 2 km, resulting in 1.5 sensors per kilometer of barrier length.

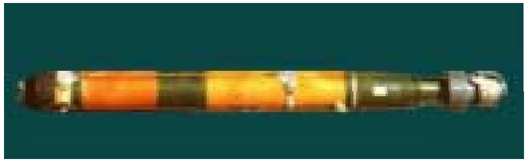


Ref: MITRE (R. Evans)

99-NUWC/0594U.M2

0160-BL

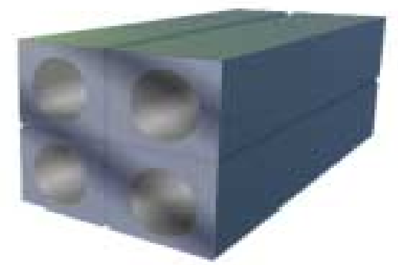
Heavyweight Torpedo Batteries



Primary Function ASW and ASUW Heavyweight torpedo for submarines
Power Plant Liquid (Otto) monopropellant fueled swash plate engine with pumpjet propulsor.
Length 19 feet (5.79 meters)
Weight 3,695 lbs (1662.75 kg) (MK-48 ADCAP)
Diameter 21 inches (53.34 centimeters)
Range Officially "Greater than 5 miles (8 km)"
Claimed

	40 kt	55 kt
MK-48 ADCAP	54,685 yd	42,530 yd

Weapon acquisition range 1600 yards
Speed Officially "Greater than 28 knots (32.2 mph, 51.52 kph)"
Reportedly - 40 - 55 kt.
Actual 55 knots
Depth Officially "Greater than 1,200 ft (365.76 meters)"
Reportedly 3,000 ft
Guidance System Wire guided and passive/active acoustic homing
Warhead 650 lbs (292.5 kg) high explosive



Assumed: 4 ADCAP-like units per launcher. Size of total package: 4ft x 4 ft x 20 ft; 20,000 lbs (See Bunker Estimation Technique, previous slide).

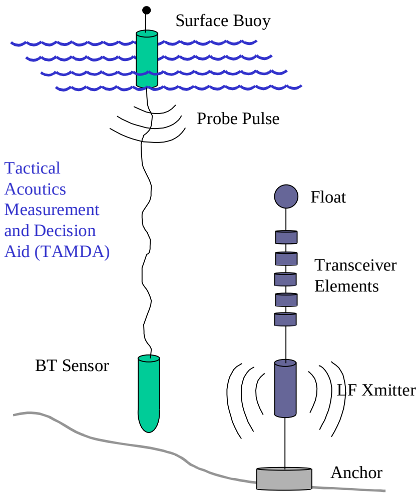
Note: These units are assumed to be able to communicate directly with undersea sensor nets (IUSS, ADS, and DADS).

Plays as: Torpedo Launch from point in space, vice submarine or surface platform.

Ref: FAS Web Site

99-NUWC/0594U.M6 0160-JR

TAMDA/LFAS Sources



TAMDA (surface, roughly sonobuoy size) provides, via a combination of probes, acoustic projections, and receivers acoustic environmental information on Bottom Reflection Loss, Reverberation, Bottom Depth, Bottom Type, Bottom Scattering Strength, sound velocity profile and ambient noise monitoring.

LFAS (bottom, roughly 21” dia and 10 ft long in capsule), acting in conjunction with other receiver sources or LFAS units, can act as an illuminator and receiver for multi-static targeting. It can also provide limited insitu environmental data, particularly direct measurement of propagation loss.

TAMDA or a similar environmental monitoring system will be necessary to plan and place bottom acoustic sensors effectively in the real world. An active source will also be necessary to mount an effective acoustic ASW campaign against modern SSs.

For Loop 3; TAMDA is assumed to be employed as a data-gathering device prior to the planning and placement of any acoustic fields. LFAS is presumed to be placed with each 100x100nmi DADS array, four to a field.

Notional Adversary

- Population 5 times U.S.
- GDP Comparable to U.S.
- Defense Budget ½ of U.S.
- Coast Line over ½ of it's borders
- Continental shelves extend to a maximum of 100 km offshore

Weapon Totals

	Carried	Required
AAW:	3,000	3,000
ASUW (Large):	340	400
ASUW (Small):	1,000	1,000
ASW:	160	100
STRIKE (Long):	300	300
STRIKE (Short):	700	700

NOTE: The 60 extra ASW weapons were applied to the ASUW (large) weapons requirement.

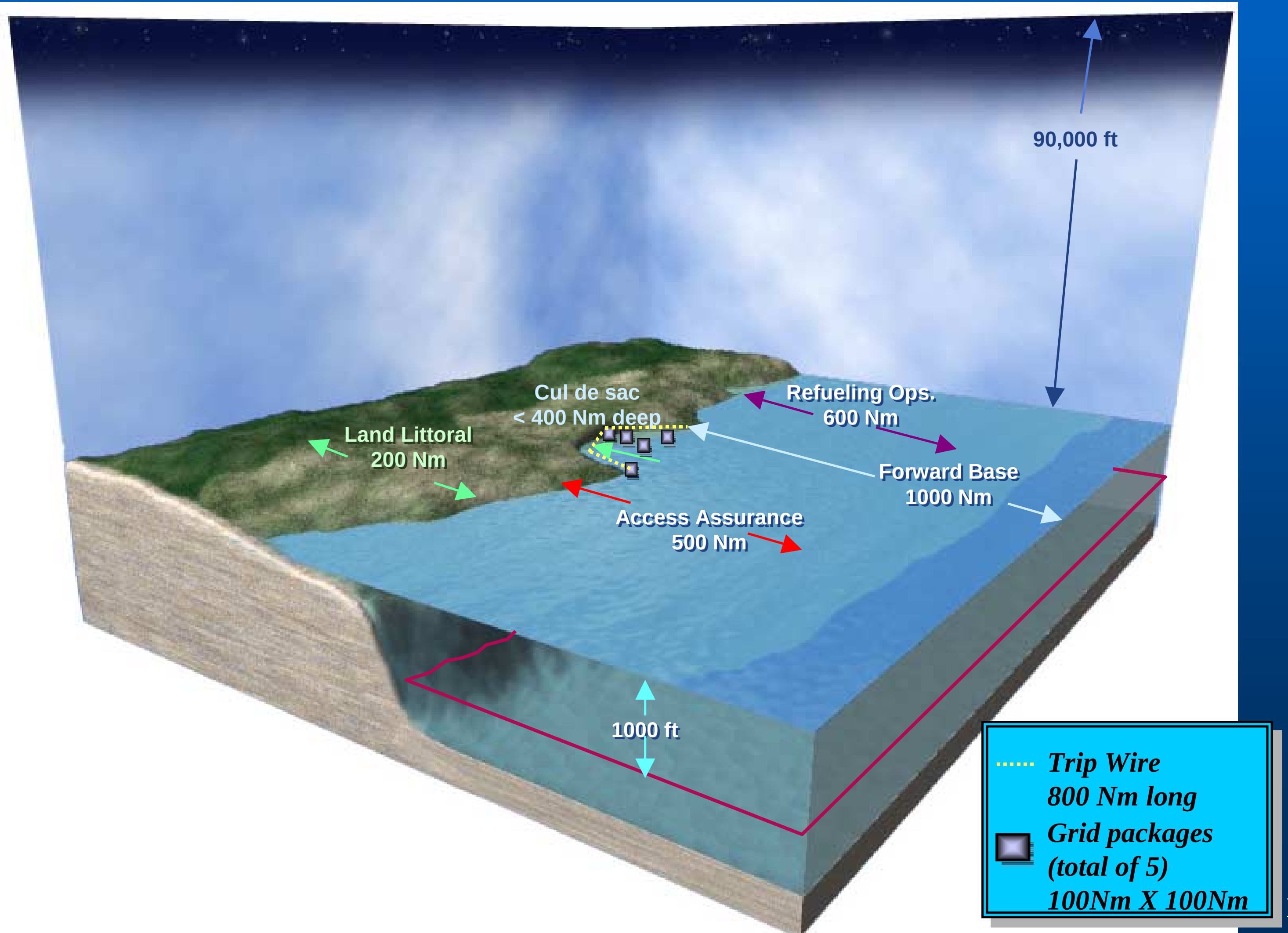
Weight and Volume

- **Total Volume** **170,000 ft^3**
- **Total Weight** **6,000 LT**
- **Total Cost** **??????**

CNAN Distributed Grid and Craft Payload

	Number Elements	Total Volume (ft^3/element)	Total Weight (Tons/element)
CM Radar Picket	1337	23,610	668
DADS	4160	1,602	208
TAMDA	20	8	1
LFAS	20	480	18
UC V Small	15	525	4
RSTA	12	4,944	148
IR SAM	2000	53,000	400
Air Mines	800	3,601	200
Tomahawk	300	13,959	570
SubBAT	500	1,200	48
FSAM	500	625	37
SM-3/TBMD	1000	19,360	2,000
NTACM	700	21,889	1,575
TORP BATT	40	12,783	399
H RPOON	340	10,540	432
		168,126 Total ft^3	5,989 Total LT

CNAN Geography



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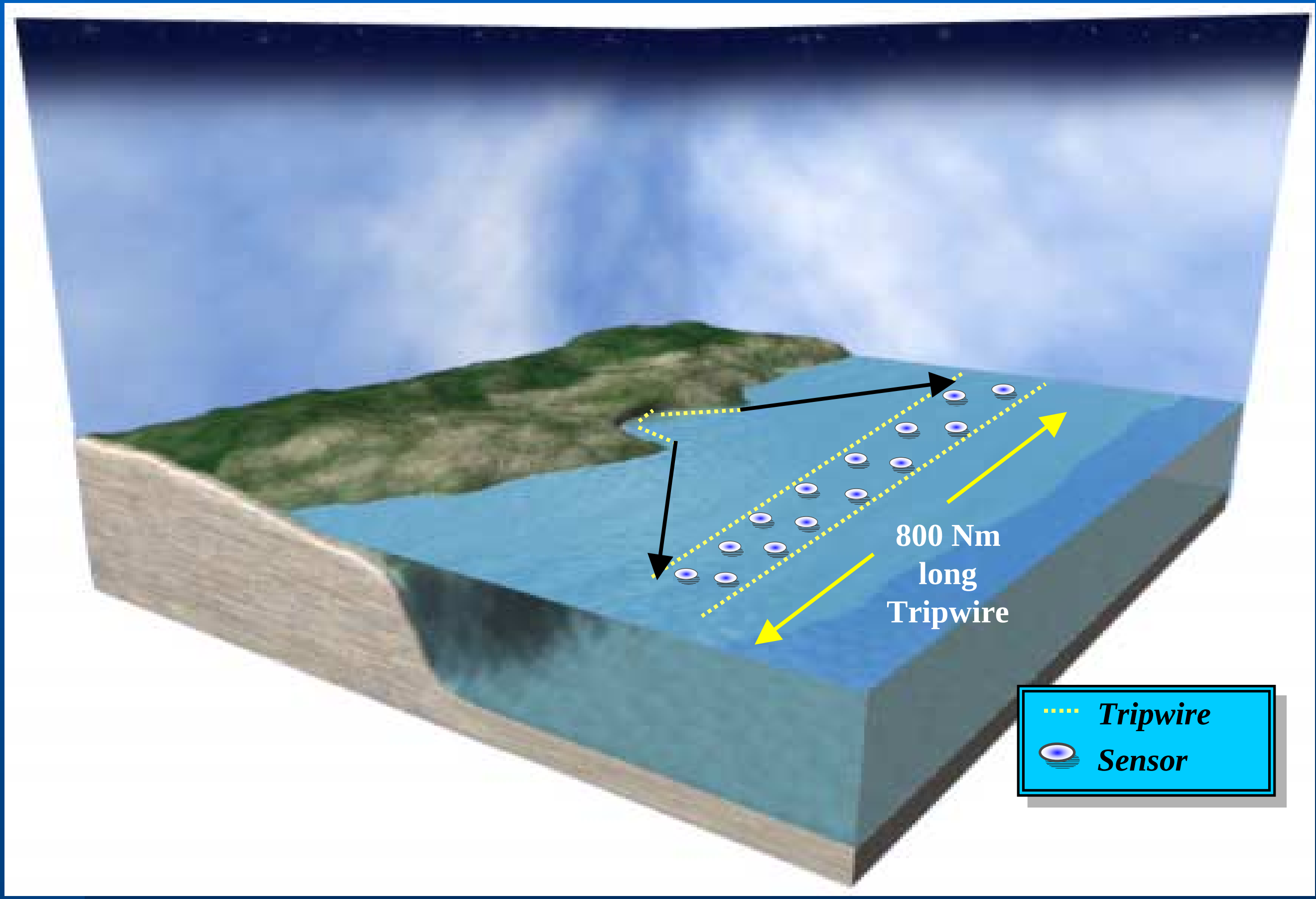
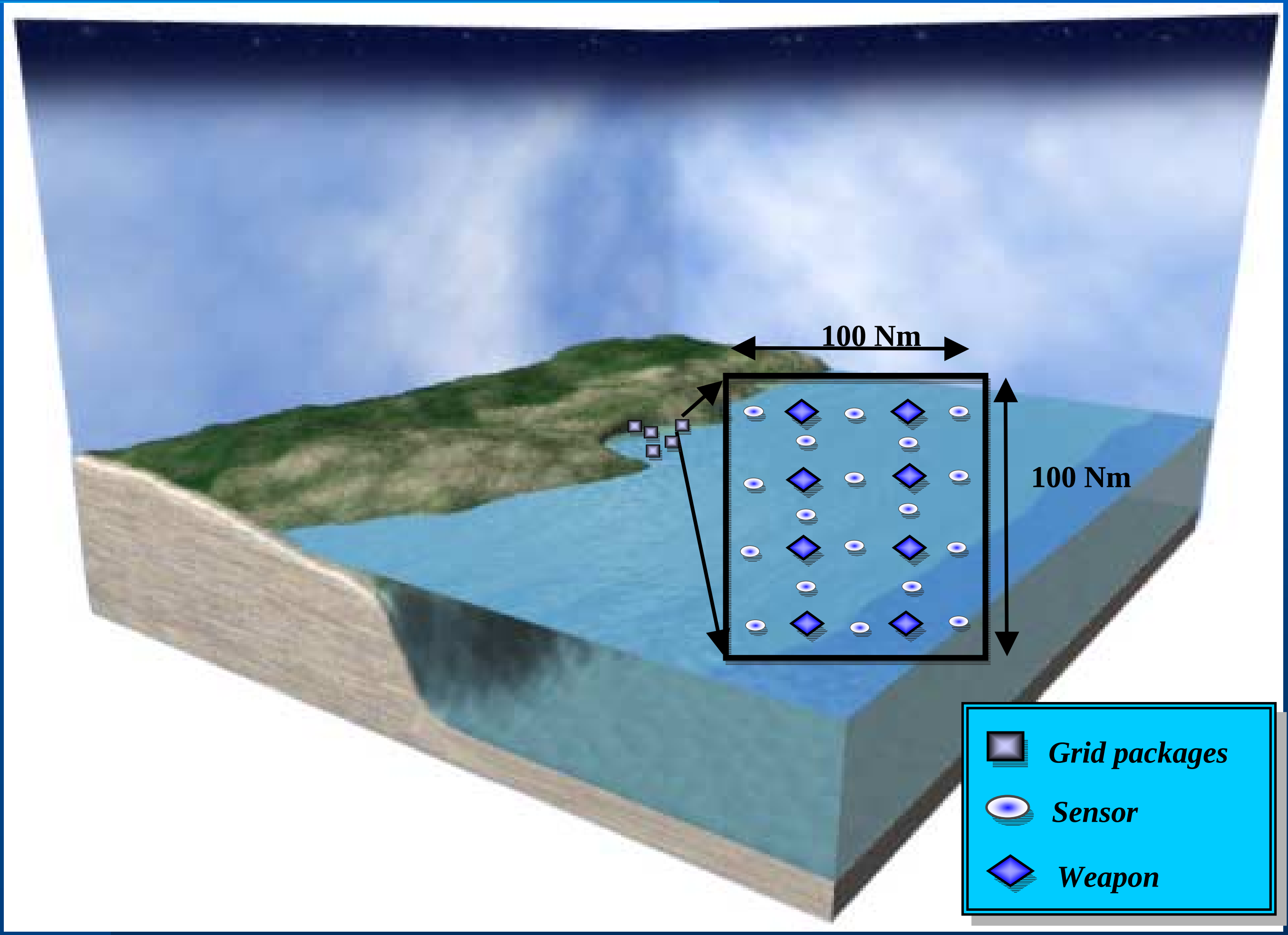
Tripwire Architecture



Grid Architecture



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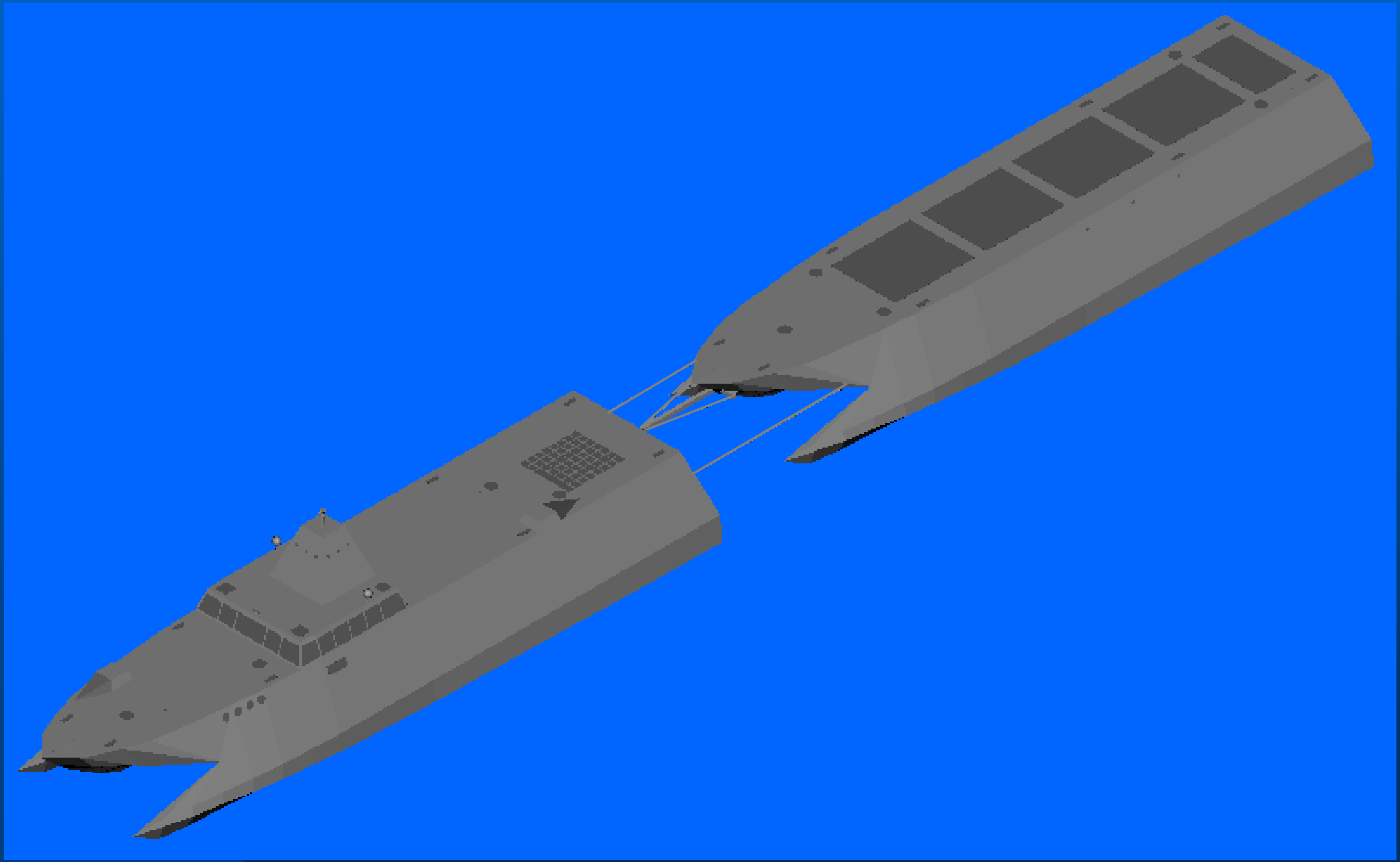
Combatant and GDM



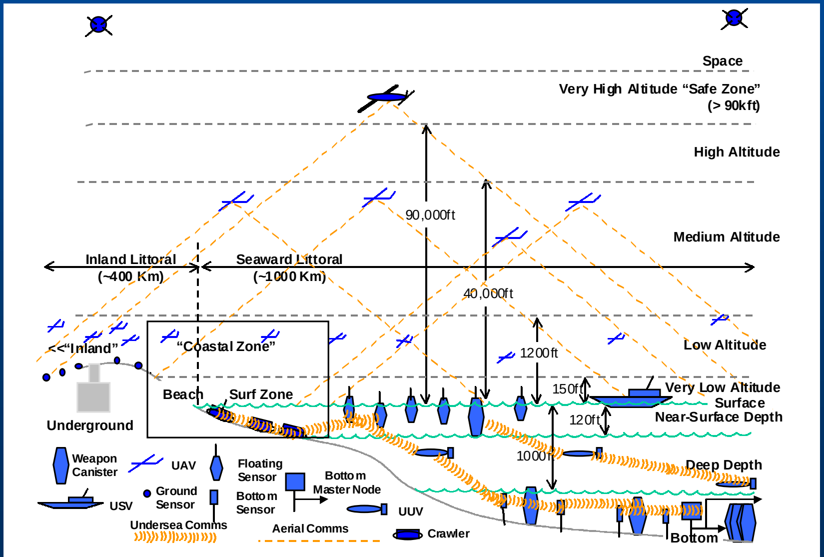
Required Operational Capabilities (ROC)

- Sea Lance
  - Grid Operations
  - Independent Operations
  - Special Operations
  - Escort Operations
  - Network Centric Warfare

Required Operational Capabilities

Sea Lance

- Grid Operations
- Independent Operations
- Special Operations
- Escort Operations
- Network Centric Warfare



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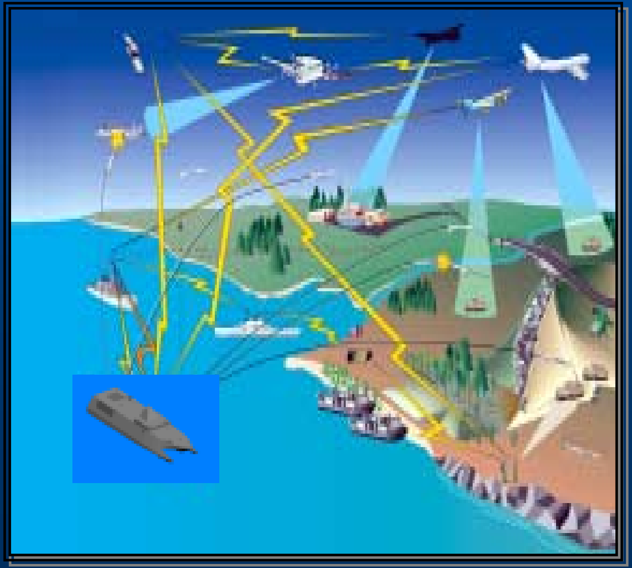


