Sea-Force Presentation Outline

- Introduction
- Requirements & Alternatives
- Hull
- Flight Deck
- Propulsion
- Electrical
- Logistics
- Combat Systems
- Total Ship Evaluation
- Conclusions

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

2002 TSSE Faculty and Team Members

- Faculty Members
  - Professor Harney
  - Professor Papoulias

- Team Members
  - LT Luis Alvarez, USN
  - LT Jihed Boulares, Tunisia Navy
  - MAJ Keng-Shin Chong, RSN
  - LT Lynn Fodrea, USN
  - LT Brian Higgins, USCG
  - LT Seth Miller, USN
  - LTJG Korkut Murat, Turkish Navy
  - LT Koray Savur, Turkish Navy
  - LT Matt Steeno, USN
  - MAJ Chong-Ann Teh, RSN
  - LT Dwight Warnock, USN

More information at www.nps.navy.mil/tsse/

Design Project Guidance

…to examine the concepts associated with "seabasing".

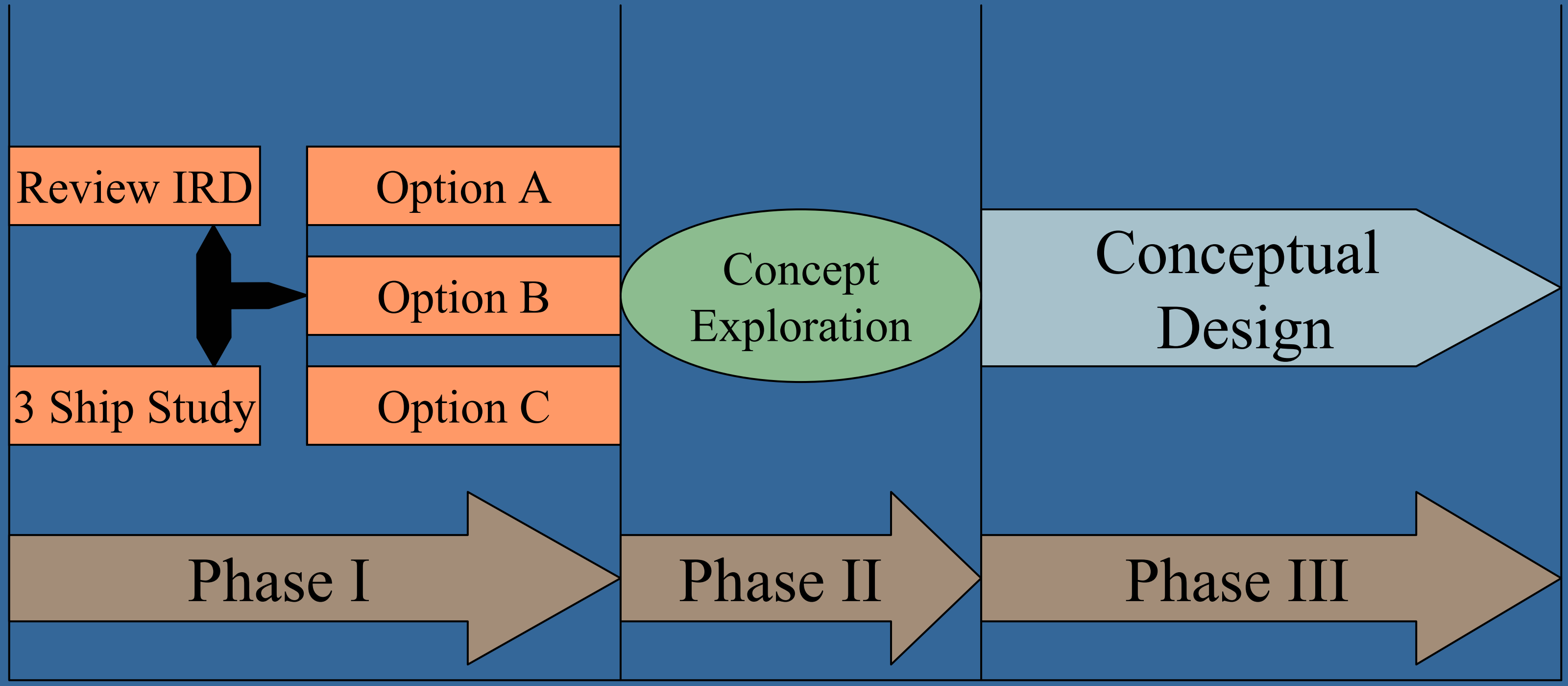
and

…produce a design for a ship to enable effective seabasing.

and

…explore the feasibility of building an LHA, MPF, and LMSR on a common hull form.

Project Overview

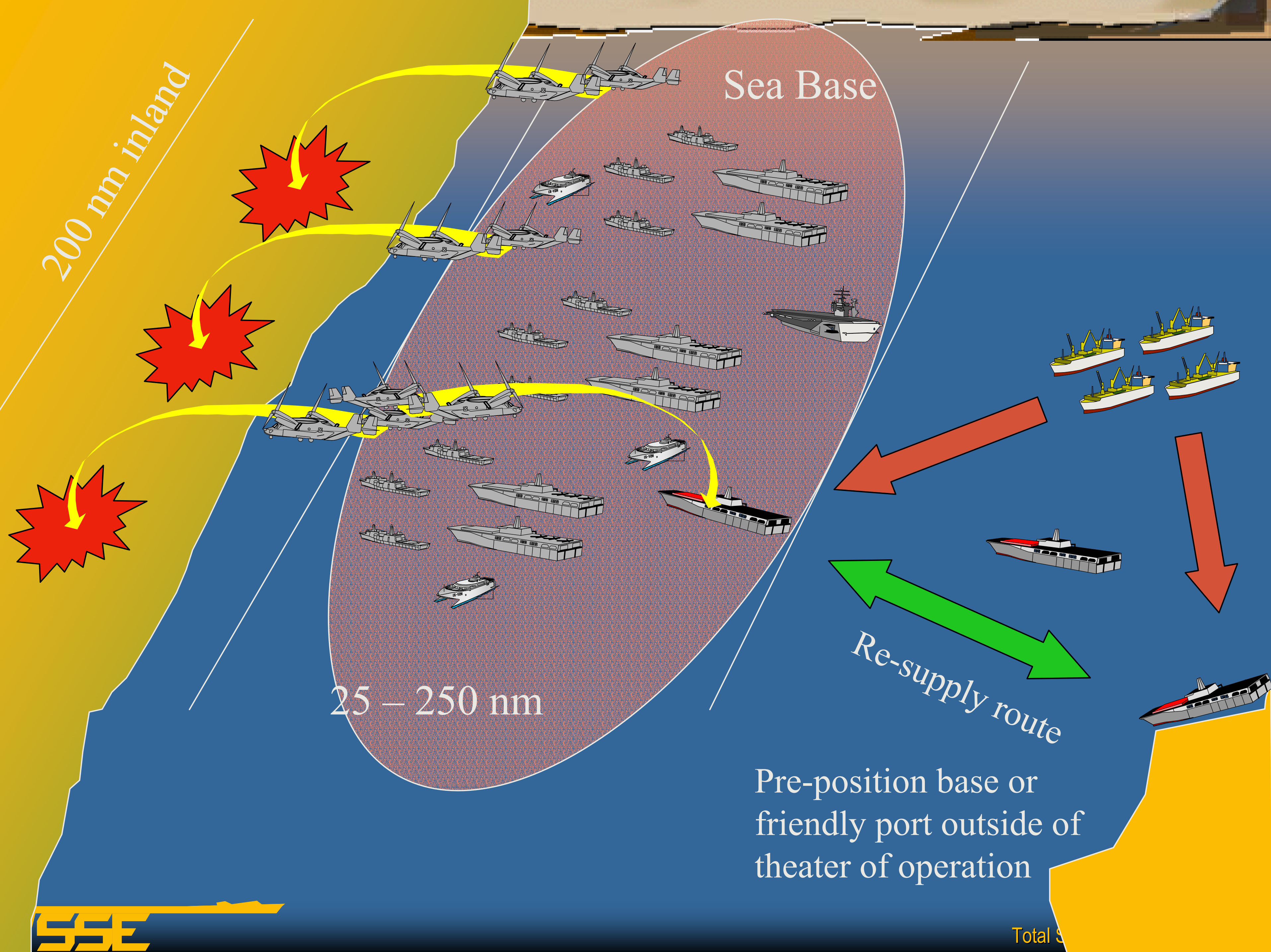


Design Constraints

- Access to major U.S. ports.
- Draft and height not greater than that of a CVN.
- Length less than 1000 ft.
- Displacement not greater than 100k LT
- Technology ready for shipboard installation in 2020.