Required Operational Capabilities

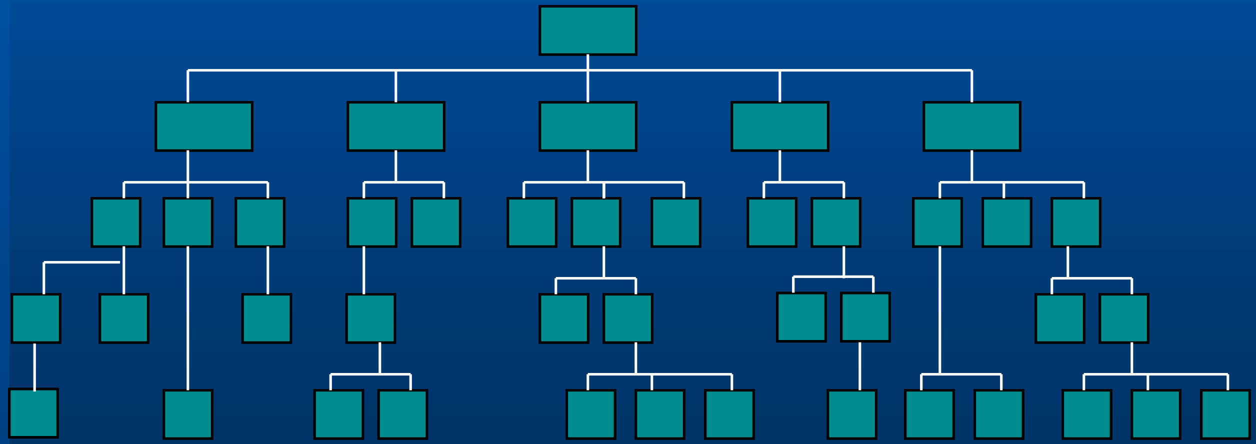
- Sea Lance
  - Grid Operations
    - Deploy Grid
    - Monitor Grid
    - Protect Grid
    - Control Grid
  - Independent Operations
  - Special Operations
  - Escort Operations
  - Network Centric Warfare

Required Operational Capabilities

- Sea Lance
  - Grid Operations
    - Deploy Grid
      - Deploy Sensor Grid
      - Deploy Weapons Grid
      - Deploy Tripwire
      - Deploy Weapons and Sensor Grid
    - Monitor Grid
    - Protect Grid
    - Control Grid
  - Indep. Ops
  - Spec Ops
  - Escort Ops
  - NCW

Functional Groupings

- Similarities throughout branches of the capabilities breakdown
- Created Functional Groupings



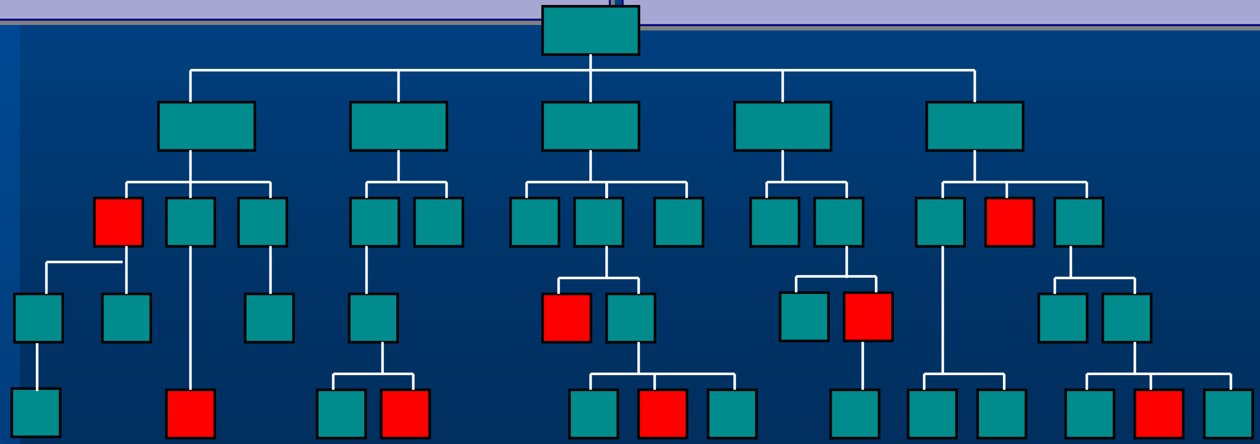
Functional Groupings

Combatant

- Maximum Speed 38 knots
- Range 3000 Nm at 13 knots
- Max crew size of 20
- Under $100 Million dollars
- Max displacement 1000 LT
- Transit in sea state 6, deployment in sea state 4

Sea Lance/Grid System

- Anti-ship missile defense
- Area air defense
- Interoperable with any Joint/Combined Task Force
- Operate in mined waters
- Perform precision strike



Presentation Outline

Introduction

TSSE Program

Operational Scenario

Requirements Documents

Alternative Architectures

Measures Of Effectiveness

Analysis Of Alternatives

Design Drivers

Design Enablers

Technical Evaluation

Summary

Alternative Architectures

- Medium Combatant (450 LT)
  with Tow (450 LT)
- All Medium Combatants (600 LT)
- A Mixture of Medium (800 LT)
  and Small (250 LT) Combatants

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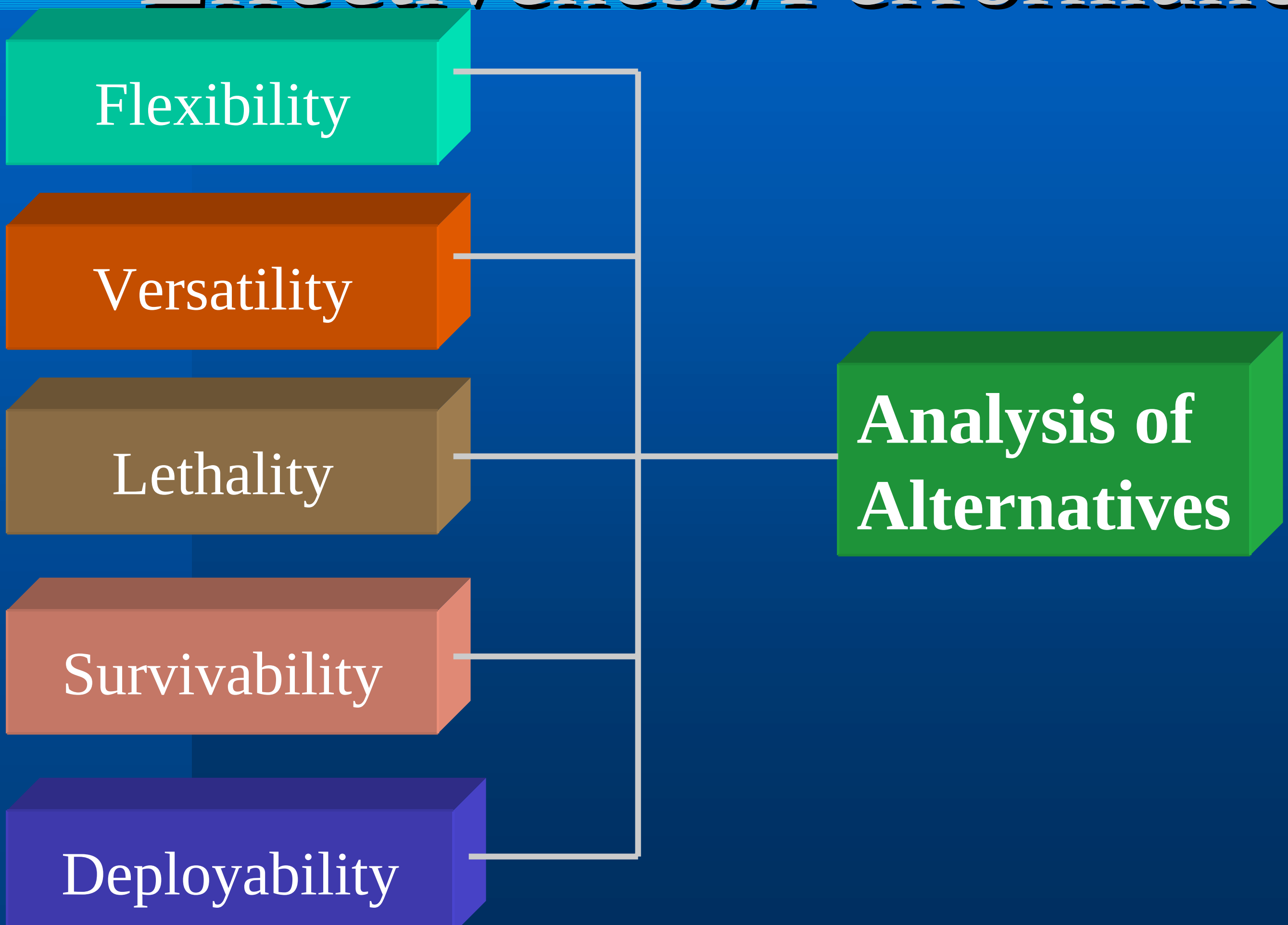
Measures Of Effectiveness/Performance

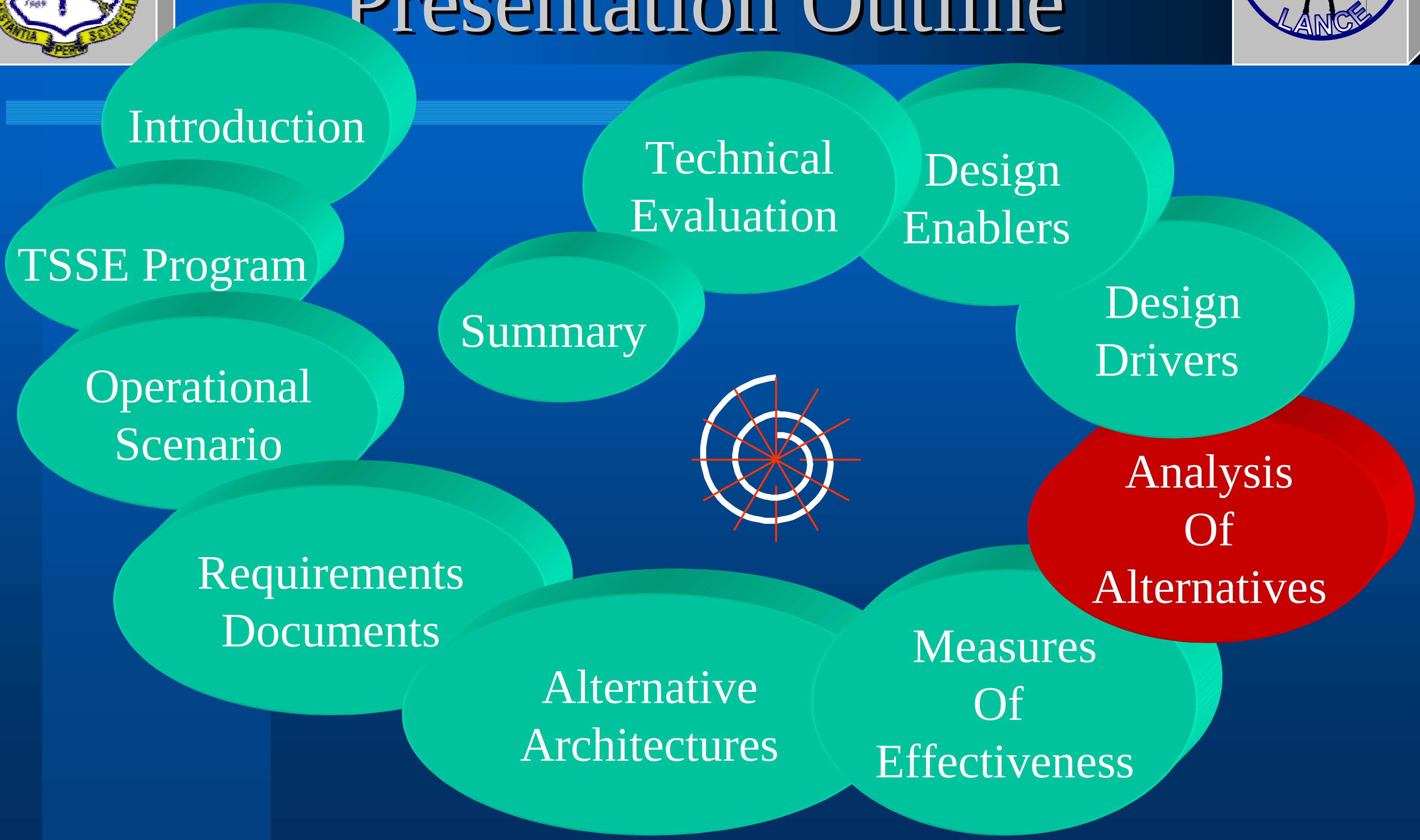


Measures Of Effectiveness/Performance

- **Determine Factors which affect each MOE/MOP**
- **Recurring Factors**
  - **Cost**
  - **Organic Weapon & Sensor Capability**
  - **Seakeeping**
  - **Speed**

Measures Of Effectiveness/Performance	Flexibility	Versatility	Lethality	Survivability	Deployability
1. Range	X				X
2. Speed	X		X	X	X
3. Grid Deployment Order	X				
4. Payload Capacity	X	X			
5. Sea Keeping	X		X		X
6. Organic Sensor Capacity	X	X	X		
7. Cost a. Total Fuel Consumed b. Number of personnel at risk c. Procurement d. Maintenance/Upkeep	X	X	X	X	X
8. Multiple Mission Capability		X			
9. Modularity		X			
10. Craft Organic Weapons		X	X		
11. Weapons Load Out			X		
12. Stealth			X	X	
13. Suceptibility a. Speed b. Stealth c. Point Defense	X		X	X	
14. Vulnerability a. Armor b. Redundancy c. Egress Capability d. Arrangement of Equipment/Spaces				X	
15. Endurance					X
16. Habitability					X
17. Logistic Support					X

Presentation Outline



Cost Analysis

- **Doubling displacement increases cost by a factor of 1.5**

$$Cost = (1.8066)\left(Displacement^{0.585}\right)$$

$$800 \text{ LT Option} = (1.8066)(800^{0.585}) = \$90{,}192{,}000 \approx \$90 \text{ Million}$$

$$600 \text{ LT Option} = (1.8066)(600^{0.585}) = \$76{,}222{,}000 \approx \$76 \text{ Million}$$

$$450 \text{ LT Option} = (1.8066)(450^{0.585}) = \$64{,}416{,}000 \approx \$64 \text{ Million}$$

$$250 \text{ LT Option} = (1.8066)(250^{0.585}) = \$45{,}672{,}000 \approx \$46 \text{ Million}$$

Option I (450 LT with 450 LT Tow):	**50 Craft (400 LT)** **50 GDM (400 LT)** **$4.17 Billion**
Option II (600 LT):	**60 Craft** **$4.57 Billion**
Option III (250 LT and 800 LT):	**45 Craft (250 LT)** **45 Craft (800 LT)** **$6.11 Billion**

Cost Analysis

- **Equalize option costs based on most expensive option**

Option I (450 LT Combatant):	**$64 Million per craft**
	Additional $1.94 Billion
	30 Additional Craft
Option II (600 LT):	**$76 Million per craft**
	Additional $1.54 Billion
	20 Additional Craft
Option III (250 LT and 800 LT):	**Additional $0 Billion**
	0 Additional Craft

Analysis of Alternatives

250 LT and 800 LT

Advantages	Disadvantages
Fighter and Freighter	Combatant Capabilities
Plenty of Volume/Weight	800 LT Utility
No Tow Speed Limitations	800 LT Liability
	Relative Stealth
	Expensive

Deployability | Survivability | **Lethality** | Versatility | Flexibility

Analysis of Alternatives

450 LT with 450 LT Tow

Advantages	Disadvantages
Good Payload Fraction	High risk
Plenty of Volume	Combatant/Tow Motions
Genuine Combatant	Reduced Speed
Increased Range	
Commonality of Hull Forms	

Deployability Survivability Lethality Versatility Flexibility

Analysis of Alternatives

600 LT

Advantages

- Only one Hull Design
- No Tow Speed Restriction
- Smaller RCS than 800LT

Disadvantages

- Limited after Deployment
- Weight/Volume Limitations
- Fighter and Freighter
- Relative Stealth
- Expensive

Deployability | Survivability | Lethality | Versatility | Flexibility

Analysis of Alternatives

Catamaran

Advantages	Disadvantages
Proven Technology	Higher risk
Stability/Deployability	Weight Limitations
High Speed Performance	Accelerations
Increased Volume/Deck Area	
Stealth Attributes	

Deployability | Survivability | Lethality | Versatility | Flexibility

Analysis of Alternatives

Diesels Vs. Gas Turbine

Water Jets Vs. Propellers

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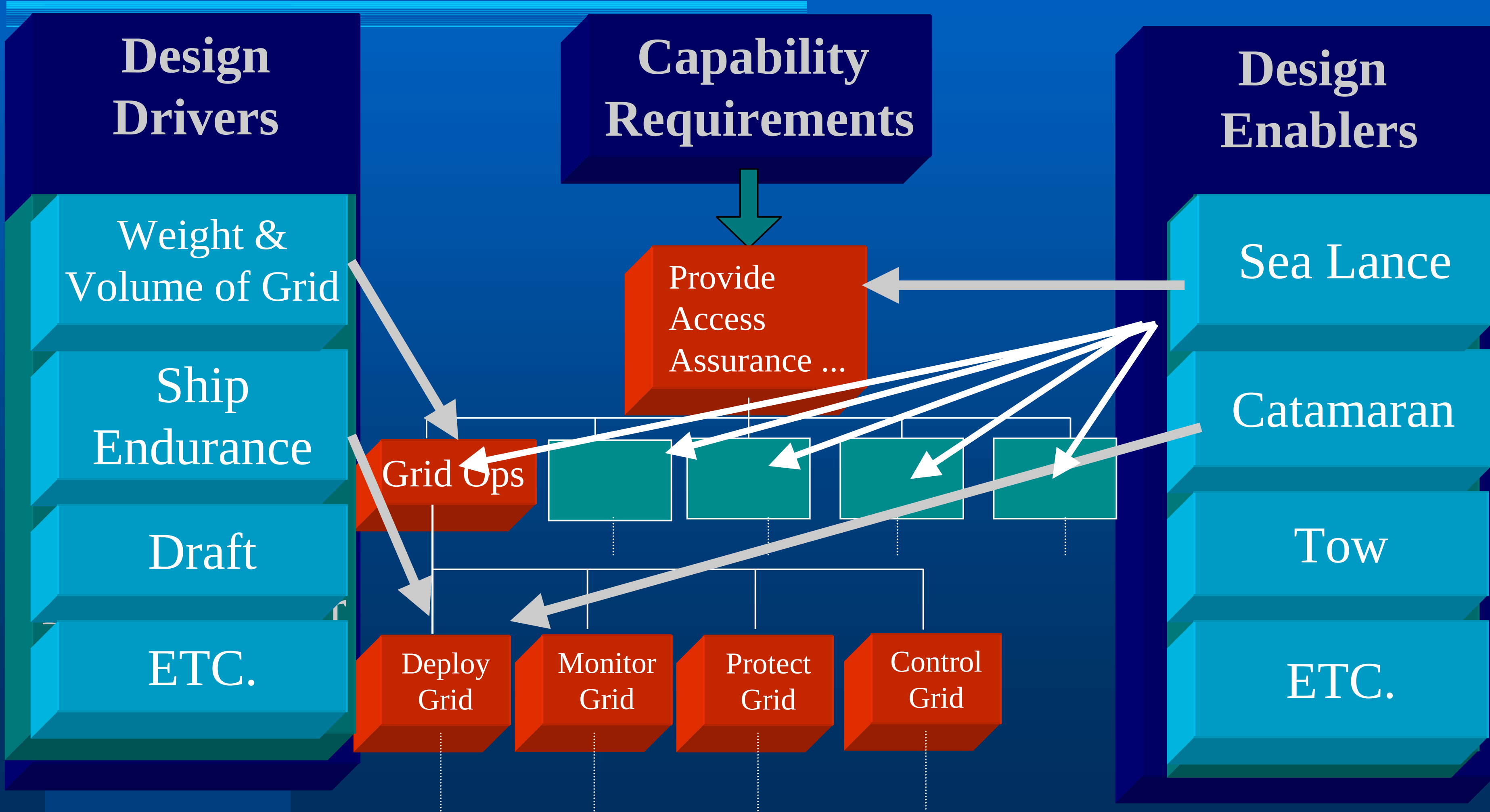
Matching Enablers to Drivers



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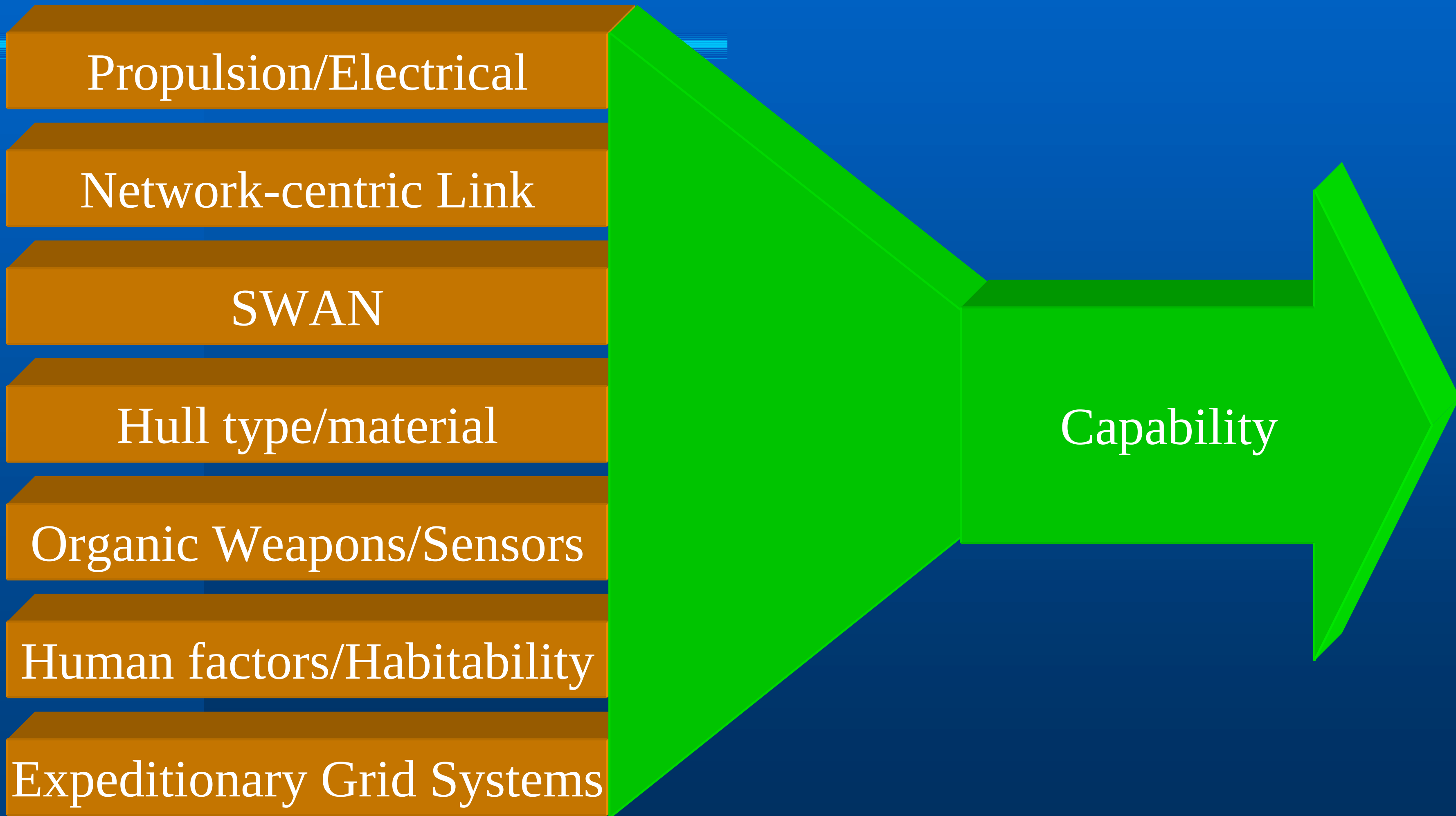
Technology to Capability



Technology to Capability

- Propulsion/Electrical
- Network-centric Link
- SWAN
- Hull type/Material
- Organic Weapons/Sensors
- Human factors/Habitability
- Expeditionary Grid Systems

Capability

Diesel Vs. Gas Turbine

- Fuel Consumption
- Weight
- Reduction Gear
- Intakes / Exhaust
- Maintenance
- GT Break-through?

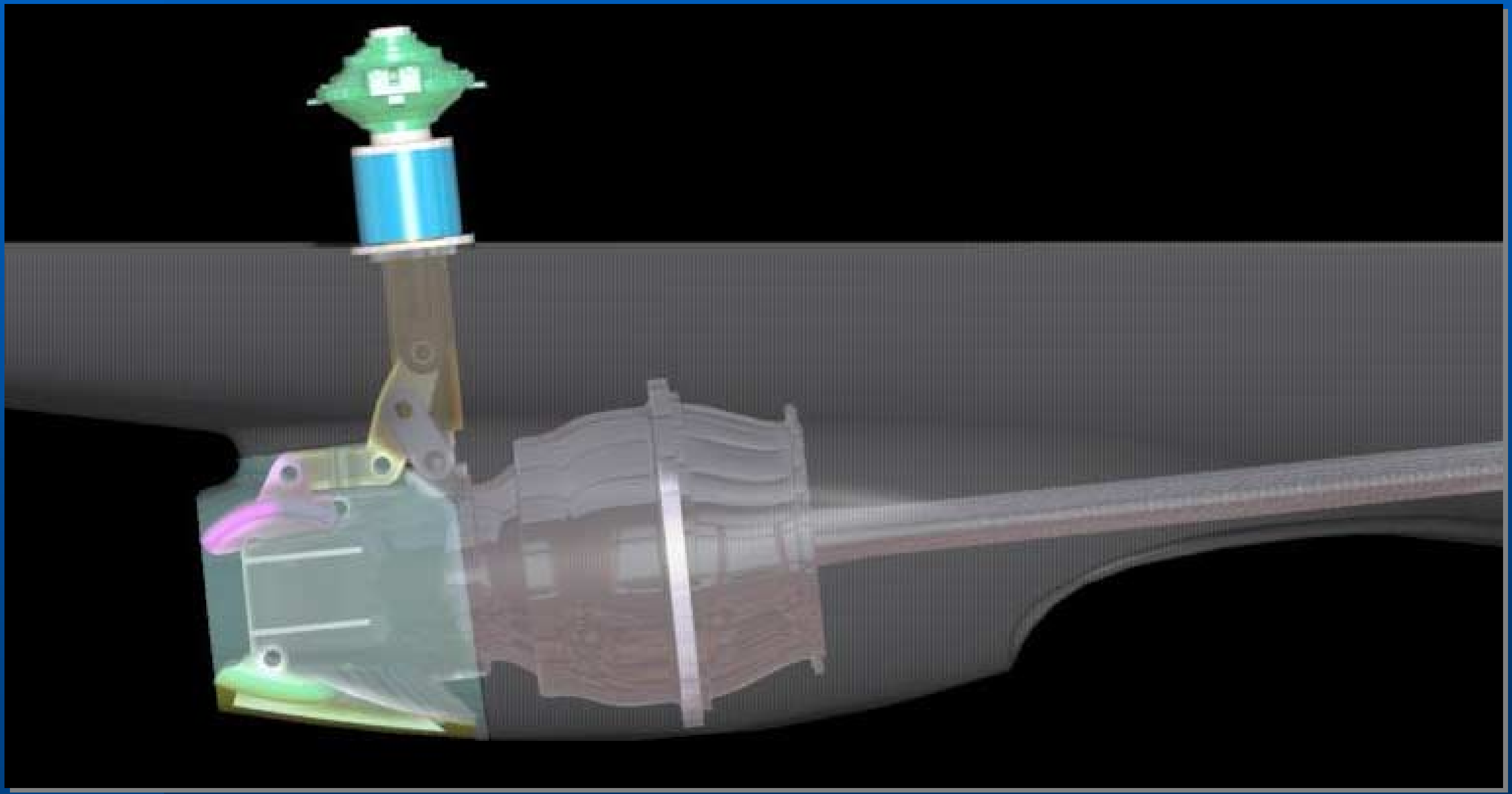
Conventional Vs. Electric Drive

- ↓ **Fuel Efficiency**
  - **7% Transmission loss**
  - **5% Best Case SFC bonus**
- ↑ **Weight**
  - **Extra Electric Motors**
  - **Larger Generators and Rectifiers**
- ↑ **Cost & Risk**
- ☑ **Dovetail DD21**

Propulsors

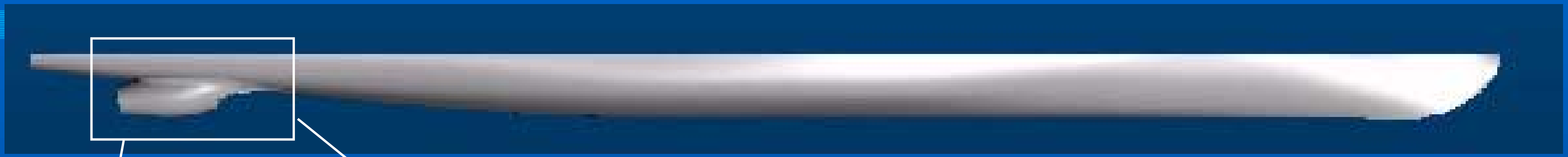
- Propeller
  - Size & Reduction Gear
  - Performance while planing
- Conventional Waterjet
  - 15 knot efficiency
- Bird-Johnson AWJ21
  - Efficiency / Cavitation
  - Risk

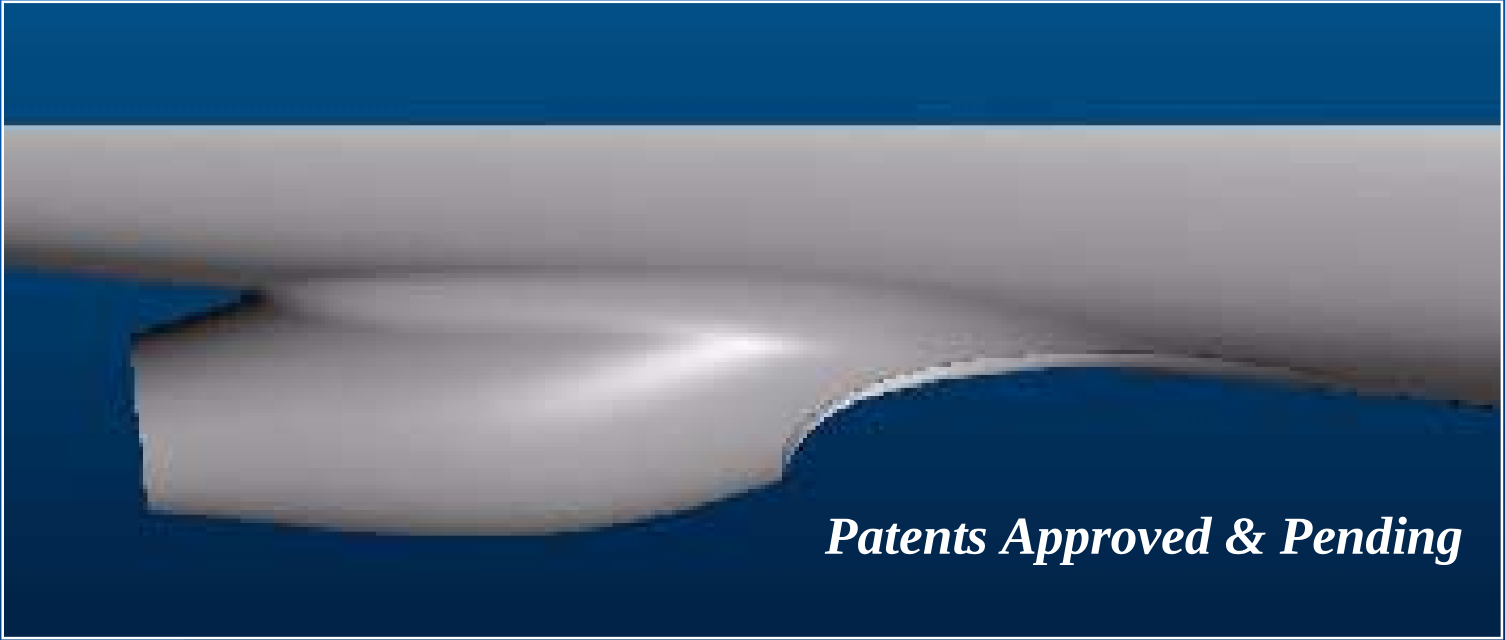
Bird-Johnson AWJ21



Bird-Johnson
Proprietary

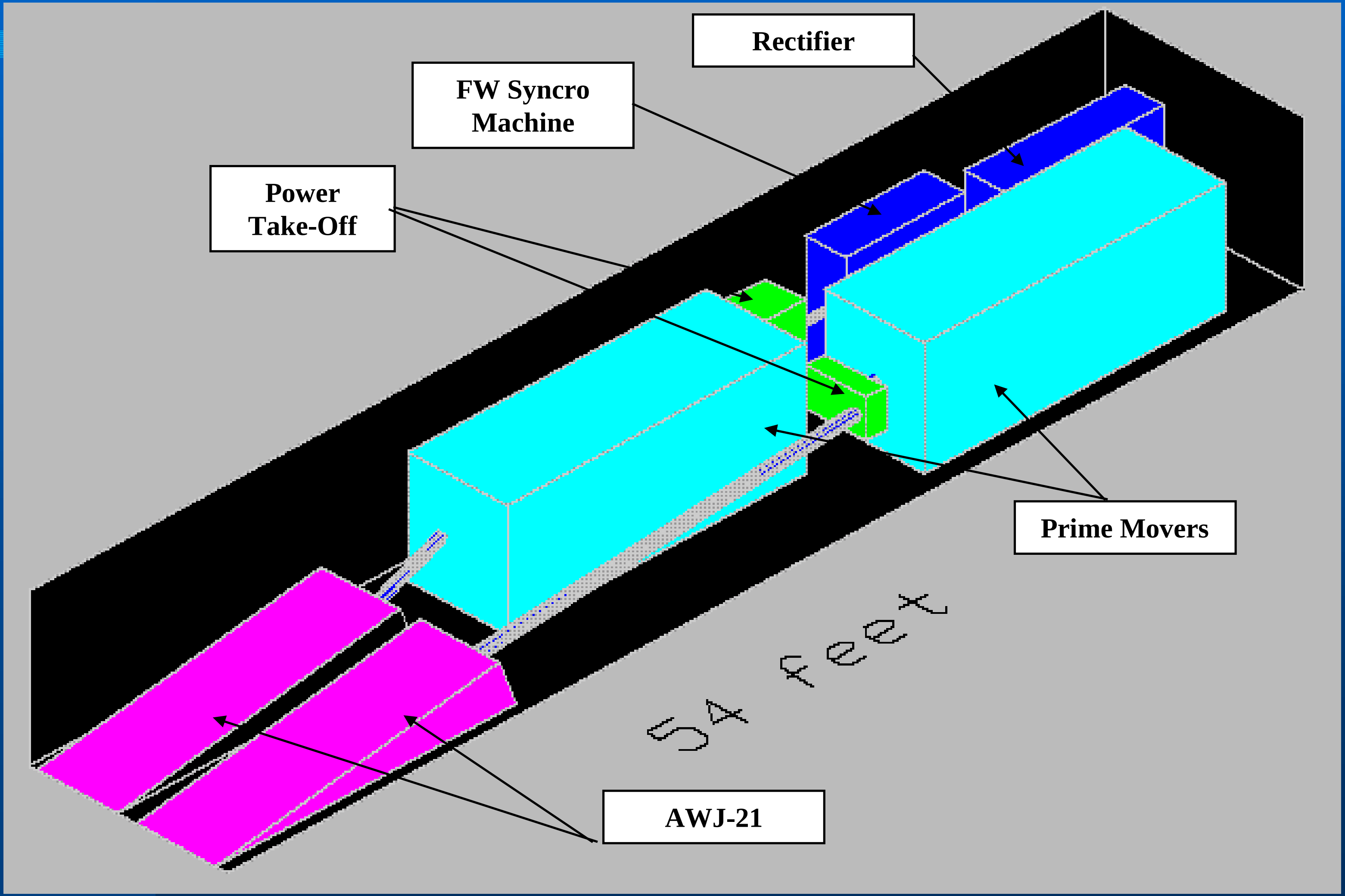
Bird-Johnson AWJ21





Bird-Johnson Proprietary

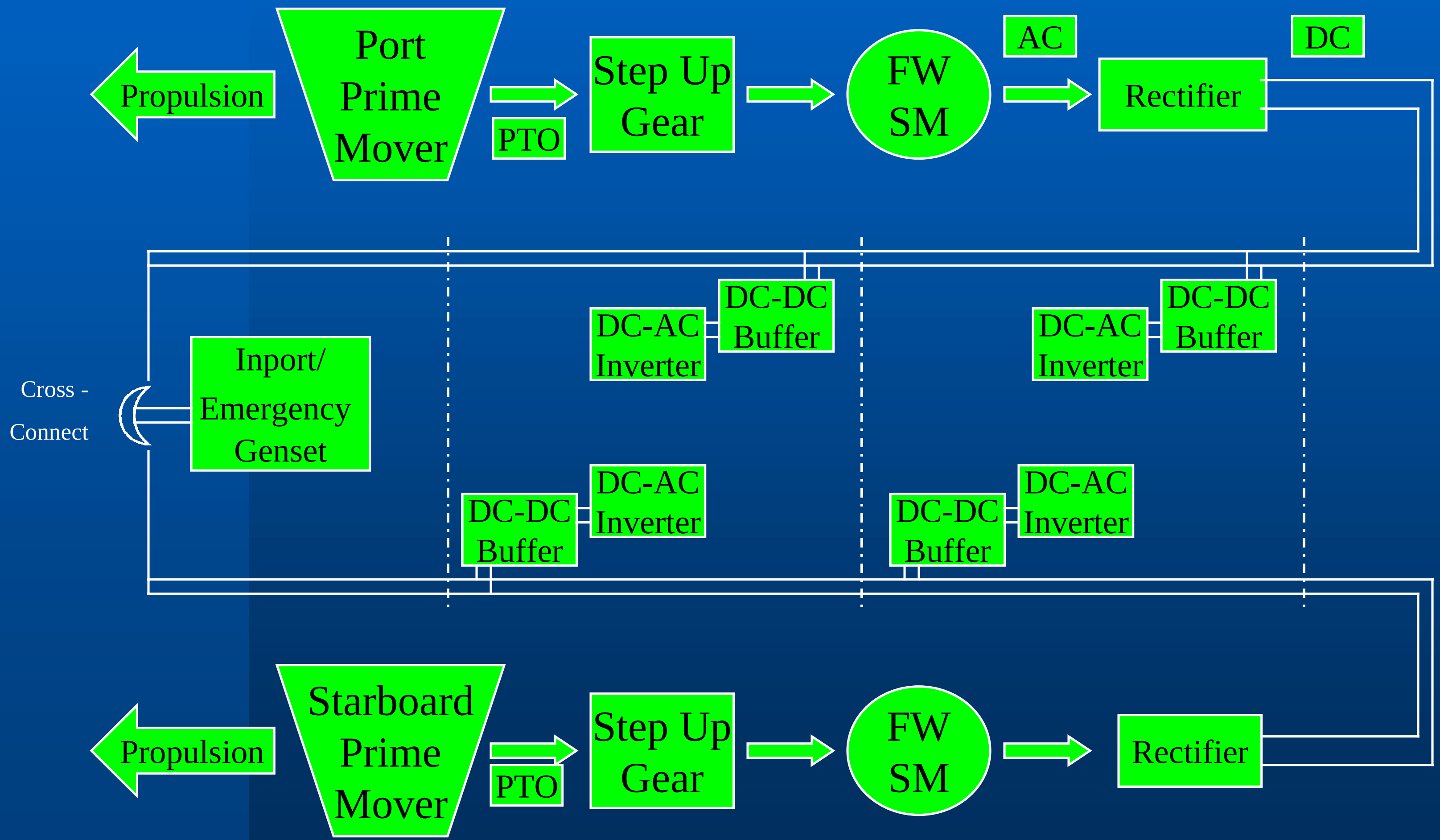
Engine Room


Rectifier
FW Syncro Machine
Power Take-Off
Prime Movers
54 feet
AWJ-21

Electric Power System

- TOSA
  - Flexibility & Upgrades
- PTO Power Generation
  - Simplicity & Weight savings
- DC Zonal Distribution
  - Simplicity & DD 21 Dovetail

DC Zonal Distribution



Technology to Capability

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- Hull type/material
- Organic Weapons/Sensors
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- Expeditionary Grid Systems

→ Capability

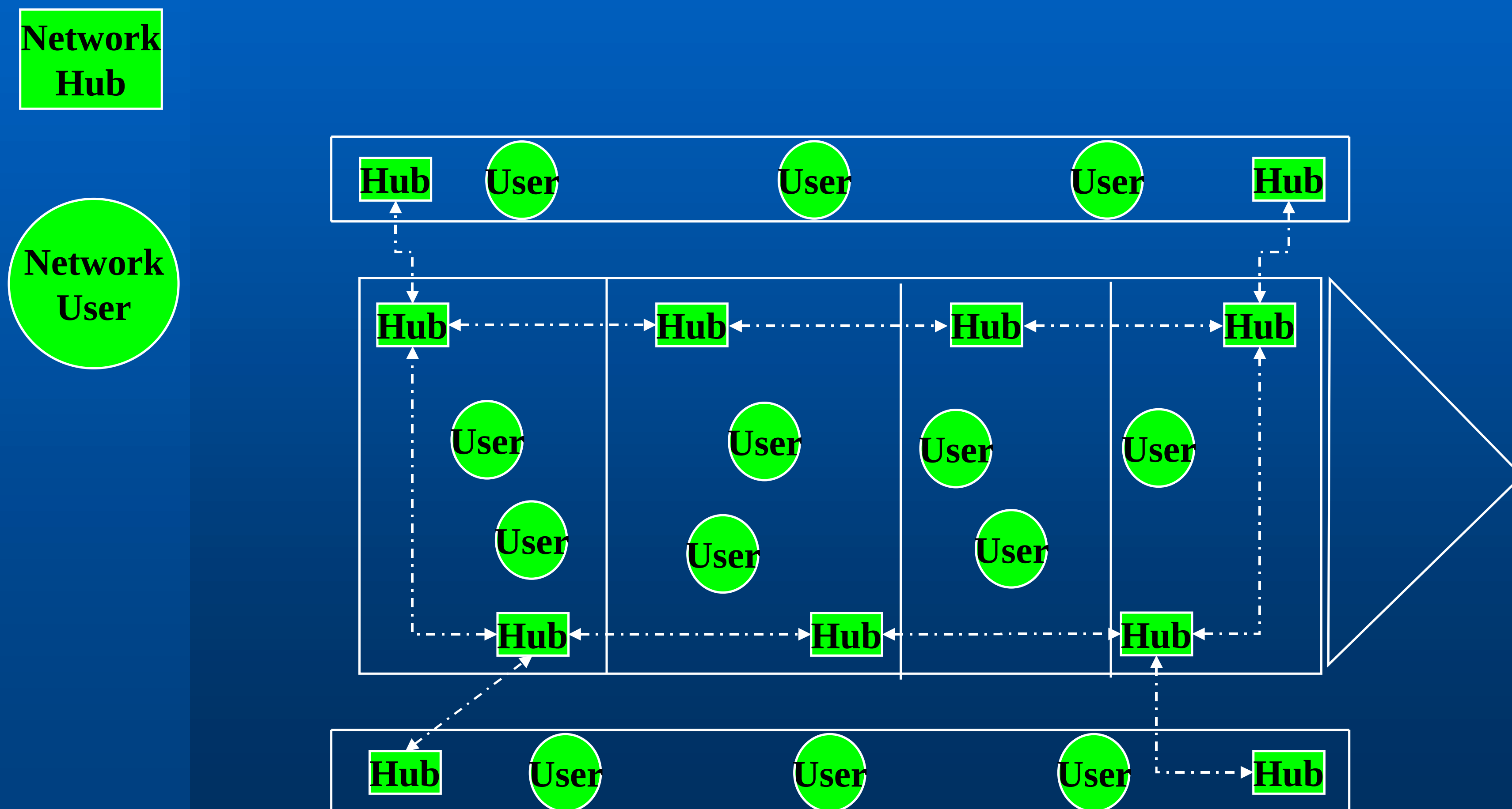
Sea Lance C4ISR

- Grid "Teamnet"
- Notional Idea
  - Acoustic Modems
  - RF Gateways
- Exterior Net
  - Tadil J/Link 16