Design Philosophy

Priority	Weighting Factors
1. Aviation Capability	High
2. Indefinite Sustainment	High
3. Operation Flexibility	High
4. Combat Sys. Defensive	High
5. Modularity	Medium
6. Manning Reduction	Medium
7. Speed	Medium
8. Maintainability	Medium
9. Cost	Low
10. Combat Sys. Offensive	Low
11. Appearance	Low


200 nm inland
Sea Base
25 – 250 nm
Re-supply route
Pre-position base or friendly port outside of theater of operation

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Requirements Analysis

- Systems Engineering and Analysis
  - Initial Requirements Document requests family of ships capable of Sea Basing and STOM
- TSSE System Engineering Methodology
  - “Top Down” analysis of IRD
    - Traceability
    - Context
  - “Bottom Up” study of planned platforms
    - LHA(R), MPF(F), LMSR

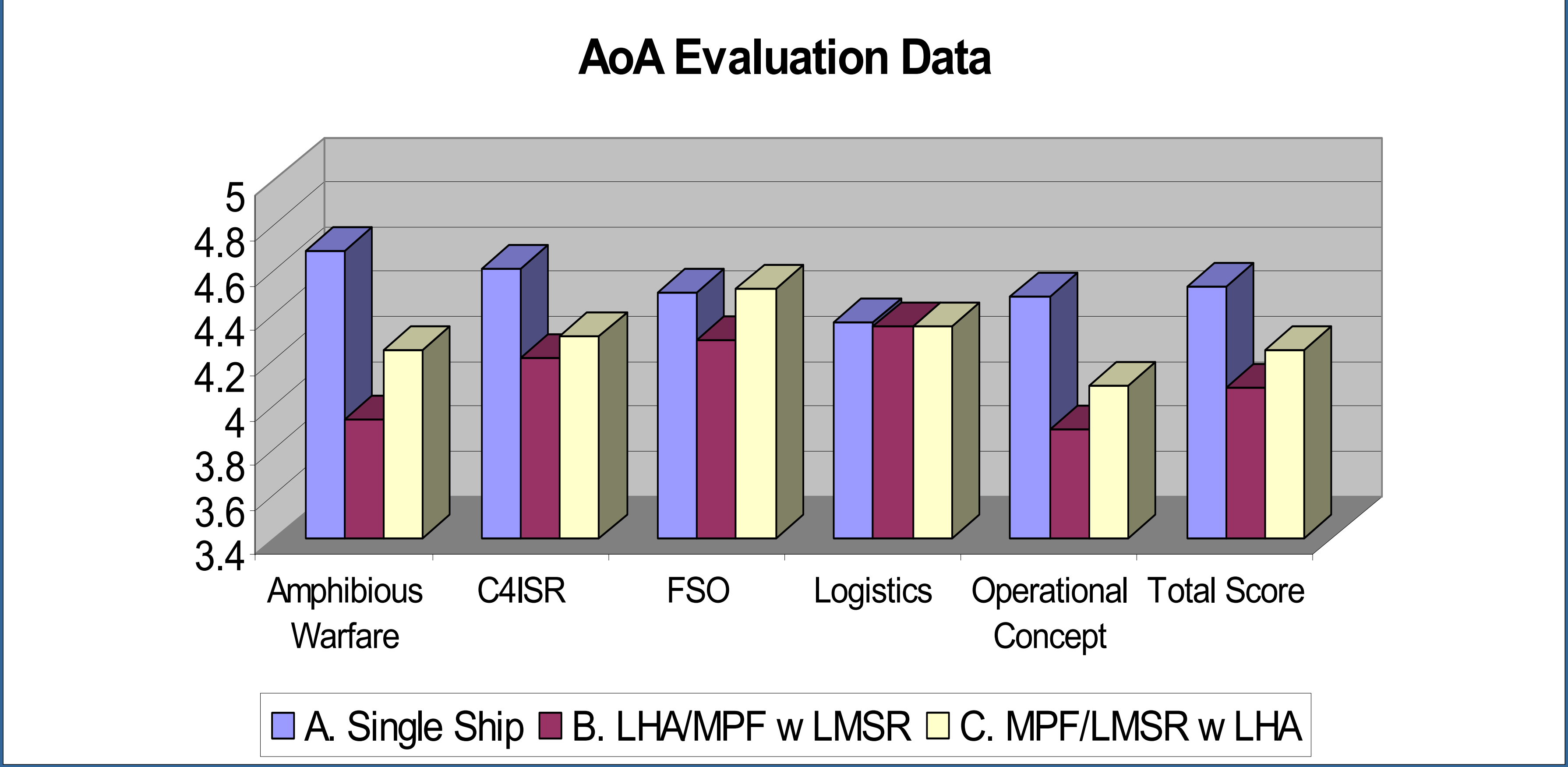
Notional MEB Composition

	Number	Weight (LT)	Volume (ft^3)
Troops	18,000	--	--
Vehicles	1,748	50,814	2,650,000
Aircrafts	204	2,118	14,400,000
Provisions (pallets)	4,800	2,544	304,000
Ordnance (pallets)	17,280	18,414	1,100,000
Fuel – GCE & ACE	--	30,714	1,345,000
Total for MEB	**18,000 troops 1,748 vehicles 204 aircrafts 22,080 pallets**	**104,604**	**19,799,000**
Total per Ship	**3,000 troops 292 vehicles 34 aircrafts 3,680 pallets**	**17,434**	**3,300,000**