Sea Lance C4ISR

- Combatant Comms
  - Ship to Ship/Air
    - VHF
    - UHF
  - Satellite
    - EHF (MILSTAR)
    - Global Broadcast System
  - Data Links
    - Teamnet
    - Tadil J/Link 16

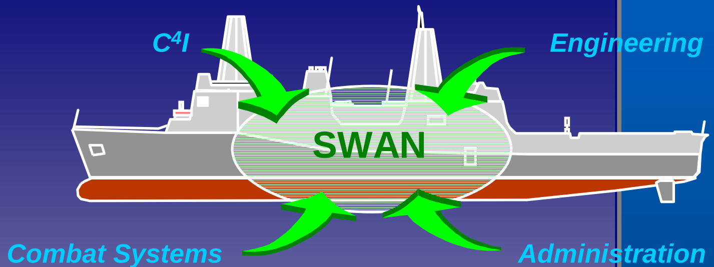
Combatant Onboard Network

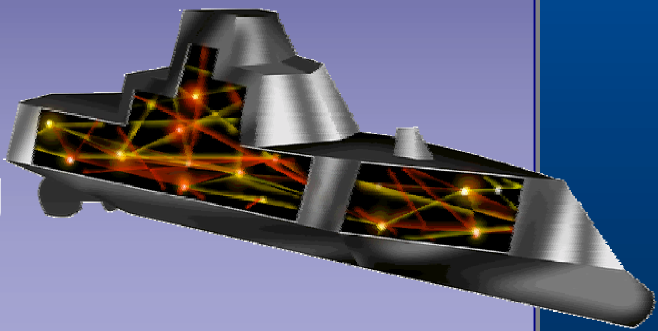


Combatant Onboard Network

- Fast Ethernet Mesh LAN
  - Reliable & Inexpensive
- Functional Separation
  - Flexibility & Up-gradable
- Total Integration
  - Operational systems
  - Engineering control & sensing
  - Combat Systems
  - Administrative

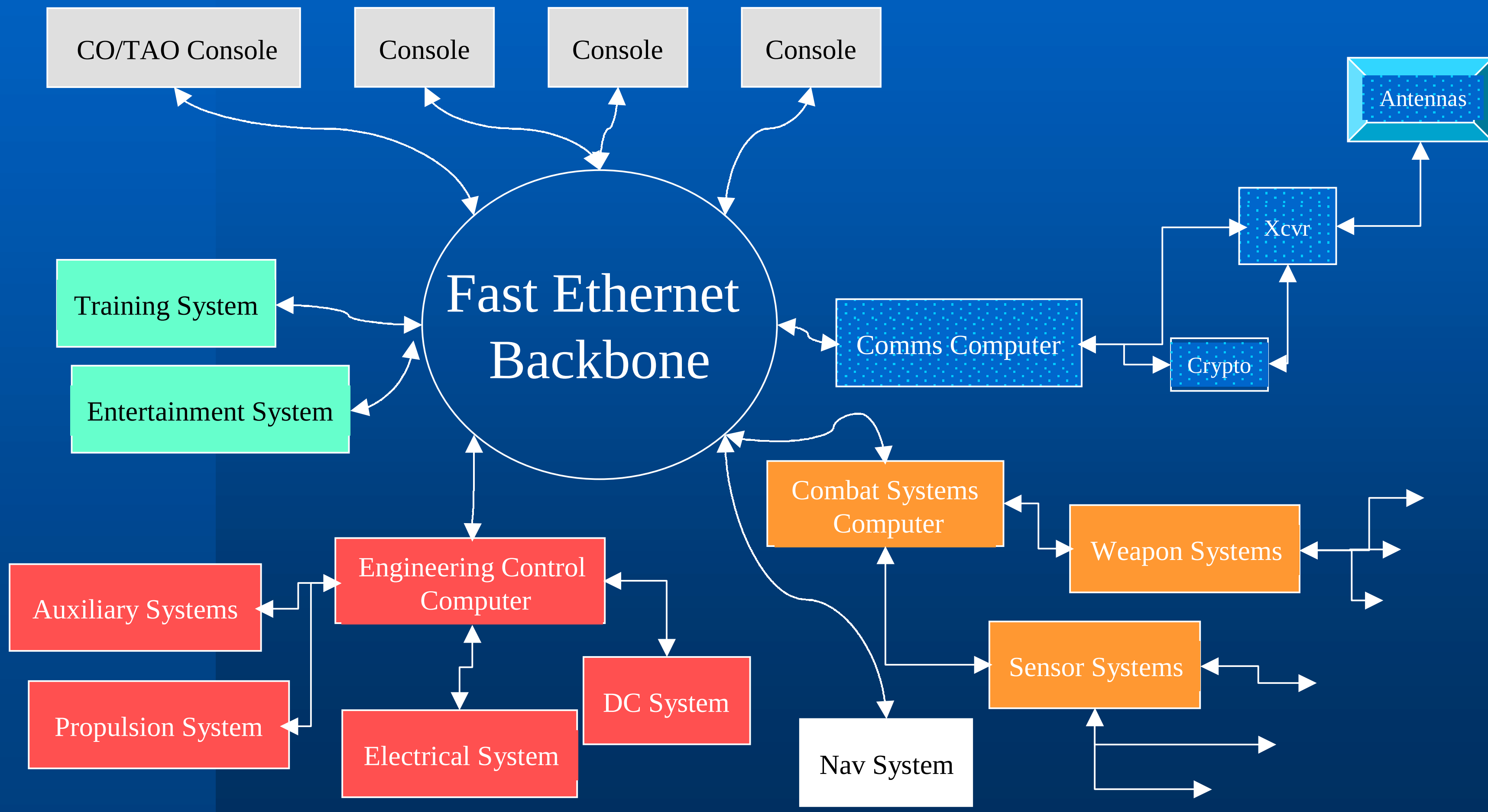
LPD 17





DD 21

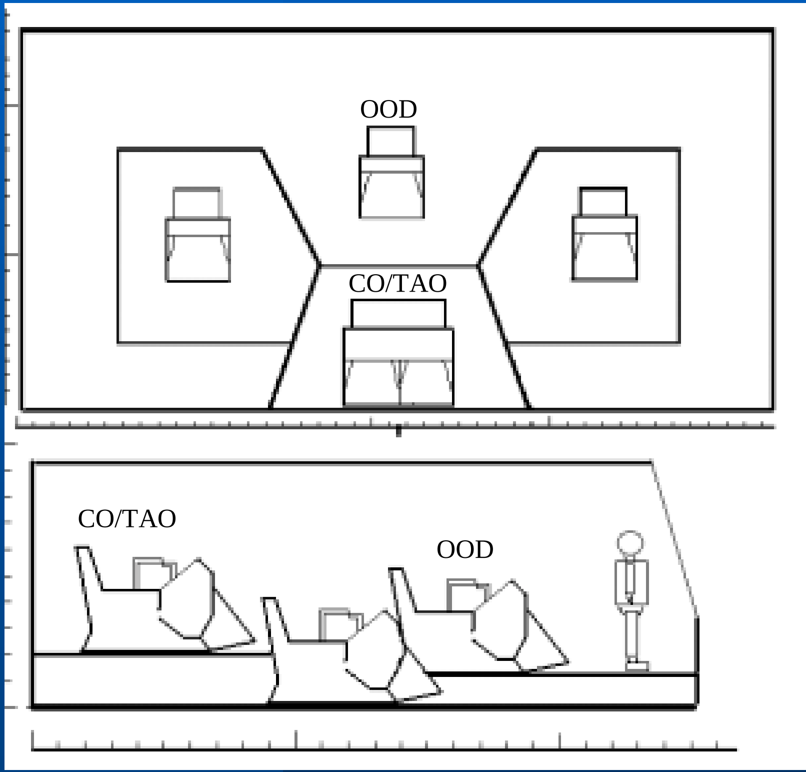
Combatant Onboard Network



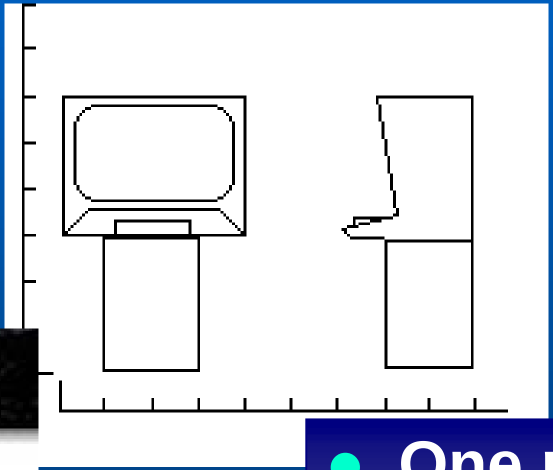
Control Spaces

- Control Center/Bridge
  - All watchstanding
- Engineering Station
  - Maintenance/Diagnostic Station

Control Center/Bridge



Engineering Station



- One per Engine Room
- Battery back-up & Alternate data paths for “no power” ops.
- Maintenance only (not manned)

Technology to Capability

- Propulsion/Electrical
- Network-centric Link
- SWAN
- Hull type/material
- Organic Weapons/Sensors
- Human factors/Habitability
- Expeditionary Grid Systems

Capability

Combatant/GDM Characteristics

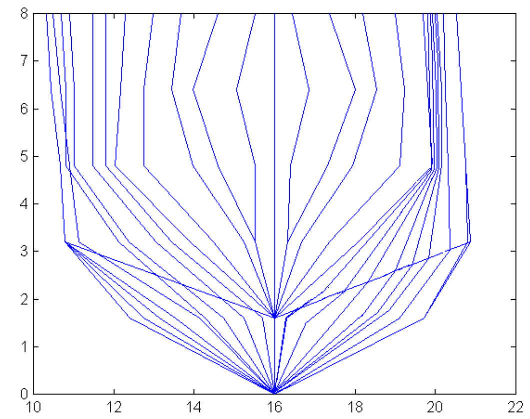
Combatant

- Wave-Piercing Catamaran
- Full Load Disp.: 450 LT
- Light Ship Disp.: 283 LT
- LCB/LCG: 16’ aft CL
- VCG: 10’ above keel
- Submerged Length: 158’
- Length at Waterline: 146’
- Length Overall: 167’
- C_B : 0.625
- C_P : 0.857 C_X : 0.729

GDM

- Wave-Piercing Catamaran
- Full Load Disp.: 450 LT
- Light Ship Disp.: 146 LT
- Other characteristics similar to combatant

Table of Offsets/Body Plan



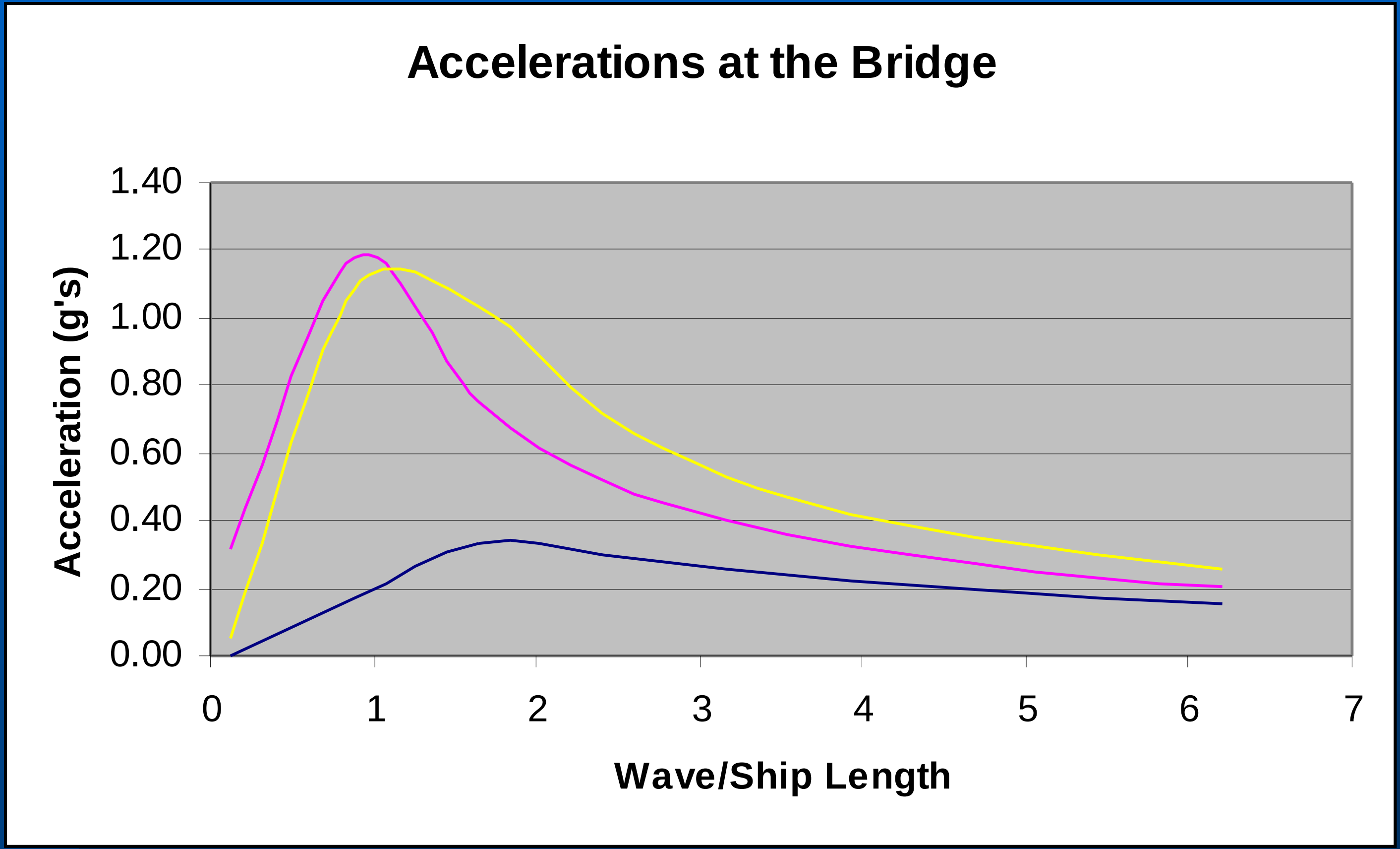
Sea Lance Table of Offsets for B=10' T=8'

Station		Water Line (feet) 0		1.6		3.2		4.8		6.4		8	
0	0	16	16	16	16	16	16	16	16	16	16	16	16
7.9	1	16	16	16	16	15.52	16.33	15.52	16.39	15.06	16.85	15.52	16.45
15.8	2	16	16	16	16	15.52	16.33	14.59	17.32	13.96	18.01	14.59	17.37
23.7	3	16	16	16	16	15.23	16.68	13.96	17.95	13.43	18.53	13.67	18.19
31.6	4	16	16	16	16	14.48	17.37	12.74	19.11	12.74	19.23	12.97	19.00
39.5	5	16	16	16	16	13.90	18.07	12.04	19.92	12.16	19.81	12.28	19.69
47.4	6	16	16	15.69	16.27	13.43	18.53	11.81	20.16	11.81	20.11	11.81	20.06
55.3	7	16	16	15.24	16.30	13.05	18.71	11.47	20.21	11.47	20.16	11.47	20.11
63.2	8	16	16	14.74	16.31	12.37	18.90	11.02	20.29	11.02	20.23	10.91	20.18
71.1	9	16	16	14.28	19.12	12.12	19.28	10.80	20.31	10.80	20.25	10.69	20.20
79	10	16	16	14.14	19.71	11.13	20.81	10.90	20.76	10.66	20.64	10.49	20.52
86.9	11	16	16	13.52	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
94.8	12	16	16	13.13	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
102.7	13	16	16	12.40	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
110.6	14	16	16	12.40	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
118.5	15	16	16	12.40	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
126.4	16	16	16	12.40	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
134.3	17	16	16	12.75	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
142.2	18	16	16	12.75	19.71	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
150.1	19	16	16	16	16	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52
158	20	16	16	16	16	10.78	20.87	10.66	20.76	10.43	20.64	10.32	20.52

Motions Summary

- Vertical Accelerations are an issue
  - Above NAVSEA requirements
    - Utilize wave piercing catamaran
    - Utilize ride stabilization system
    - Anticipate results similar to other commercial designs
- Other vertical and lateral motions are within reasonable limits

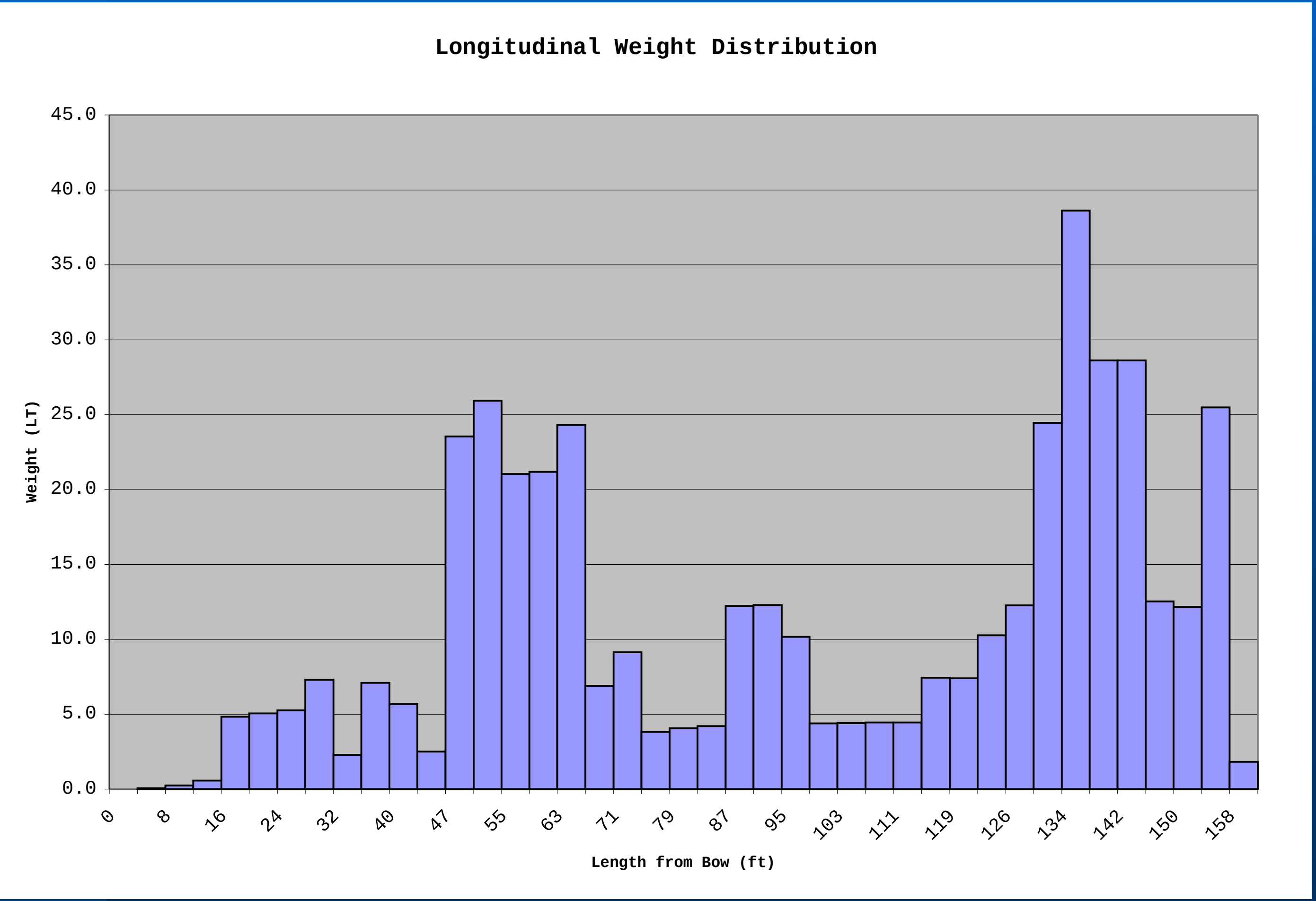
Bridge Accelerations



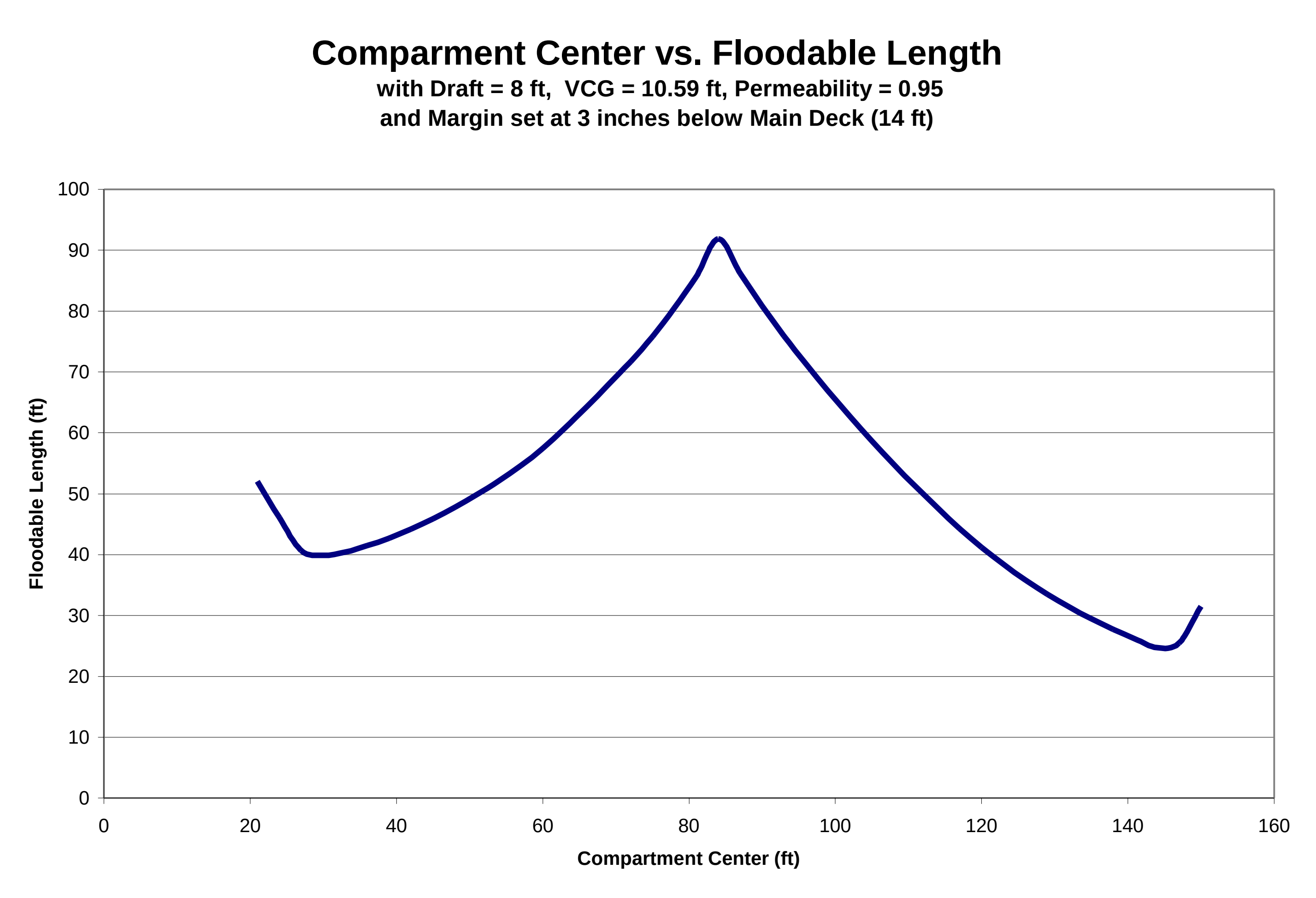
Stress/Structures Summary

- Hogging and Sagging conditions computed to determine the maximum longitudinal and transverse bending stress
  - Aluminum (5086-H34) used for the majority of design
  - Composites used in the central control station and the mast
  - Steel used for reinforcement where necessary
  - Hull structural weight validation performed against similar catamaran ferry designs
    - 125 LT structure vice 128 LT