Analysis of Alternatives

- **A. Single Ship Design**
  - One hull form
  - Combat configured or logistics configured
- **B. LHA/MPF with LMSR**
  - LHA/MPF variant – troops, hospital, combat systems
  - LMSR variant – fuel, provisions, ammo
- **C. MPF/LMSR with LHA**
  - MPF/LMSR variant – troops, hospital, stores
  - LHA variant – combat systems

Conclusions



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What we Needed in a Hull Design

- Large cargo capacity
- Large flight deck
- Space for a well deck
- Durability/Survivability
- Propulsion efficiency

Future Sealift Ship Designs

- Global Security.org
- Nigel Gee and Associates Ltd.

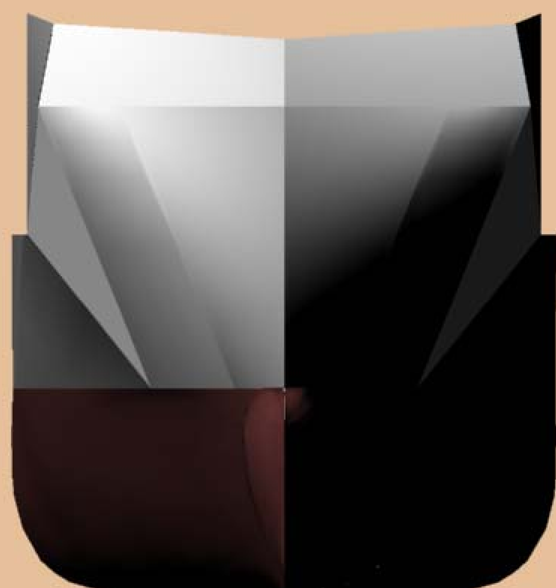
HMS Triton

- LOA…….312 ft
- Beam……66 ft
- Draft….10 ft
- Displacement…..800 LT
- Speed…..20 kts
- Launched May 2000

Additional Benefits from Tri Hull Design

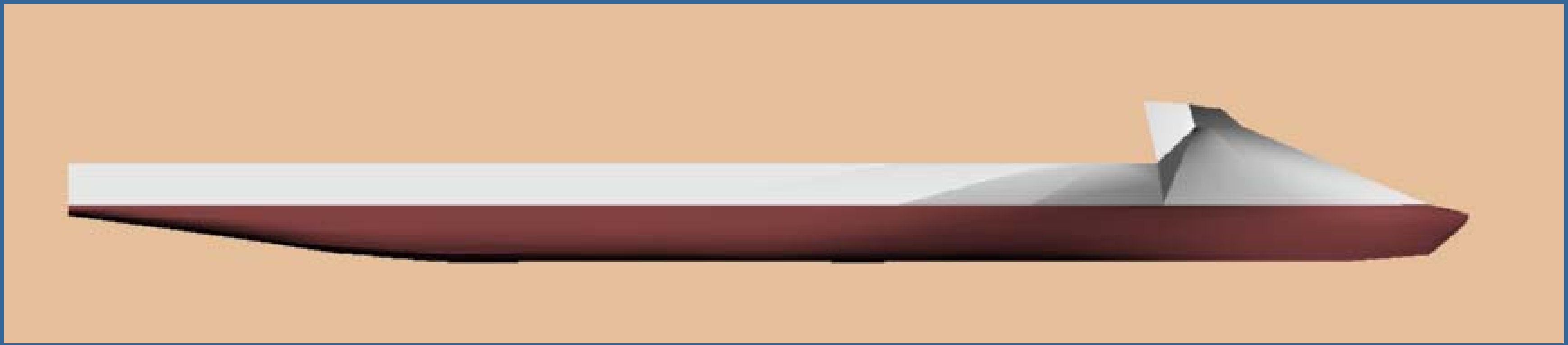
- Wide open deck layouts
- Excellent Stability
- Protection from missile/Torpedo hits