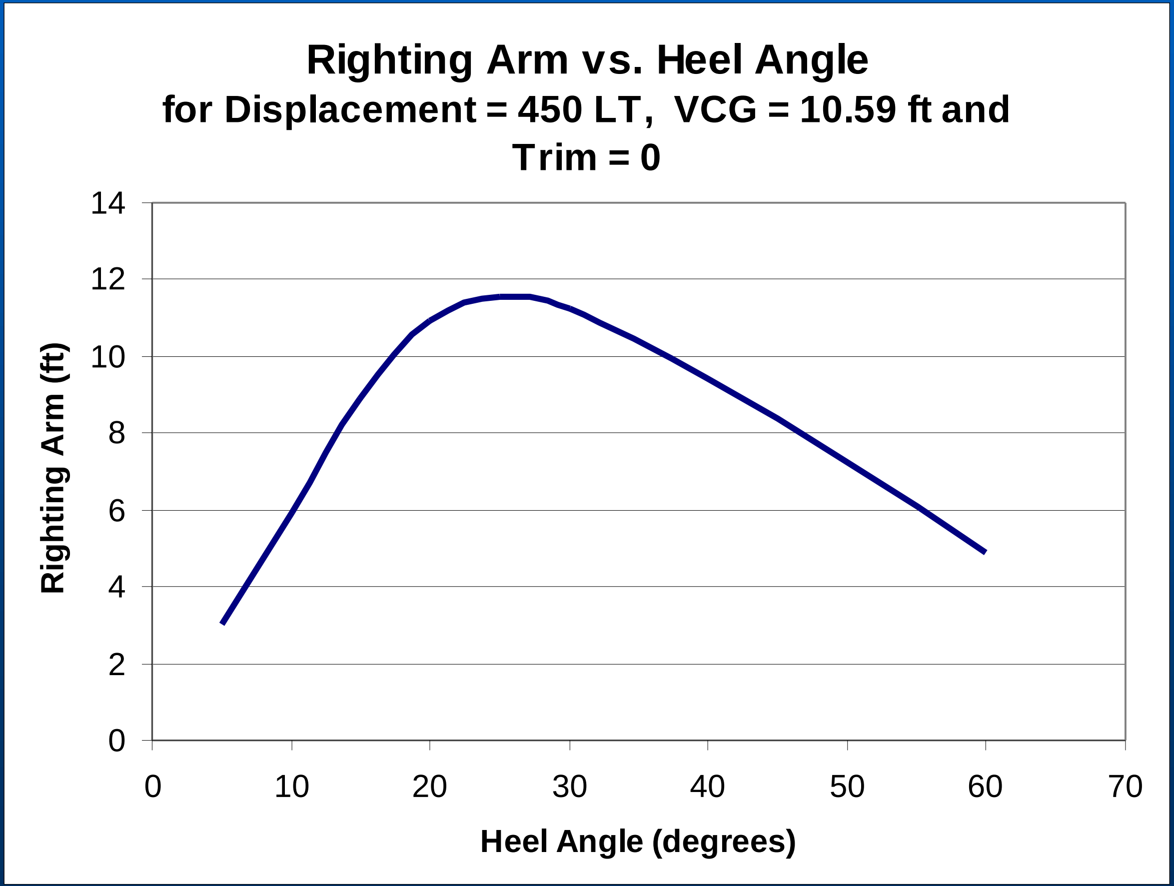
Longitudinal Weight Dist.



Floodable Length



Stability Assessment



Combatant Weight Breakdown

SWBS	Description	Weight
110	SHELL + SUPPORTS	64.1
120	HULL STRUCTURAL BULKHEADS	20.0
130	HULL DECKS	12.0
140	HULL PLATFORMS/FLATS	3.2
150	DECK HOUSE STRUCTURE	2.4
160	SPECIAL STRUCTURES	4.0
170	MASTS+KINGPOSTS+SERV PLATFORM	3.0
180	FOUNDATIONS	1.0
190	SPECIAL PURPOSE SYSTEMS	15.0
	Group Total:	**124.8**
230	PROPULSION UNITS	50.8
240	TRANSMISSION+PROPULSOR SYSTEMS	8.0
250	SUPPORT SYSTEMS	1.3
260	PROPUL SUP SYS - FUEL, LUBE OIL	1.0
290	SPECIAL PURPOSE SYSTEMS	1.0
	Group Total:	**62.1**
310	ELECTRICAL POWER GENERATION	4.5
320	POWER DISTRIBUTION SYS	3.0
330	LIGHTING SYSTEMS	1.0
340	POWER GENERATION SUPPORT SYS	0.5
390	SPECIAL PURPOSE SYSTEMS	2.0
	Group Total:	**11.0**
410	COMMAND+CONTROL SYSTEMS	3.0
420	NAVIGATION SYSTEMS	0.1
430	INTERIOR COMMUNICATIONS	0.1
440	EXTERIOR COMMUNICATIONS	1.5
450	SURF SURV SYS (RADAR)	0.7
460	UNDERWATER SURV SYS	0.3
470	COUNTERMEASURES	0.1
480	FIRE CONTROL SYSTEMS	2.8
490	SPECIAL PURPOSE SYSTEMS	1.2
	Group Total:	**9.8**

SWBS	Description	Weight
510	CLIMATE CONTROL	4.5
520	SEA WATER SYSTEMS	1.9
530	FRESH WATER SYSTEMS	0.9
540	FUEL/LUBRICANTS, HANDELING+STORAGE	3.0
550	AIR, GAS+MISC FLUID SYSTEMS	4.4
560	SHIP CNTL SYSTEMS	6.9
570	UNDERWAY REPLENISHMENT SYSTEMS	1.9
580	MECHANICAL HANDELING SYSTEMS	2.0
590	SPECIAL PURPOSE SYSTEMS	9.9
	Group Total:	**35.4**
610	SHIP FITTINGS	0.7
620	HULL COMPARTMENTATION	0.2
630	PRESERVATIVES+COVERINGS	1.8
640	LIVING SPACES	2.2
650	SERVICE SPACES	1.5
660	WORKING SPACES	0.3
670	STOWAGE SPACES	0.4
690	SPECIAL PURPOSE SYSTEMS	1.5
	Group Total:	**8.6**
710	GUNS+AMMUNITION	5.3
720	MISSLES+ROCKETS	25.8
730	MINES	0.0
740	DEPTH CHARGES	0.0
750	TORPEDOES	0.0
760	SMALL ARMS+PYROTECHNICS	0.6
770	CARGO MUNITIONS	0.0
780	AIRCRAFT RELATED WEAPONS	0.0
790	SPECIAL PURPOSE SYSTEMS	0.0
	Group Total:	**31.7**

Combatant Weight Breakdown

SWBS	Description	Weight
F10	SHIPS FORCE+EFFECTS	4.7
F20	MISSION RELATED EXPENDABLES+SYS	24.7
F30	STORES	0.8
F40	FUELS+LUBRICANTS	104.0
F50	LIQUIDS, NON-PETRO BASED	16.1
F60	CARGO	0.0
	Full Load (LT):	**433.6**
	Margin:	6.5%
	Full Load Displacement (LT):	449.9
	Light Ship (LT):	283.2
	Dead Weight (LT):	150.3
	Payload Fraction:	35%

- **Design Margin 6.5 %**
- **Full Load Disp. 449.9 LT**
- **Light Ship 283.2 LT**
- **Payload Fraction 35 %**

TSSE Total Ship Systems Engineering Team 2000

GDM Weight Breakdown

SWBS	Description	Weight
110	SHELL + SUPPORTS	64.1
120	HULL STRUCTURAL BULKHEADS	20.0
130	HULL DECKS	12.0
140	HULL PLATFORMS/FLATS	3.2
150	DECK HOUSE STRUCTURE	2.4
160	SPECIAL STRUCTURES	13.0
170	MASTS+KINGPOSTS+SERV PLATFORM	3.0
180	FOUNDATIONS	1.0
190	SPECIAL PURPOSE SYSTEMS	10.0
	Group Total:	*128.8*
230	PROPULSION UNITS	0.0
240	TRANSMISSION+PROPULSOR SYSTEMS	0.0
250	SUPPORT SYSTEMS	0.0
260	PROPUL SUP SYS - FUEL, LUBE OIL	0.0
290	SPECIAL PURPOSE SYSTEMS	0.0
	Group Total:	*0.0*
310	ELECTRICAL POWER GENERATION	1.5
320	POWER DISTRIBUTION SYS	1.5
330	LIGHTING SYSTEMS	1.0
340	POWER GENERATION SUPPORT SYS	0.5
390	SPECIAL PURPOSE SYSTEMS	1.0
	Group Total:	*5.5*
410	COMMAND+CONTROL SYSTEMS	0.0
420	NAVIGATION SYSTEMS	0.0
430	INTERIOR COMMUNICATIONS	0.1
440	EXTERIOR COMMUNICATIONS	1.0
450	SURF SURV SYS (RADAR)	0.0
460	UNDERWATER SURV SYS	0.0
470	COUNTERMEASURES	0.1
480	FIRE CONTROL SYSTEMS	0.0
490	SPECIAL PURPOSE SYSTEMS	1.2
	Group Total:	*2.4*

SWBS	Description	Weight
510	CLIMATE CONTROL	0.0
520	SEA WATER SYSTEMS	0.0
530	FRESH WATER SYSTEMS	0.0
540	FUEL/LUBRICANTS, HANDELING+STORAGE	3.0
550	AIR, GAS+MISC FLUID SYSTEMS	0.0
560	SHIP CNTL SYSTEMS	0.0
570	UNDERWAY REPLENISHMENT SYSTEMS	1.0
580	MECHANICAL HANDELING SYSTEMS	0.8
590	SPECIAL PURPOSE SYSTEMS	0.8
	Group Total:	*5.6*
610	SHIP FITTINGS	0.7
620	HULL COMPARTMENTATION	0.2
630	PRESERVATIVES+COVERINGS	1.8
640	LIVING SPACES	0.0
650	SERVICE SPACES	0.0
660	WORKING SPACES	0.0
670	STOWAGE SPACES	0.0
690	SPECIAL PURPOSE SYSTEMS	1.5
	Group Total:	*4.2*
710	GUNS+AMMUNITION	0.0
720	MISSLES+ROCKETS	0.0
730	MINES	0.0
740	DEPTH CHARGES	0.0
750	TORPEDOES	0.0
760	SMALL ARMS+PYROTECHNICS	0.0
770	CARGO MUNITIONS	0.0
780	AIRCRAFT RELATED WEAPONS	0.0
790	SPECIAL PURPOSE SYSTEMS	0.0
	Group Total:	*0.0*

GDM Weight Breakdown

SWBS	Description	Weight
F10	SHIPS FORCE+EFFECTS	0.0
F20	MISSION RELATED EXPENDABLES+SYS	0.5
F30	STORES	0.0
F40	FUELS+LUBRICANTS	103.0
F50	LIQUIDS, NON-PETRO BASED	0.0
F60	CARGO	190.0
	Full Load (LT):	440.0
	Margin:	6.5%
	Full Load Displacement (LT):	449.5
	Light Ship (LT):	146.5
	Dead Weight (LT):	293.5
	Payload Fraction:	67%

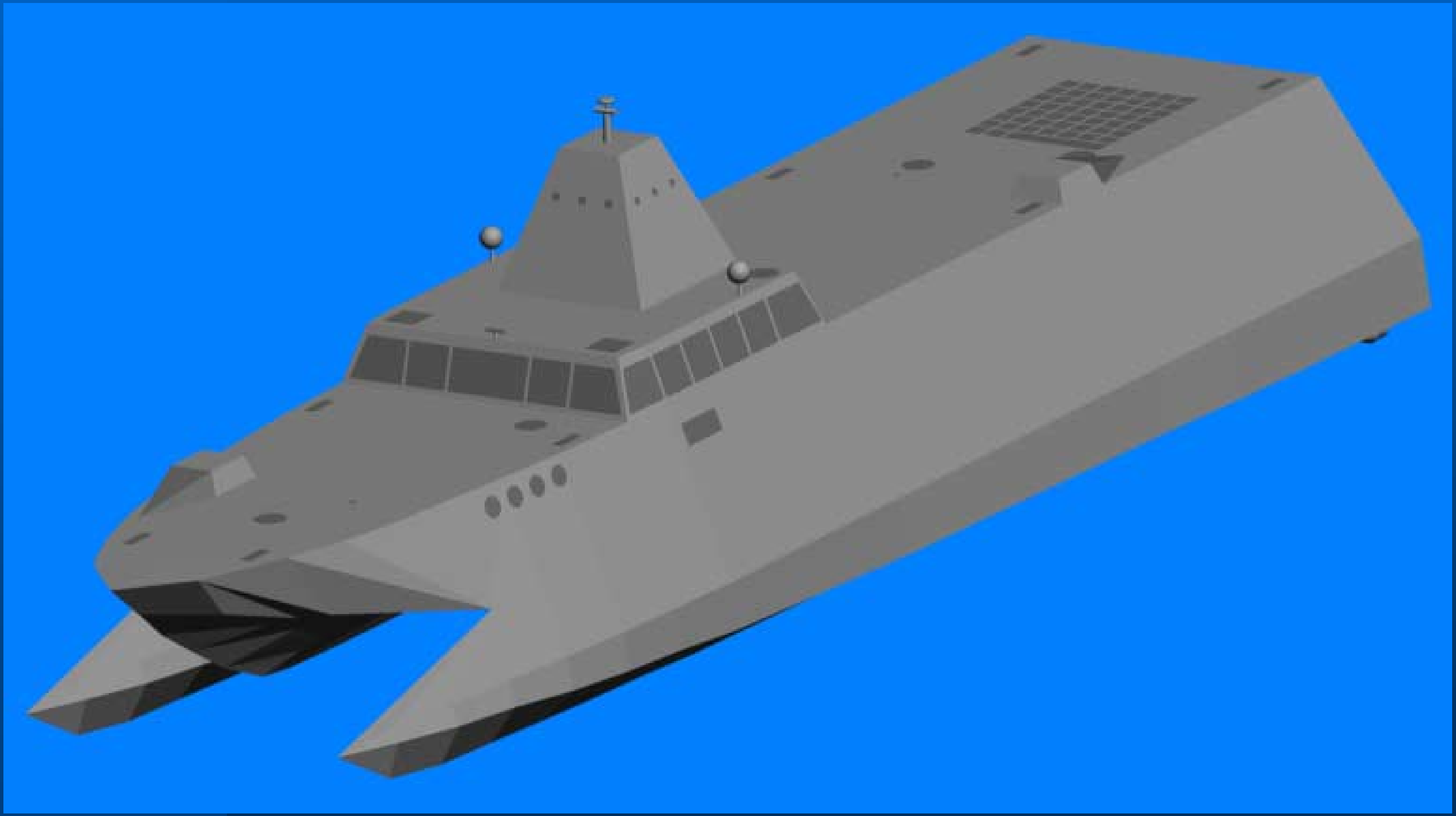
- **Design Margin 6.5 %**
- **Full Load Disp. 449.5 LT**
- **Light Ship 146.5 LT**
- **Payload Fraction 67 %**

Cost Estimation (in 2000 $)

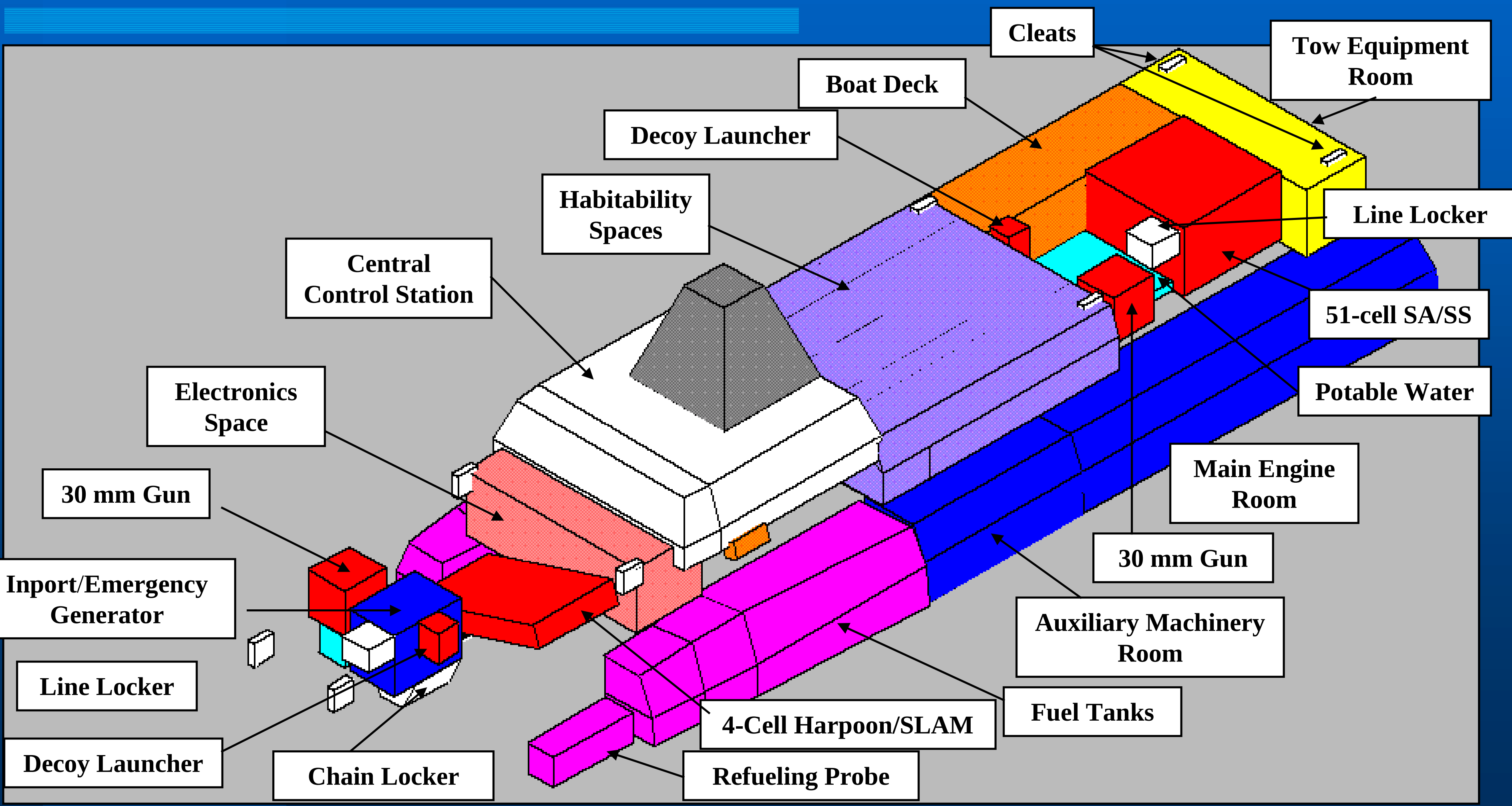
Total 2000 Acquisition Cost	; y R q	”X y R q	; yfy”X y X	; yfy”X y X
Non-recurring Engineering Cost:	$82.9	$0	$82.9	$82.9
Lead Ship:	$64.5	$19.4	$83.9	$101.5
Second Ship:	$64.2	$19.3	$83.5	$101.1
Third Ship:	$64.1	$19.2	$83.3	$100.9
Fourth Ship:	$64.0	$19.1	$83.1	$100.8
Fifth Ship:	$63.9	$19.1	$83.0	$100.7
Sixth Ship:	$63.9	$19.1	$82.9	$100.6
Seventh Ship:	$63.8	$19.0	$82.9	$100.5
Eight Ship:	$63.8	$19.0	$82.8	$100.5
Ninth Ship:	$63.8	$19.0	$82.7	$100.4
Tenth Ship:	$63.7	$19.0	$82.7	$100.4

Price of First Squadron:	**$914**	*(Delivered)*
	$1,090	*(Deployed)*
Price of Following Squadrons:	**$827**	*(Delivered)*
	$1,004	*(Deployed)*

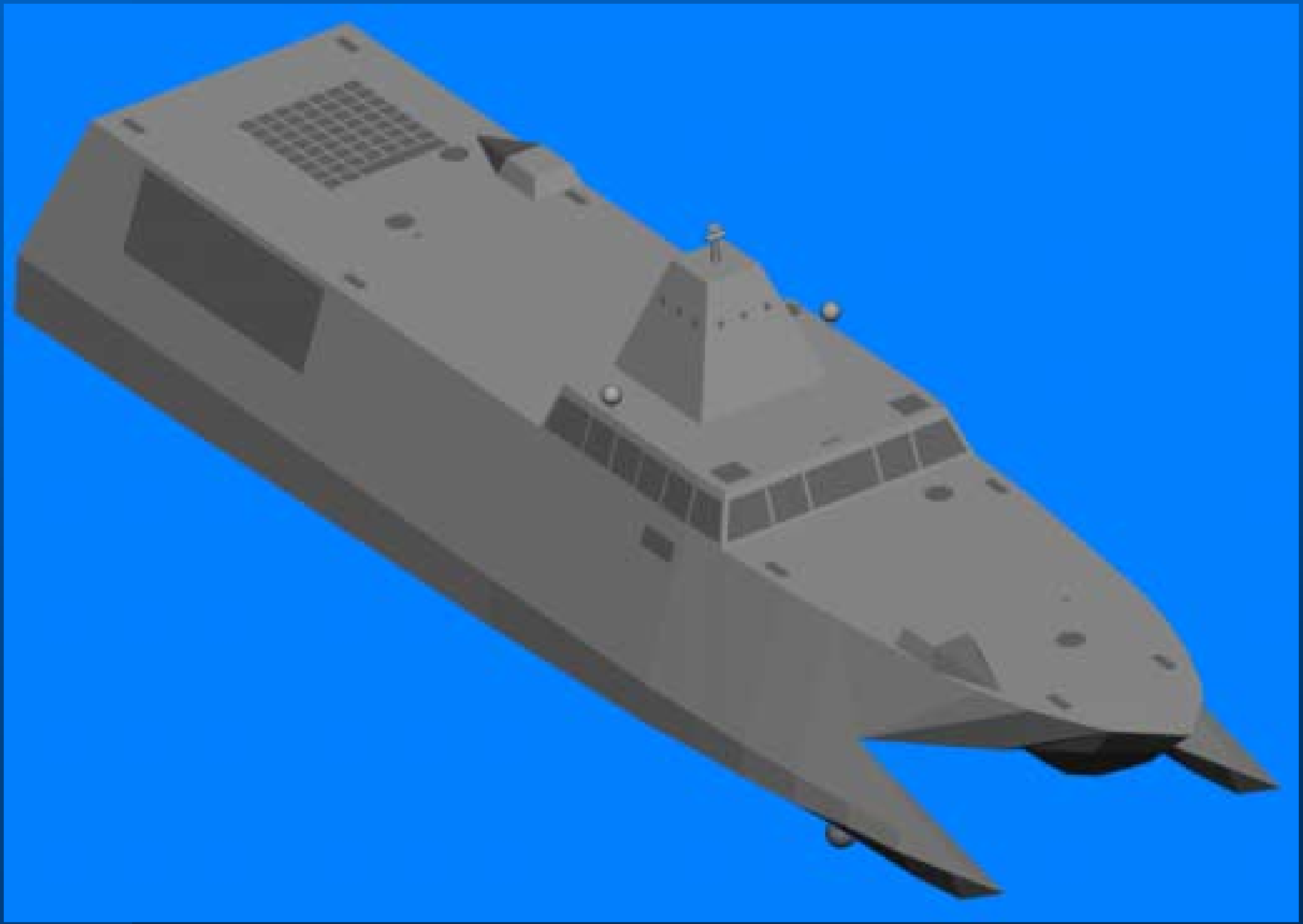
Sea Lance Exterior



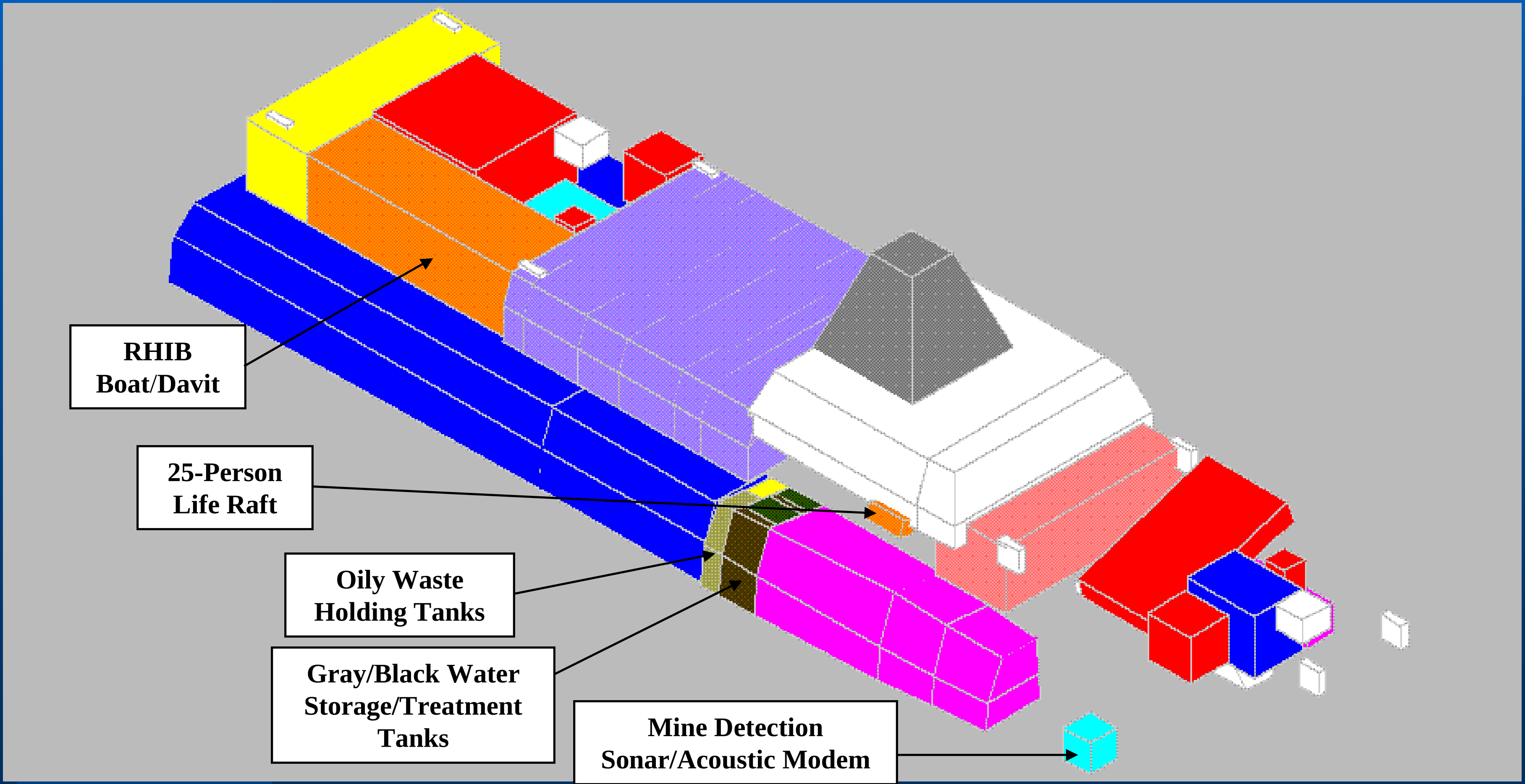
Interior Spaces



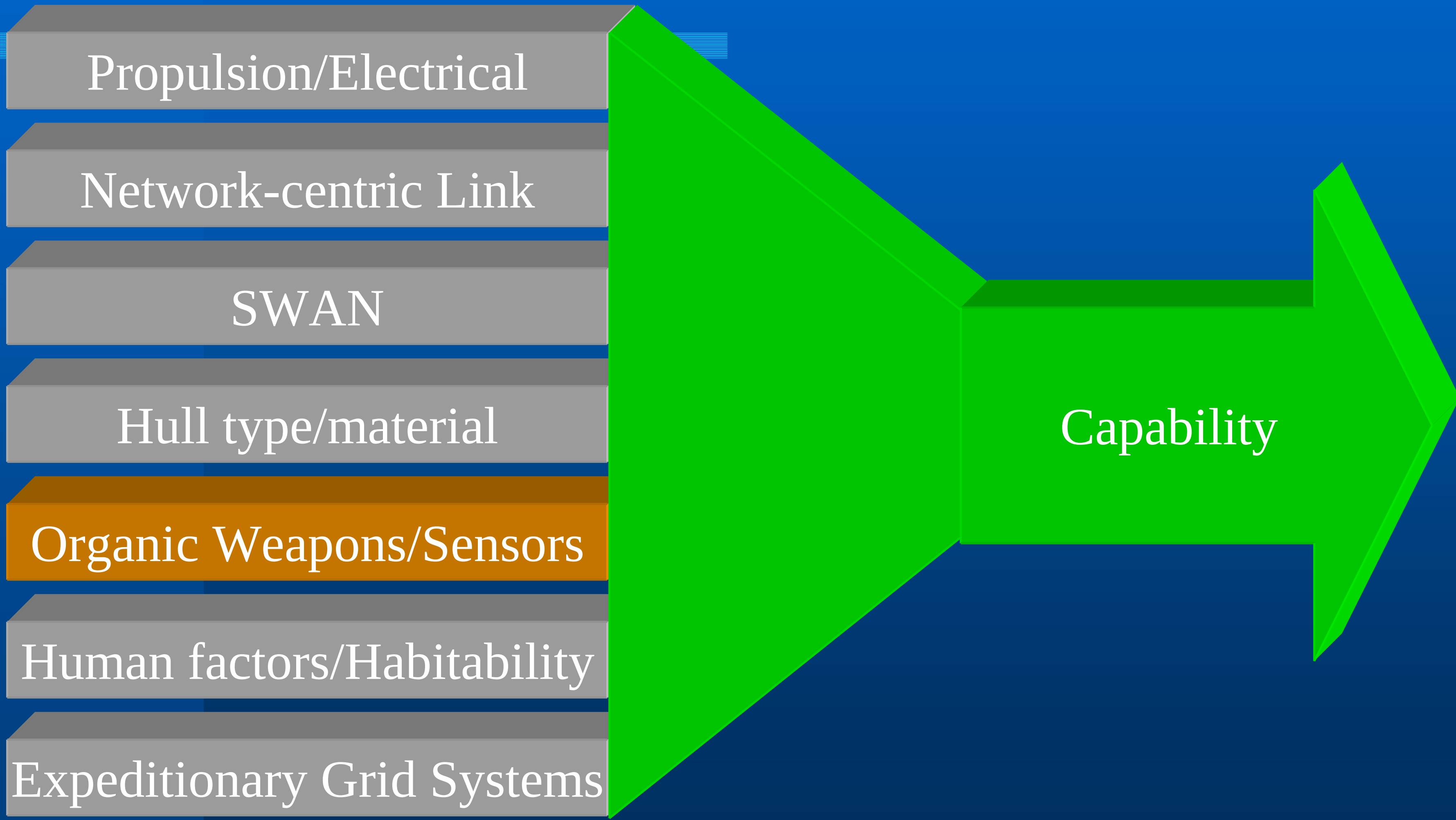
Sea Lance Exterior



Interior Spaces



Technology to Capability

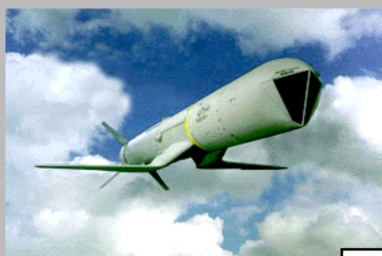


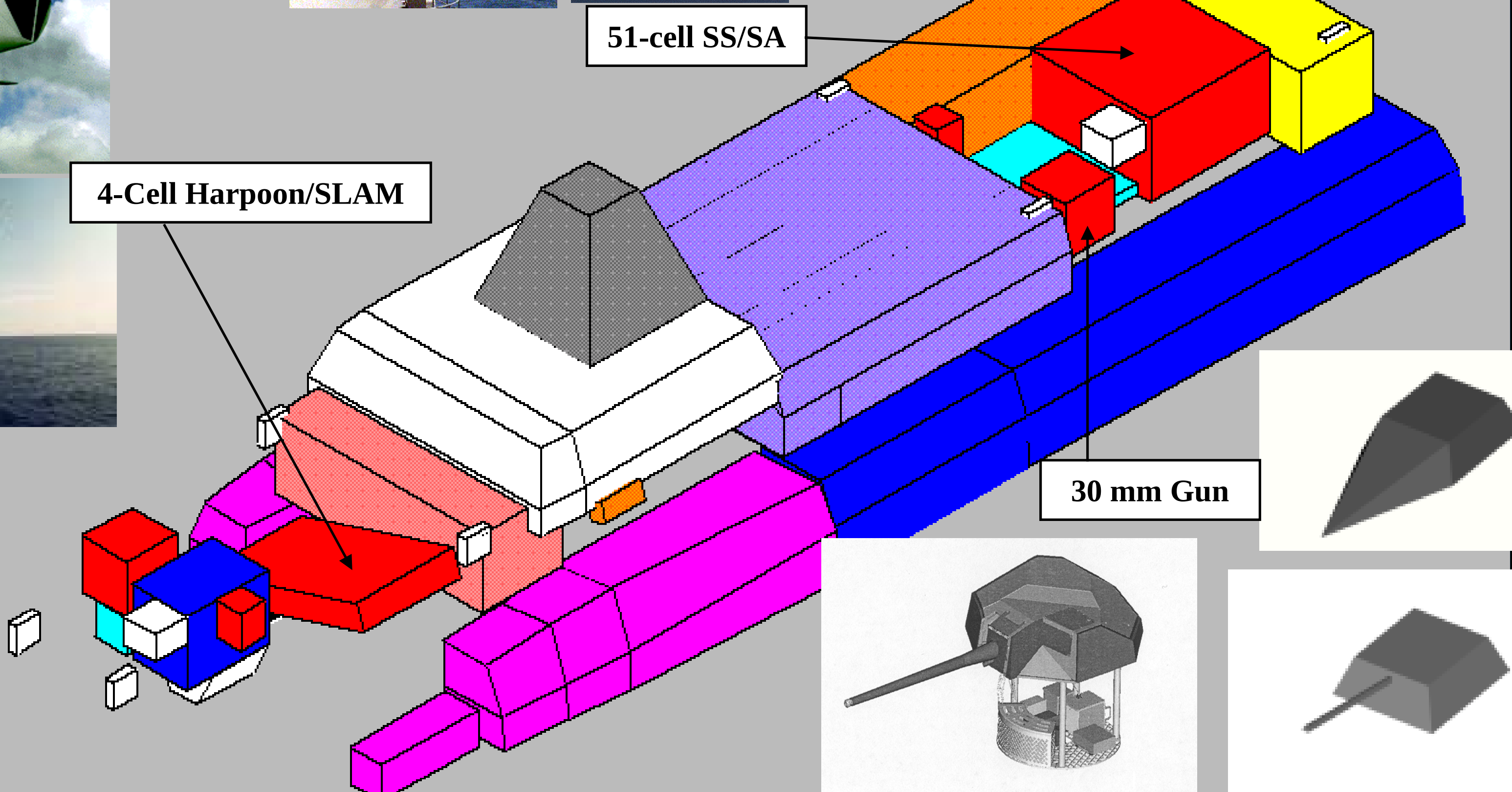
Weapons and Sensor Data

Weapon	Range	Guidance
Medium Range SSM	67 nm	Active
Dual Purpose SAM/SSM	15 nm	Active/Semi-active/IR
30 mm Gun (fore)	2 nm	

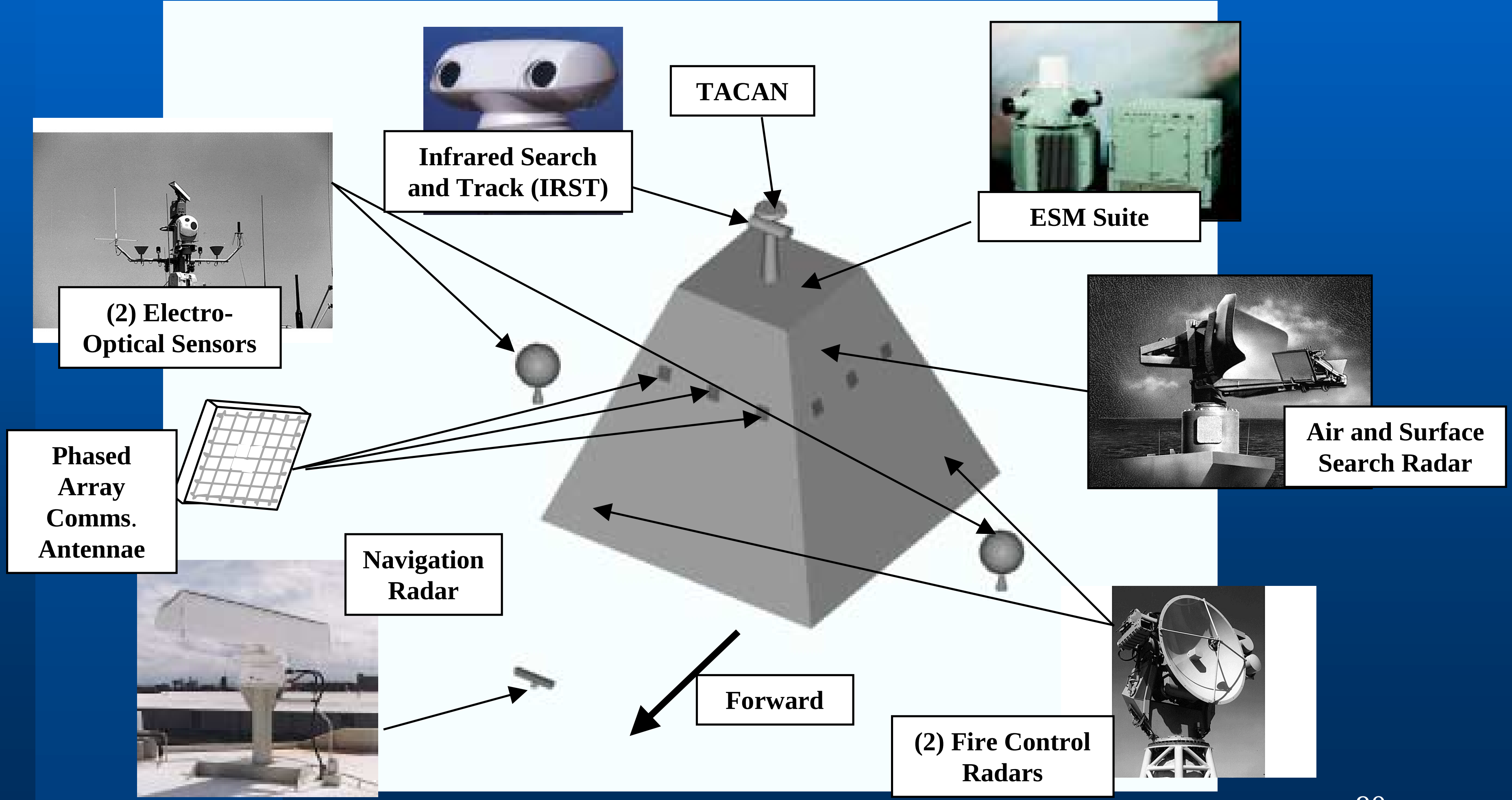
Sensor	Range	Band
Air/Surface/Missile detection	54 nm	2-4 GHz
Fire Control (fore)	20 nm	27-40 Ghz
Fire Control (aft)	20 nm	27-40 Ghz
IRST	20 nm	3-5 & 8-12 um
EO Suite (starboard)	10 nm	TV/IR 8-12 um/LRF 1.064 um
EO Suite (port)	10 nm	TV/IR 8-12 um/LRF 1.064 um
ESM	-----	2-18 GHz
Navigation Radar	25 nm	8-10 Ghz
Mine Avoidance Sonar	>350 yds	250 KHz

Combatant Weapons

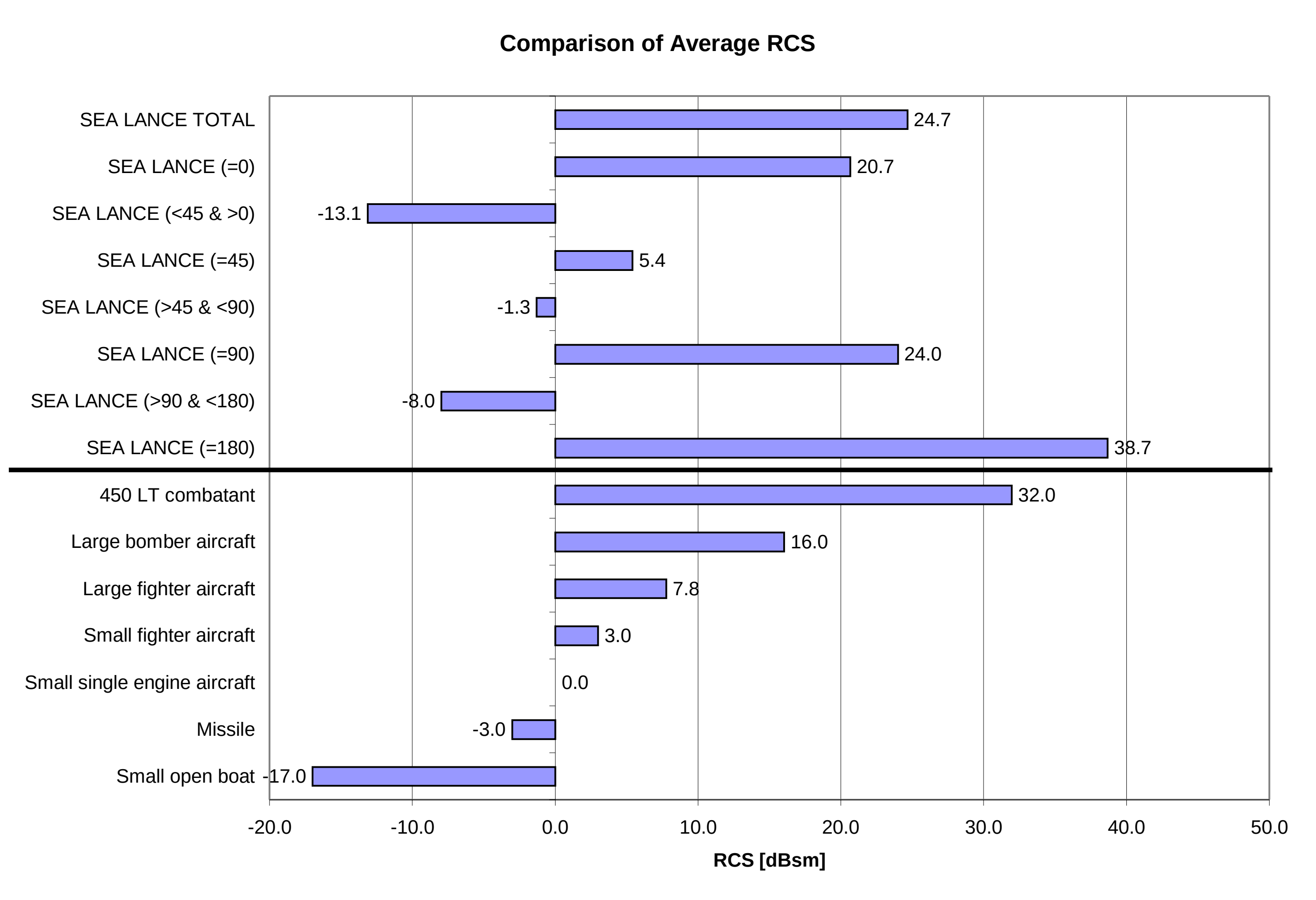




Enclosed Mast



RCS Analysis



Technology to Capability

- Propulsion/Electrical
- Network-centric Link
- SWAN
- Hull type/material
- Organic Weapons/Sensors
- Human factors/Habitability
- Expeditionary Grid Systems