Center Hull Characteristics



- Length…..990 ft
- Width……106 ft
- Draft……..42 ft
- Displacement…75,500 LT

Characteristics of Main Hull Form

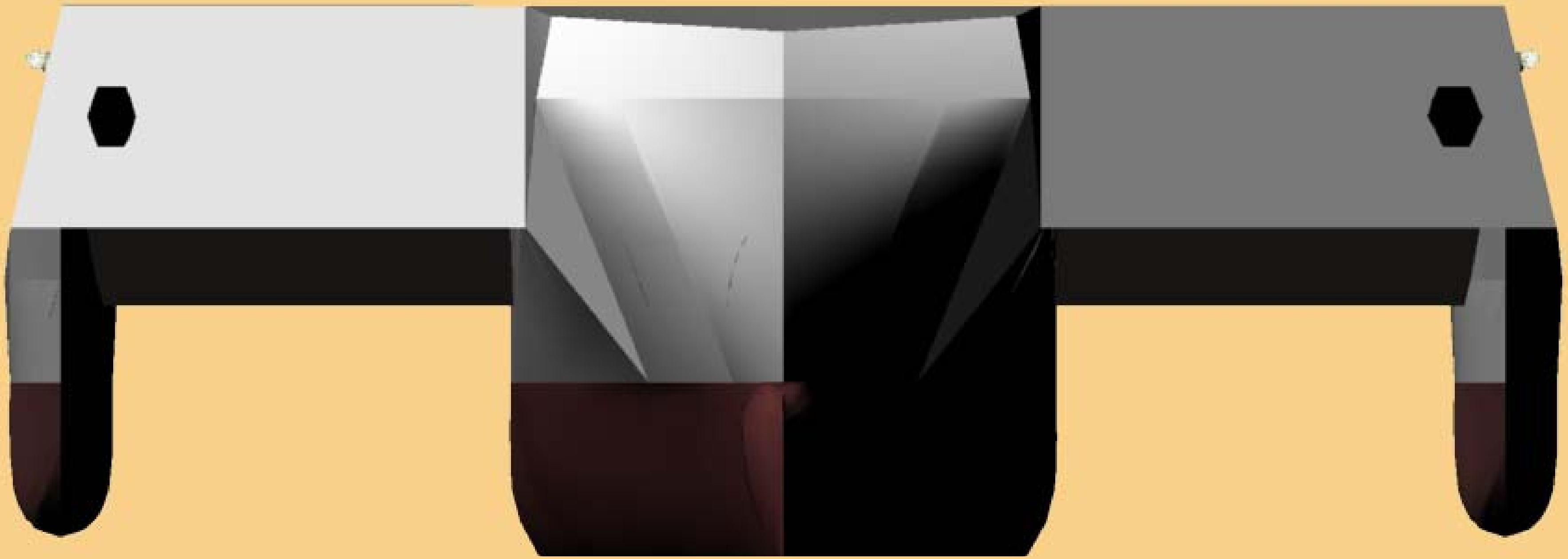


- Flat transom to facilitate a well deck
- Raised keel in stern to provide space for propulsors
- High length-to-beam ratio
- Wave piercing bow