Capability

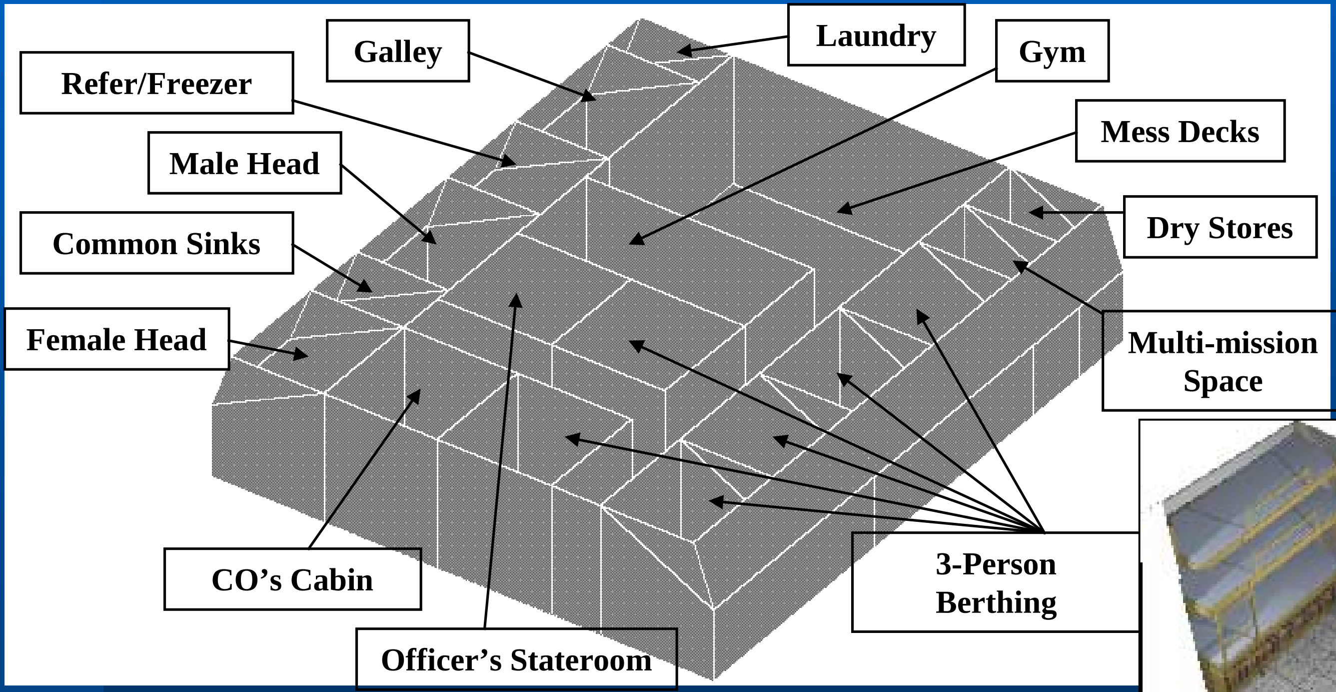
Crew

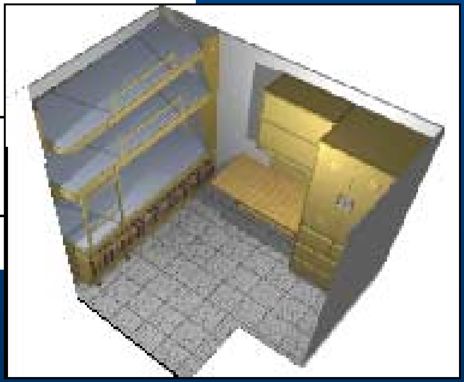
- "SeaLanceman" Rate
  - Applicants from other rates
  - General & Specialized Training
- Officers & Enlisted
  - CO
  - Officers (2)
  - Enlisted (10)
- Accomplished with 13 person crew
  - Maximum use of automation technology

Crew

- Squadron Staff
  - Commodore and Staff
- Watchstanding
  - TAO
  - Ship Control/OOD
  - Assistant TAO & Engineer as required
  - Embarked Staff
- Ship Board Operations
  - Sea & Anchor
  - UNREP
  - MIO
  - SOF Insertion

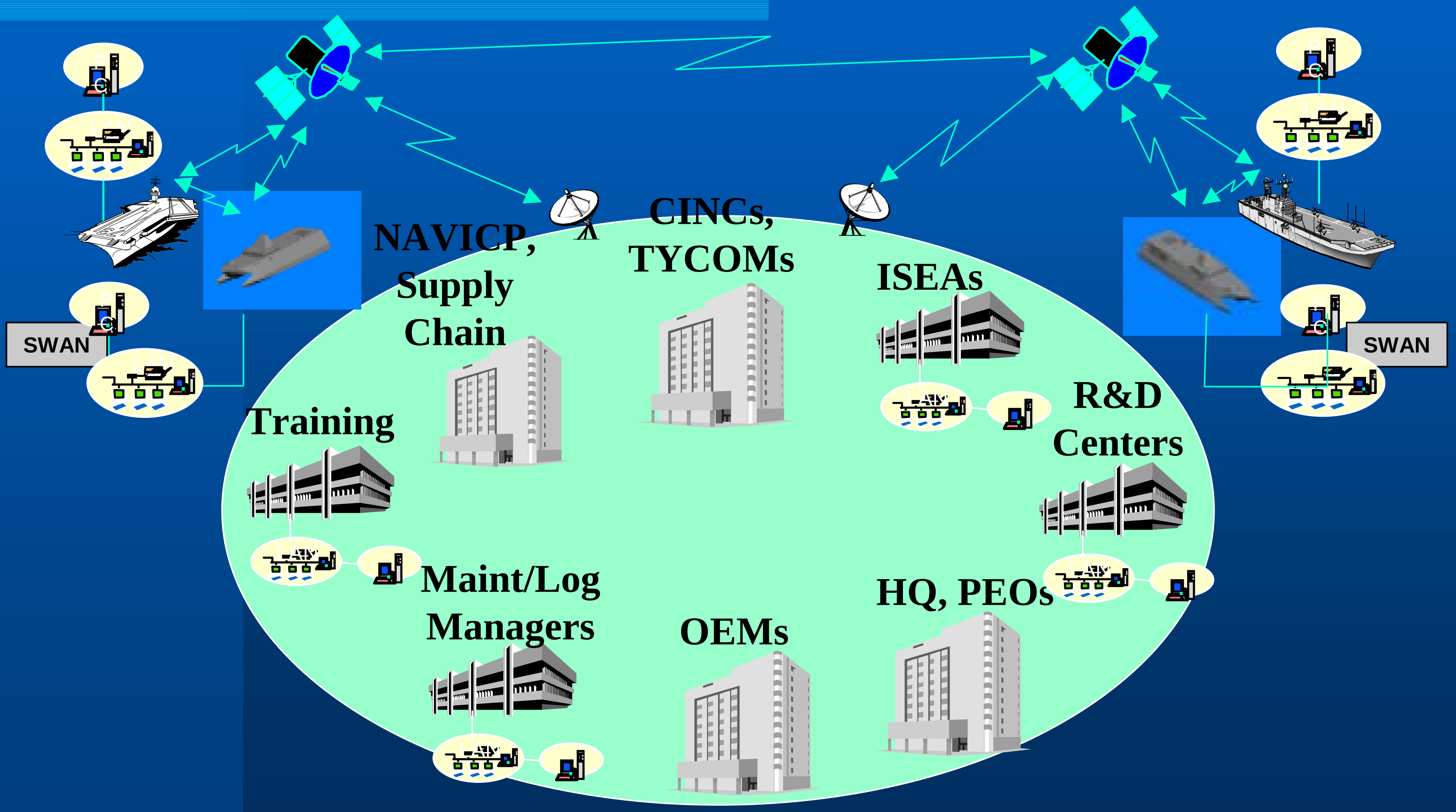
Habitability Spaces



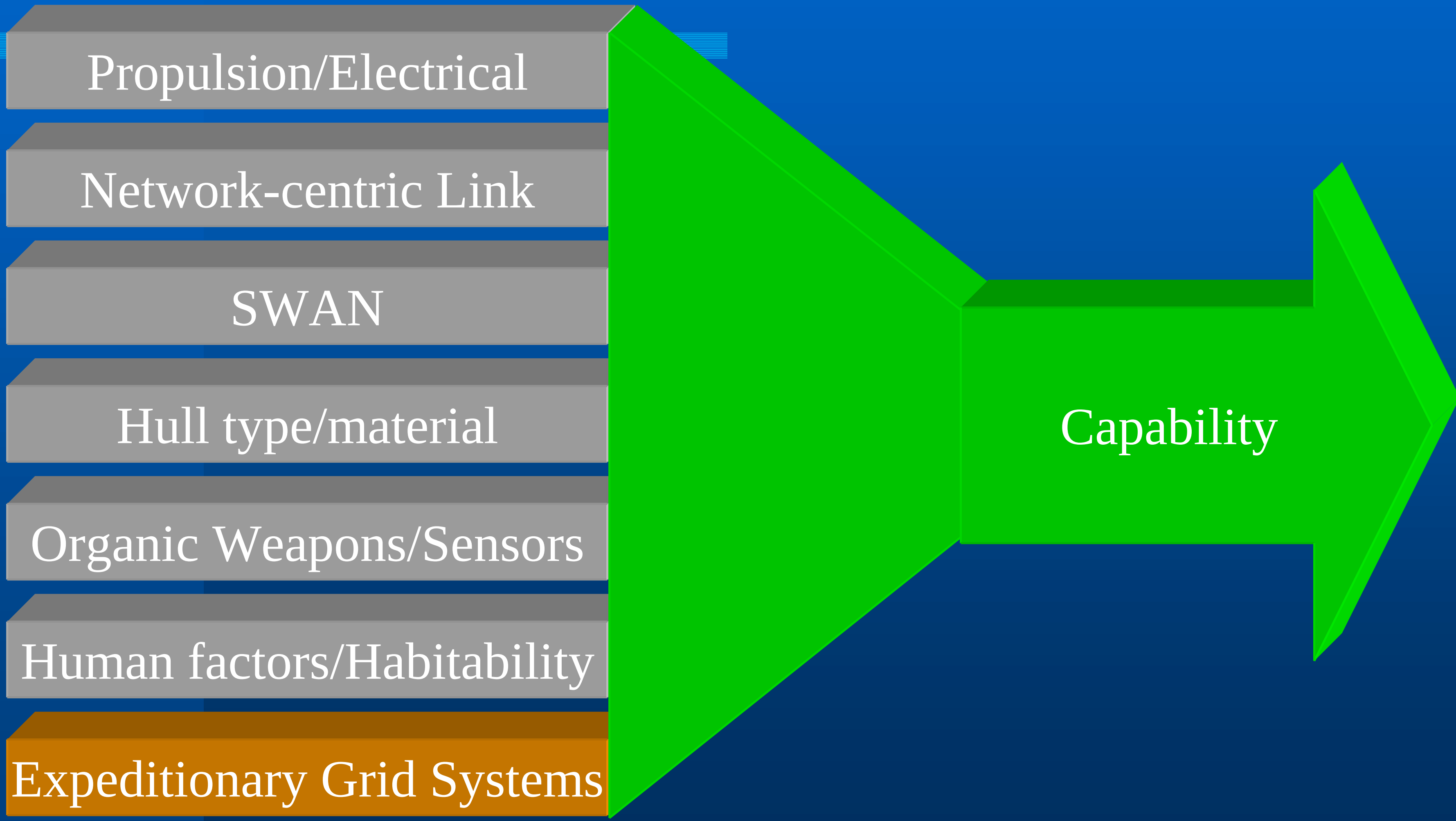


Total Ship Information Systems Architecture

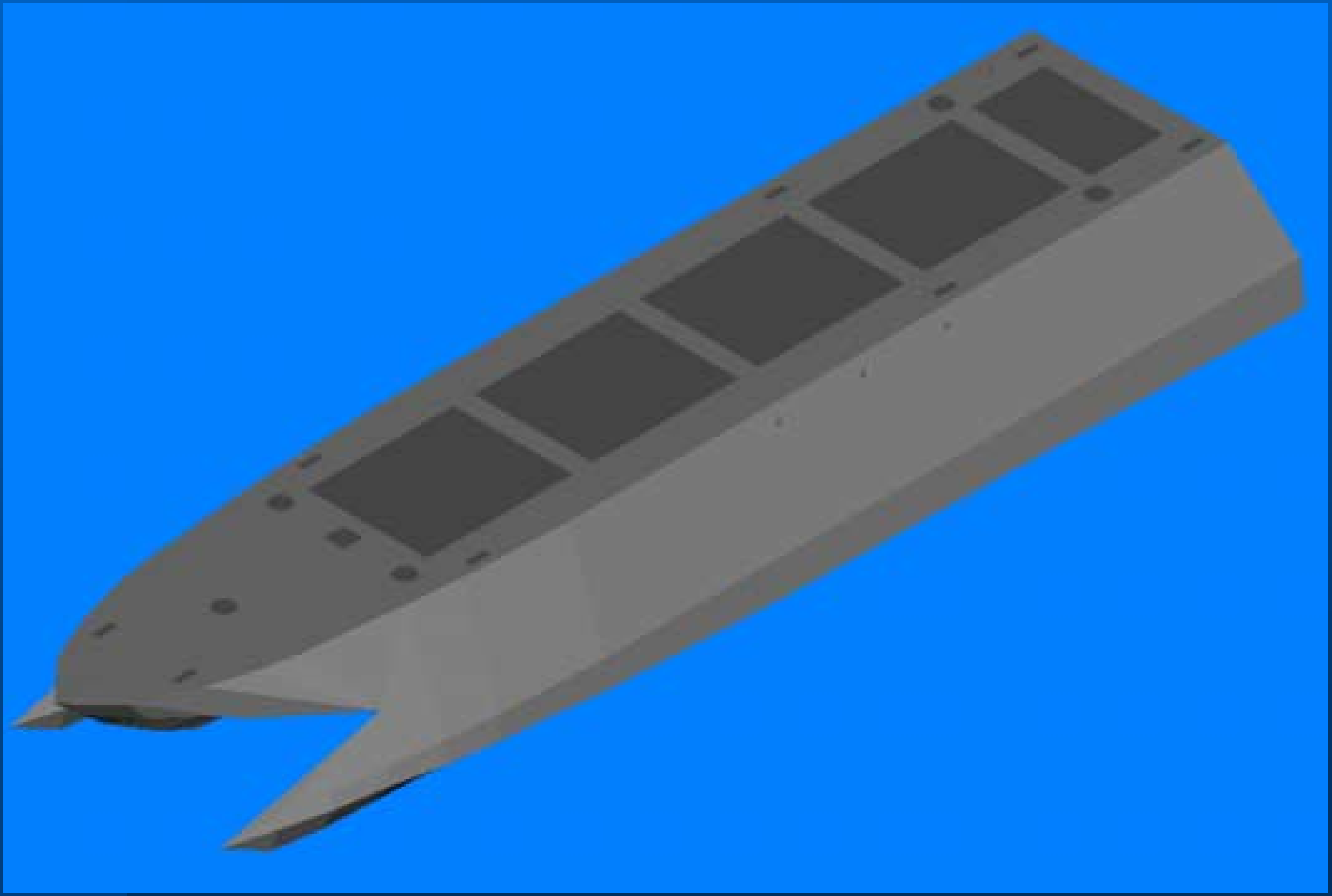
Maintenance Communications Backbone



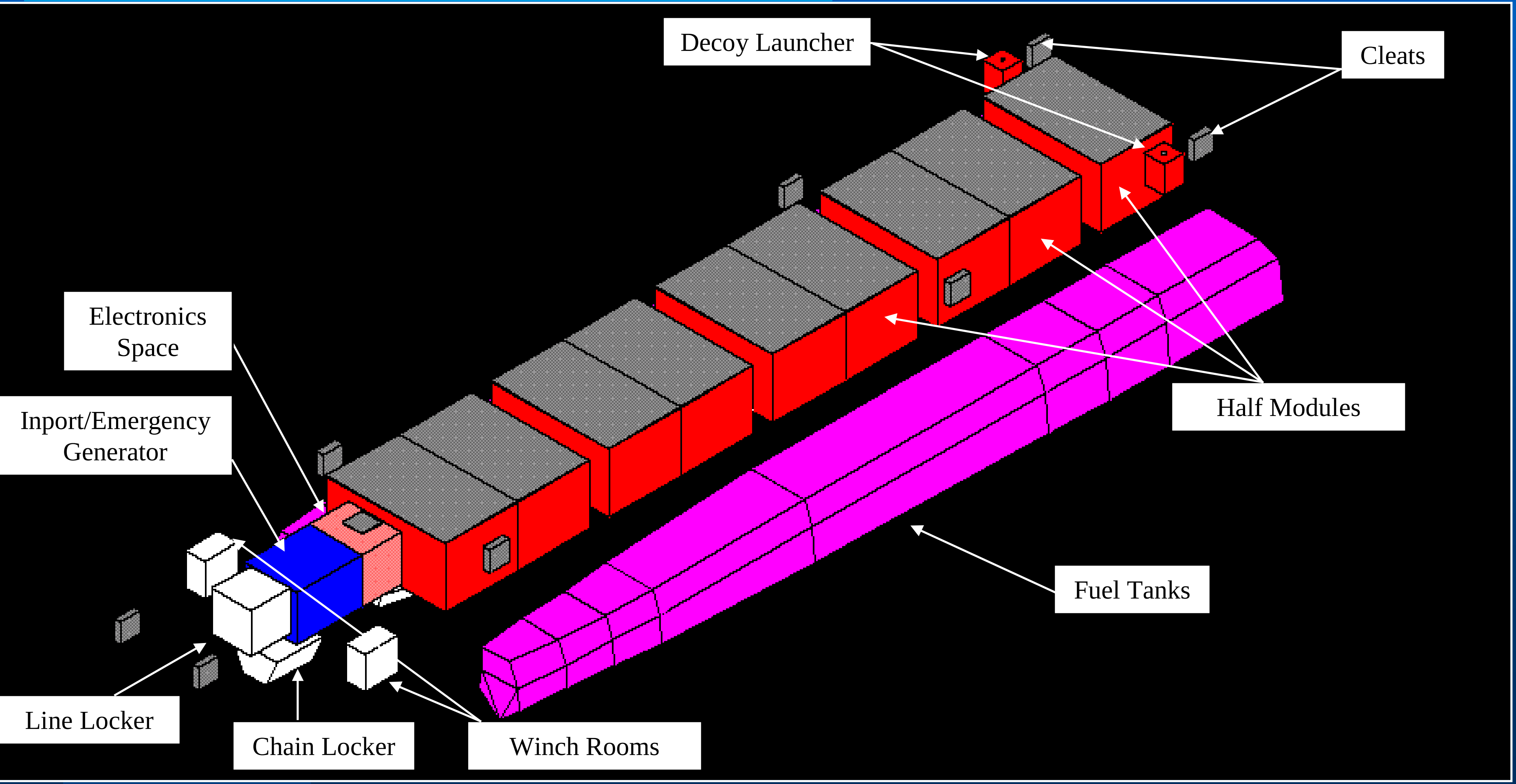
Technology to Capability



Grid Deployment Module



Grid Deployment Module

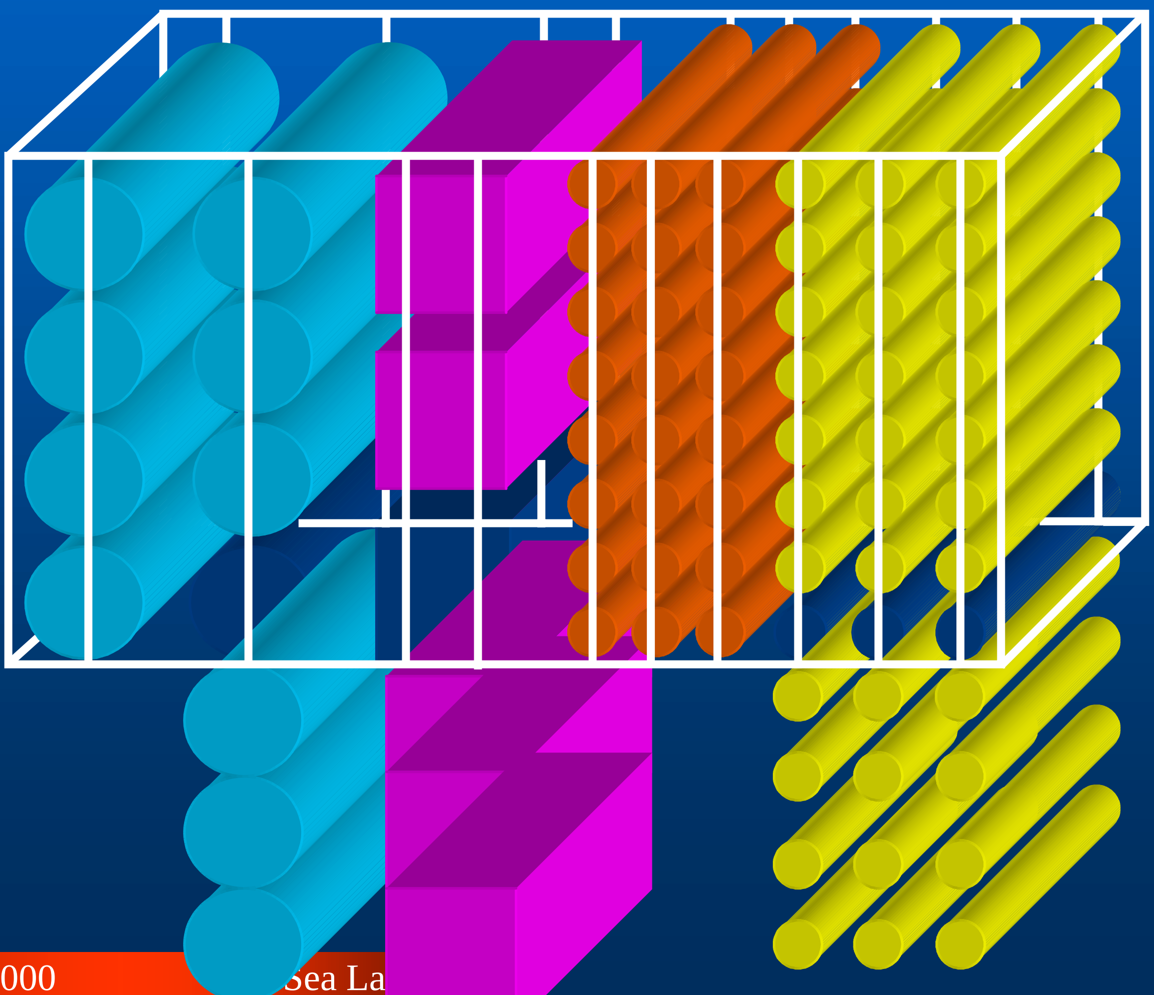


Grid Component Distribution

Module	Size	Volume
Full	18' x 22' x 9'	3564
Half	18' x 11' x 9'	1782

Item	Individual Size	Module Type	Units per module	Weight of full module
CM Pickett	1' x 20'	Full	128	64
Tomahawk	2' x 20'	Full	32	60.8
SM3	2' x 21'	Full	32	64
Torpedo	4' x 4' x 20'	Full	8	80
RSTA	4' x 5' x 20'	Full	6	73.8
Harpoon	2' x 11'	Half	32	40.6
NTACM	2' x 11'	Half	32	72
FSAM	.5' x 10'	Half	288	21
LFAS	2' x 10'	Half	32	32
DADS	.4' x 3'	Half	864	43.2
TAMDA	.4' x 3'	Half	864	43.2
Air mines	1' x 1.5' x 3'	Half	240	60
UCAV small	2.5' x 3' x 5'	Half	30	7.5

Notional Half Module



Connection Force

- **Solve for heave/pitch amplitudes:**

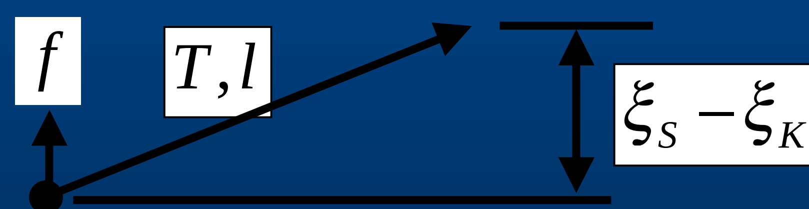
$$\eta_{3,S} = \mu_{3,S} + \nu_{3,S} f$$
$$\eta_{5,S} = \mu_{5,S} + \nu_{5,S} f$$
$$\eta_{3,K} = \mu_{3,K} + \nu_{3,K} f$$
$$\eta_{5,K} = \mu_{5,K} + \nu_{5,K} f$$

- **Form the absolute motion at the connection points:**

$$\xi_S = \eta_{3,S} - \eta_{5,S} x_S$$
$$\xi_K = \eta_{3,K} - \eta_{5,K} x_K$$

- **Apply matching condition:**

$$f = T \frac{\xi_S - \xi_K}{l}$$

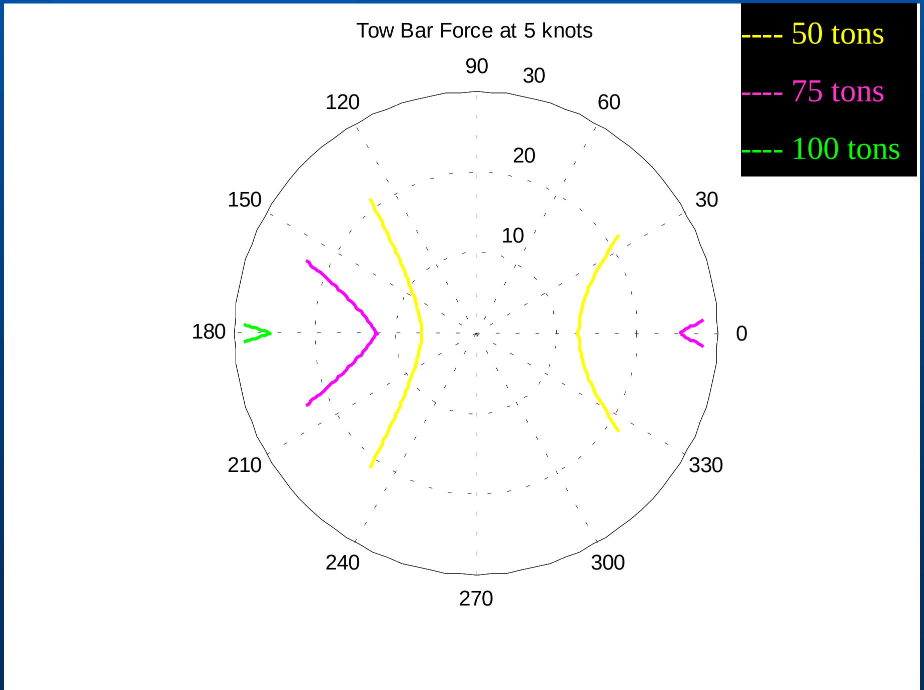


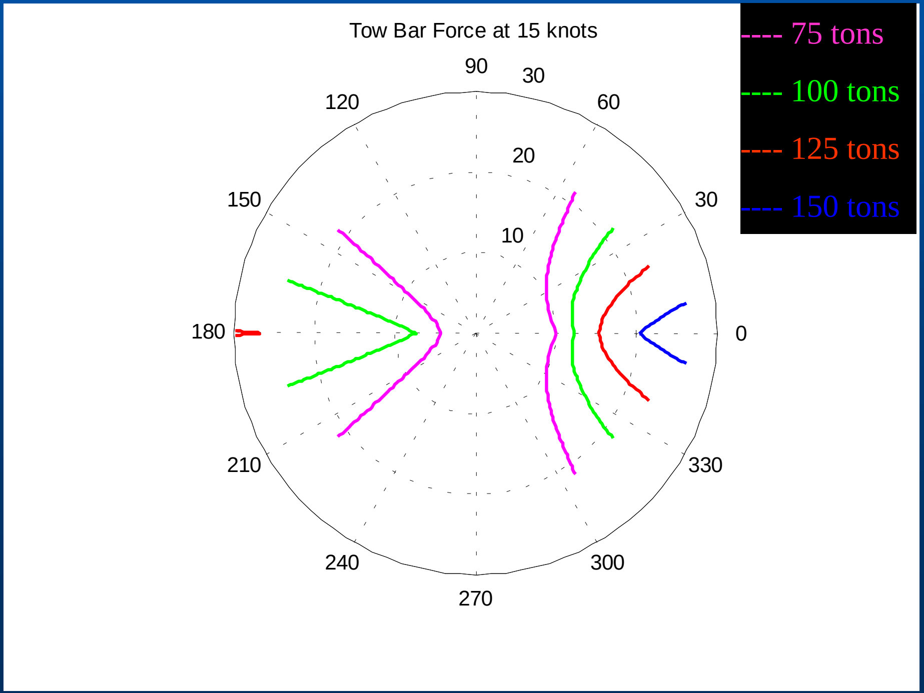
Solve the linear equation for *f*

Tow Bar Forces

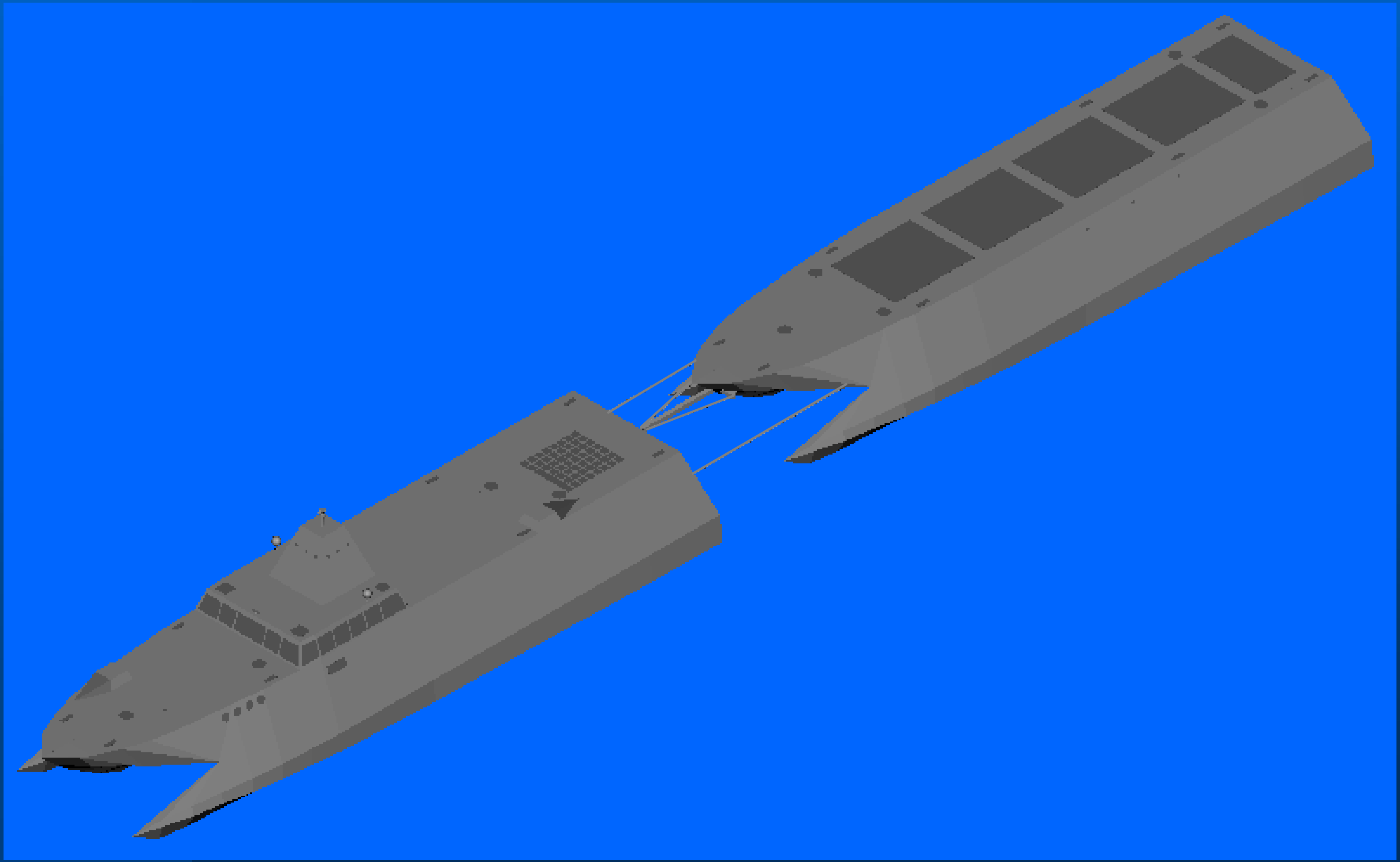
- 20 foot tow bar
- 5 knots

- 20 foot tow bar
- 15 knots

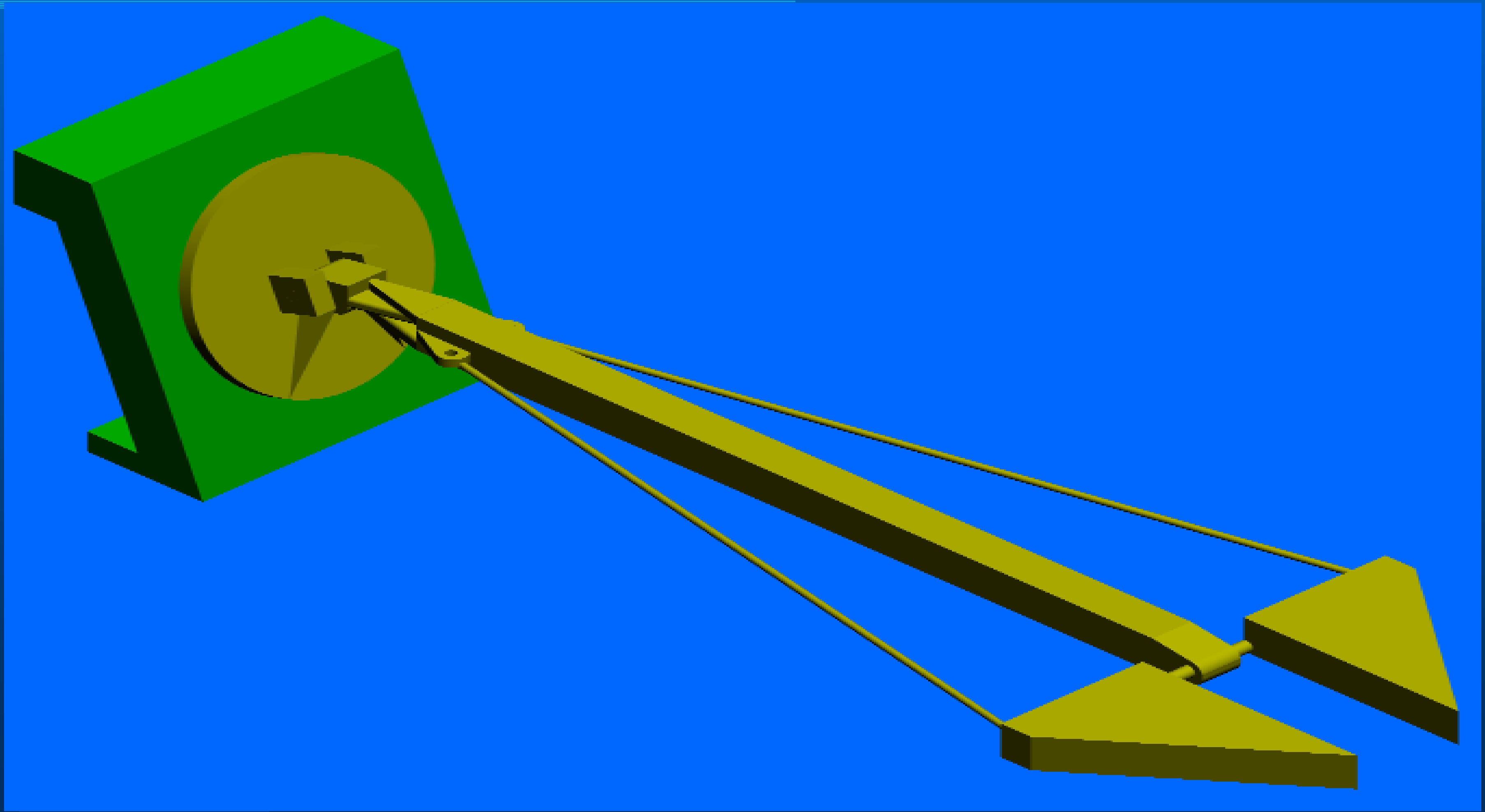




Combatant and GDM



Tow Assembly



Tow System Findings

- **Tow length determined by geometry**
- **Bar length used in strip theory**
- **Maximum forces for given length dictate thickness**
- **Turn angle limited by moment cable tension**
- **Thickness is yield stress-limited to 2/3”**

Presentation Outline

- Introduction
- TSSE Program
- Operational Scenario
- Requirements Documents
- Alternative Architectures
- Measures Of Effectiveness
- Analysis Of Alternatives
- Design Drivers
- Design Enablers
- Technical Evaluation
- Summary

Summary

- In the team's opinion, the design has fulfilled all of the requirements set forth by the sponsor and as specified in the requirements document.
- We have completed a loop around the design circle and in some specific instances several iterations have been made.
- The combatant could fill some essential gaps in the current fleet and is a cheap, flexible and capable alternative to large CRUDES ships.
- The tow is a viable option which needs further physical and computational experiments to validate its utilization.

Risk Assessment

- The tow is at risk mostly due to lack of good data to thoroughly evaluate the alternative.
- The AWJ-21 is currently in the design phase at Bird-Johnson
- Some catamaran data was extrapolated from commercial designs
- Validate the assumption that wave-piercer and ride stabilization system will reduce accelerations
- Human Factors

Recommendations

- Test and evaluate wave-piercing catamaran hull-forms
- Test and evaluate short, semi-fixed tows
- Continue composite structure analysis
- Develop catamaran ASSET module
- Replace CER data in ASSET

Questions

- **The Technical Review will commence after lunch at 1300 in the ME Conference Room**

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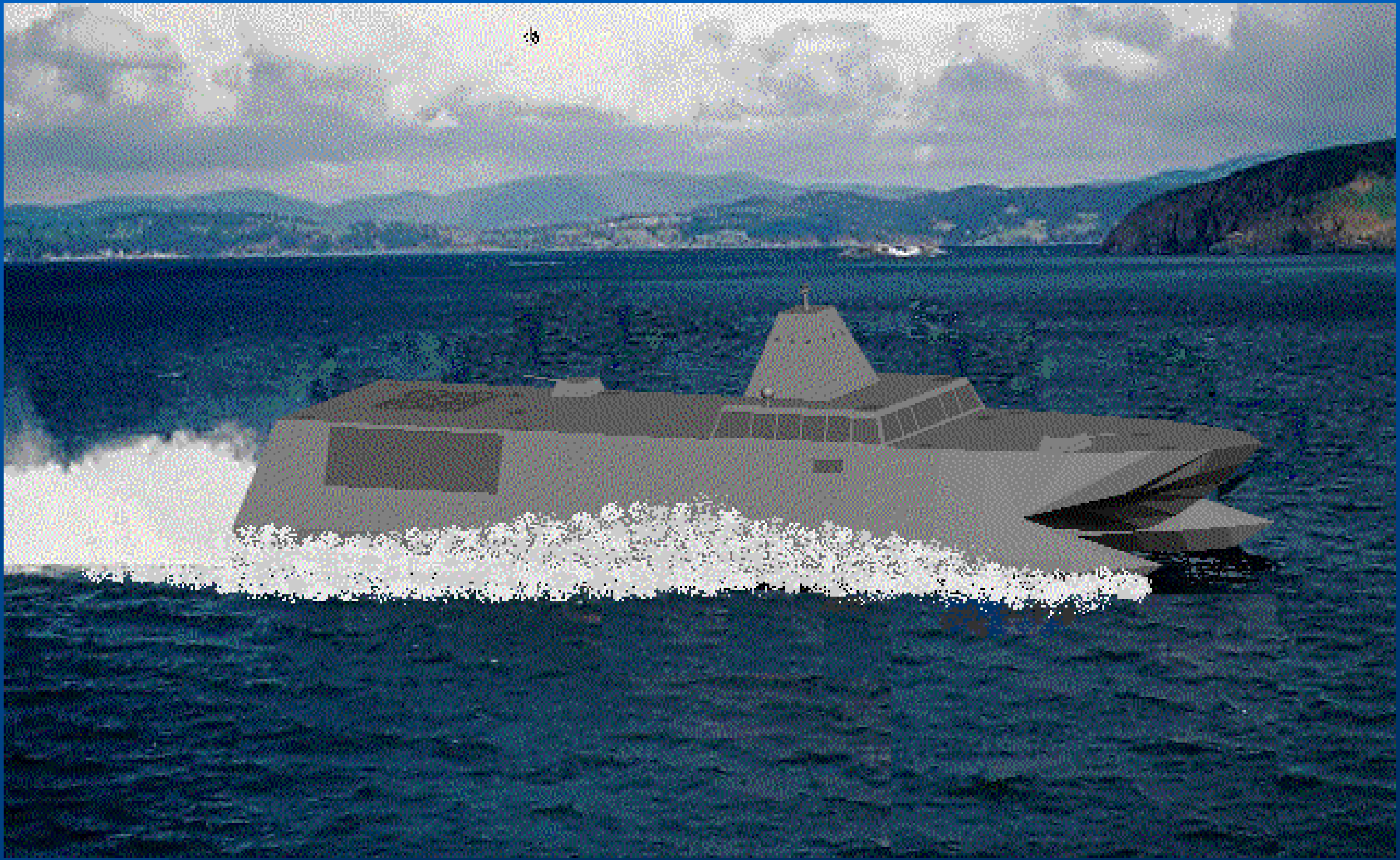
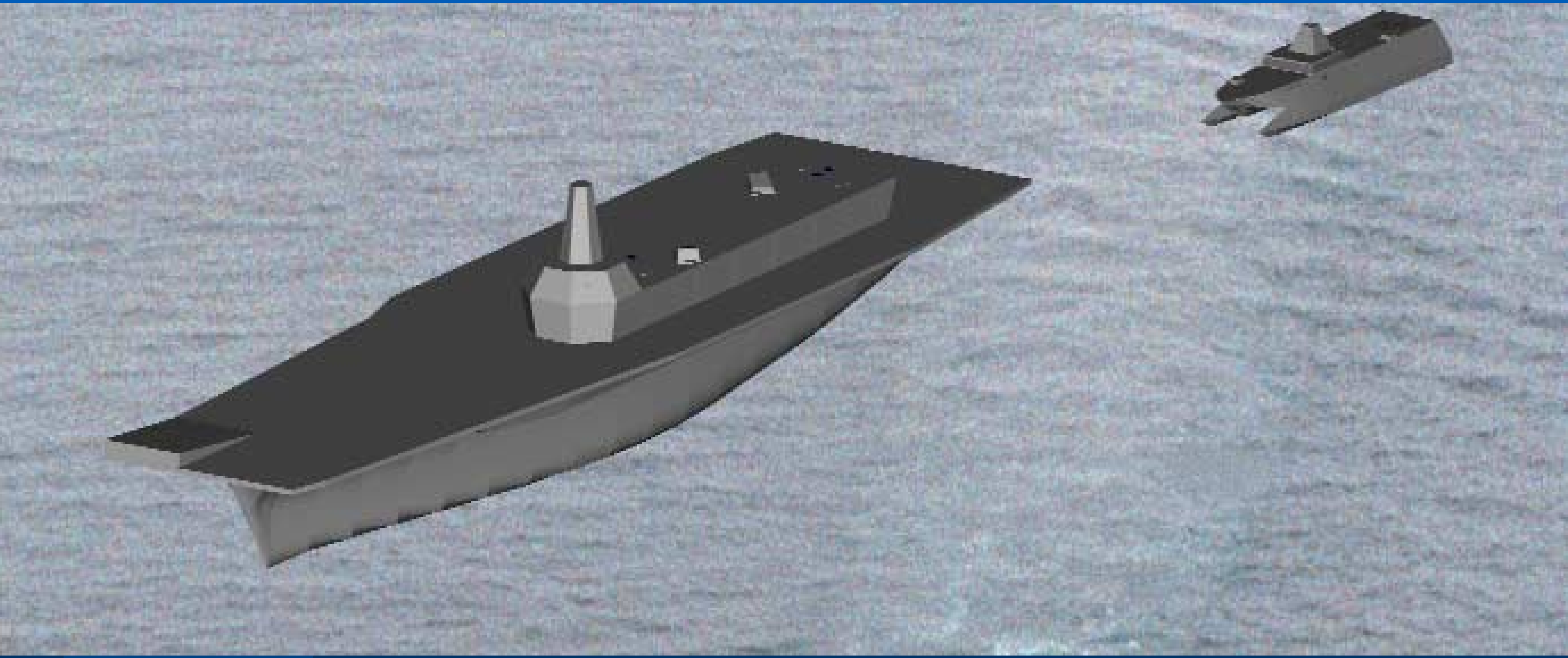
SEA LANCE



Corsair and SEA LANCE



Corsair and SEA LANCE