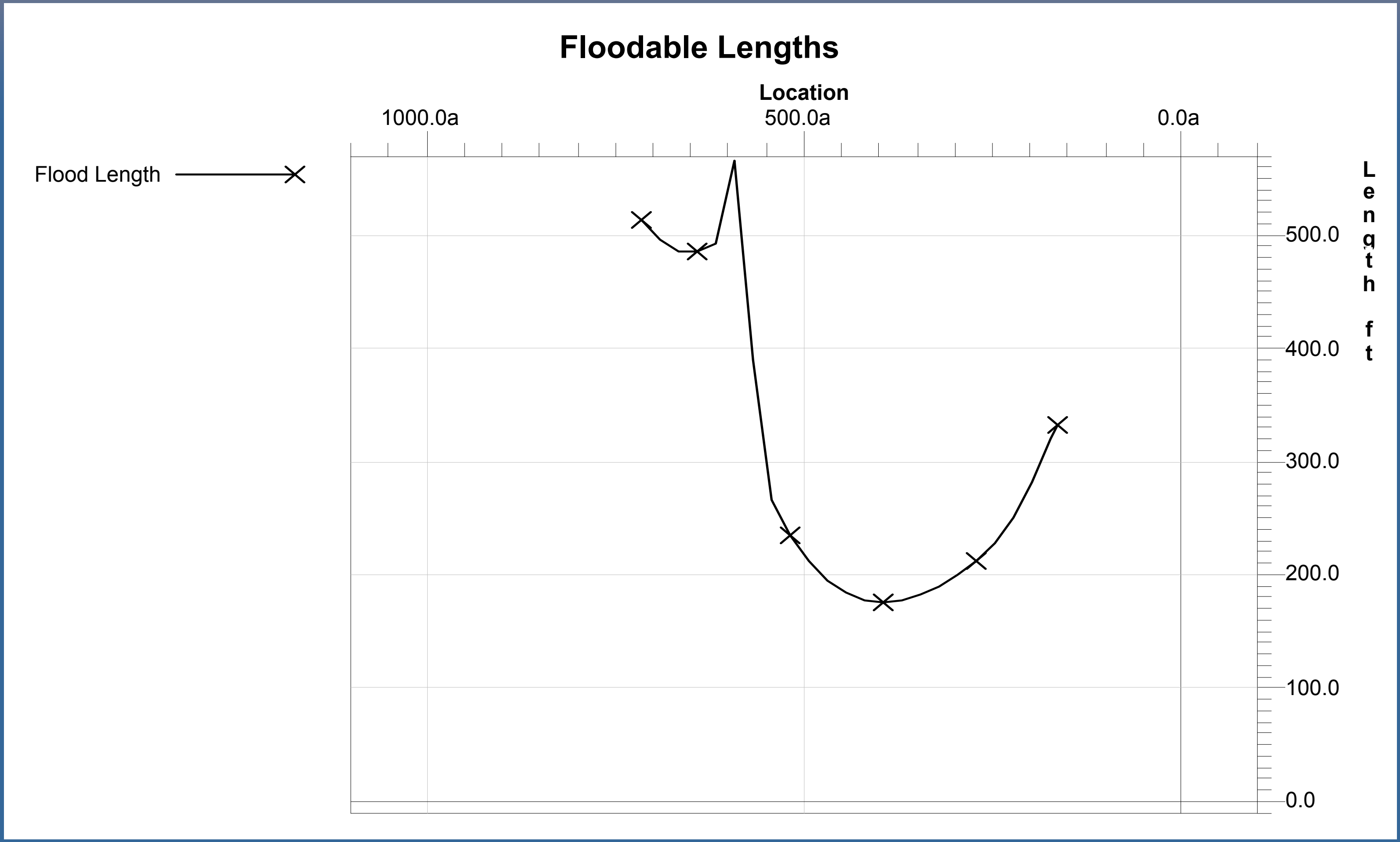
Outrigger Hull Characteristics

- Length…..550 ft
- Width……20 ft
- Draft……..32 ft
- Displacement…6000 LT

Superstructure Description



Floodable Length Calculations

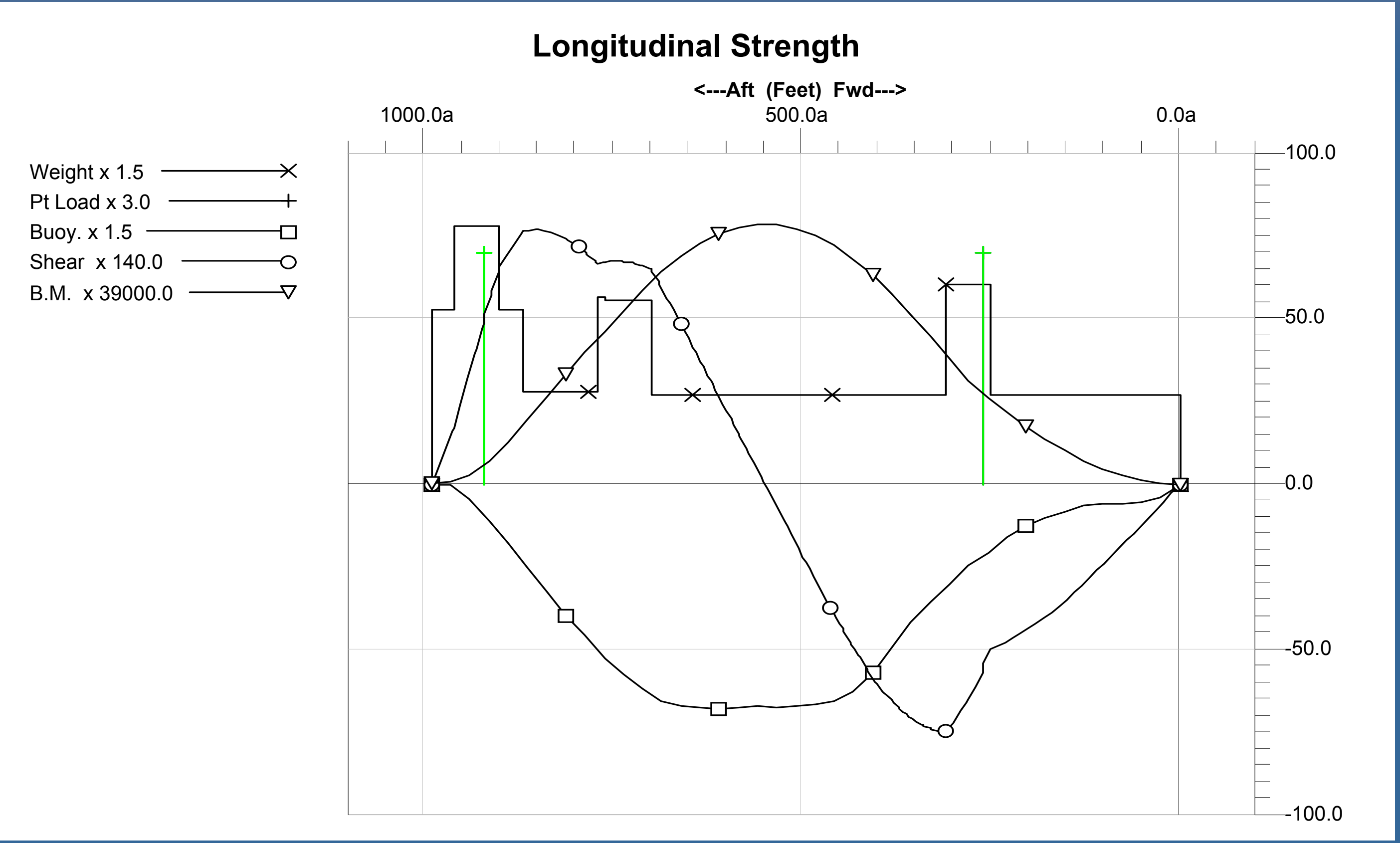


- Led to location of watertight bulkheads and spaces

Weight Breakdown

CATEGORY	WEIGHT (Long Tons)
Structure	39996
Vehicles	10624
LCAC & LCUs	1792
Aircraft	442
Supplies	3493
Personnel	267
Combat Systems	1215
Propulsion/Electrical	12500
Fuel	13119
Water	4000
TOTAL	87448

Structural Calculations: Longitudinal Stress

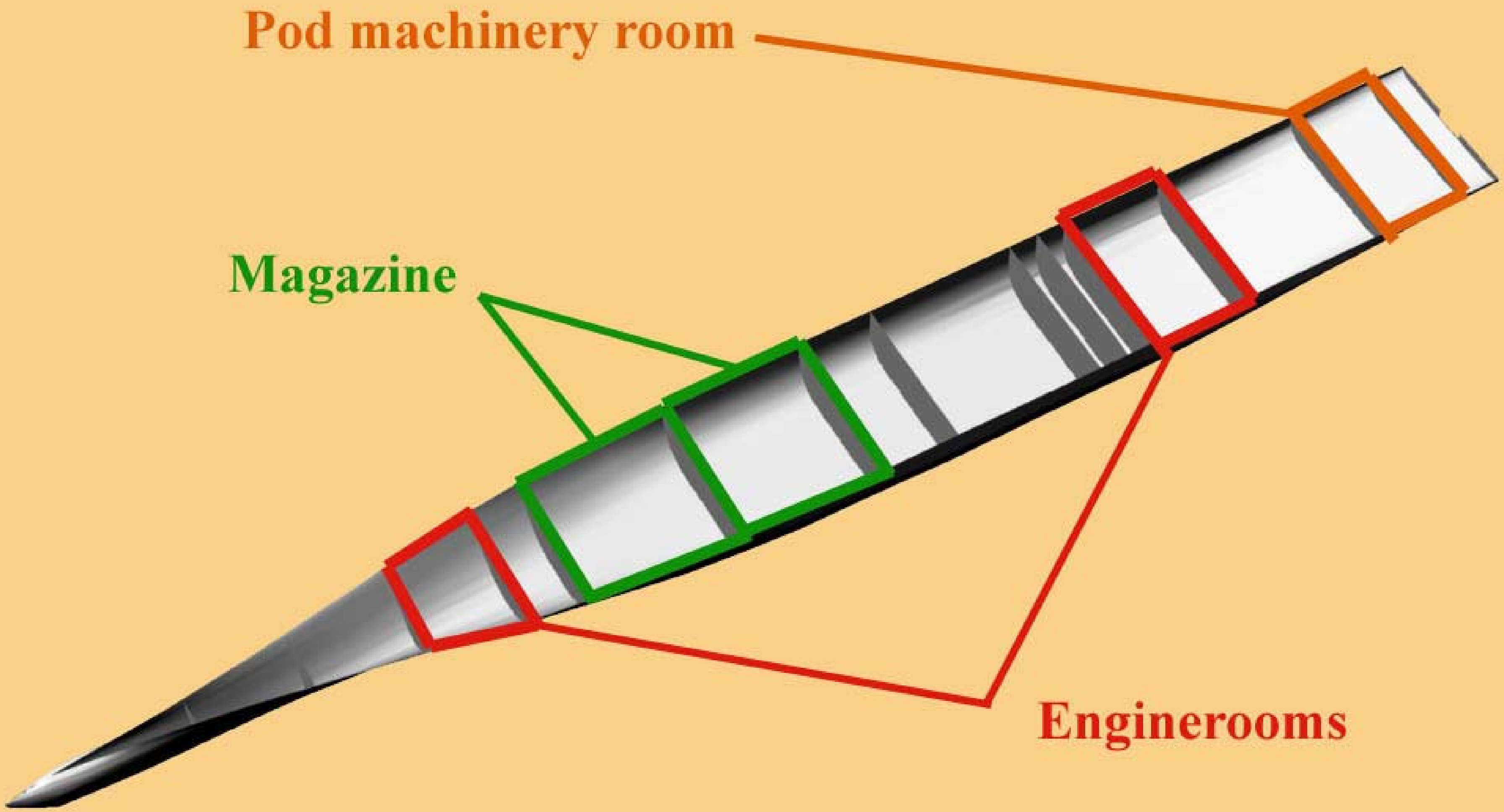


- 10,050 psi………maximum predicted stress
- 15,000 psi……………………allowable stress

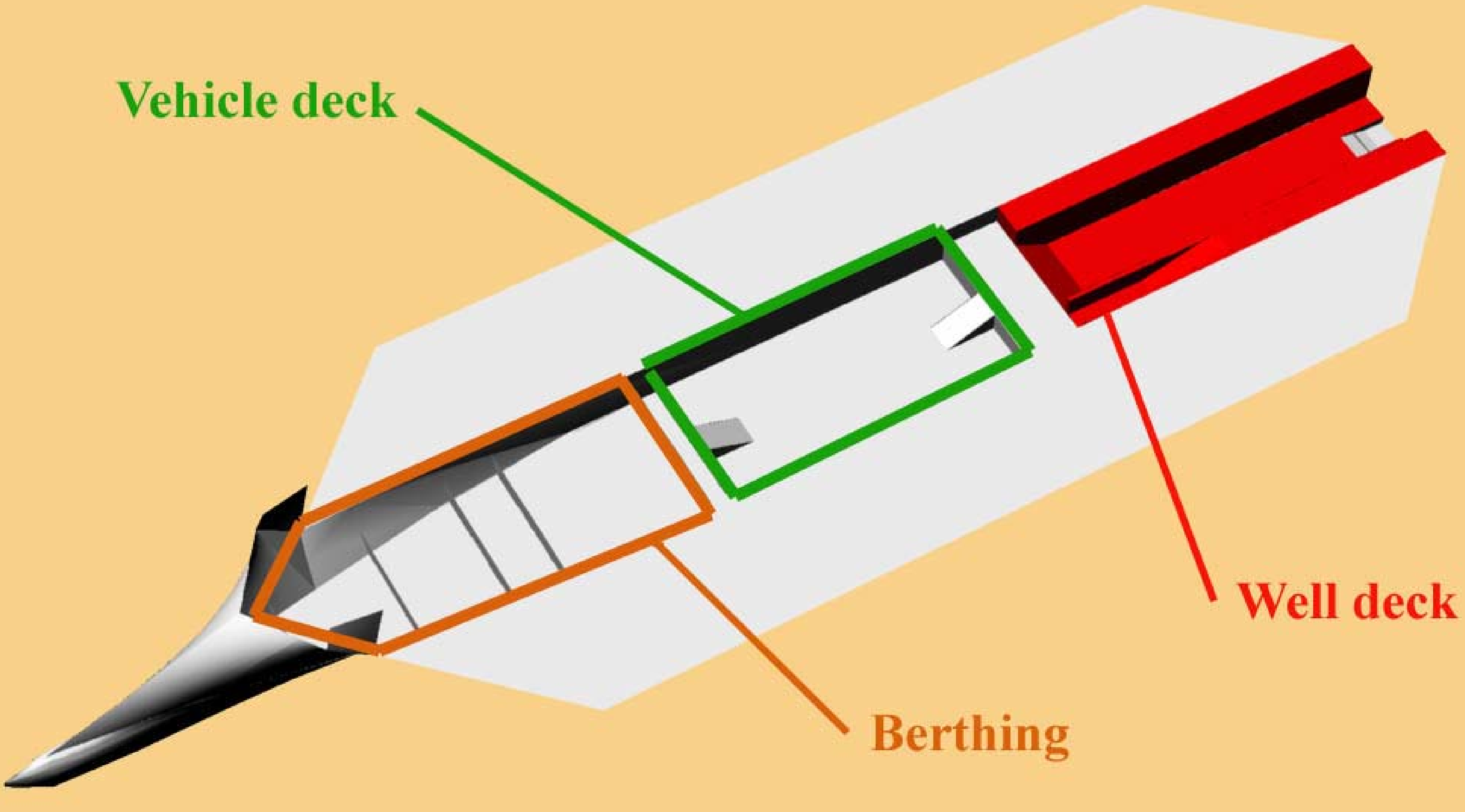
Rolling Calculations

- Based on the same analysis done at MIT for the LHA-R design.
- Predicted snap roll will be countered using anti-roll fins

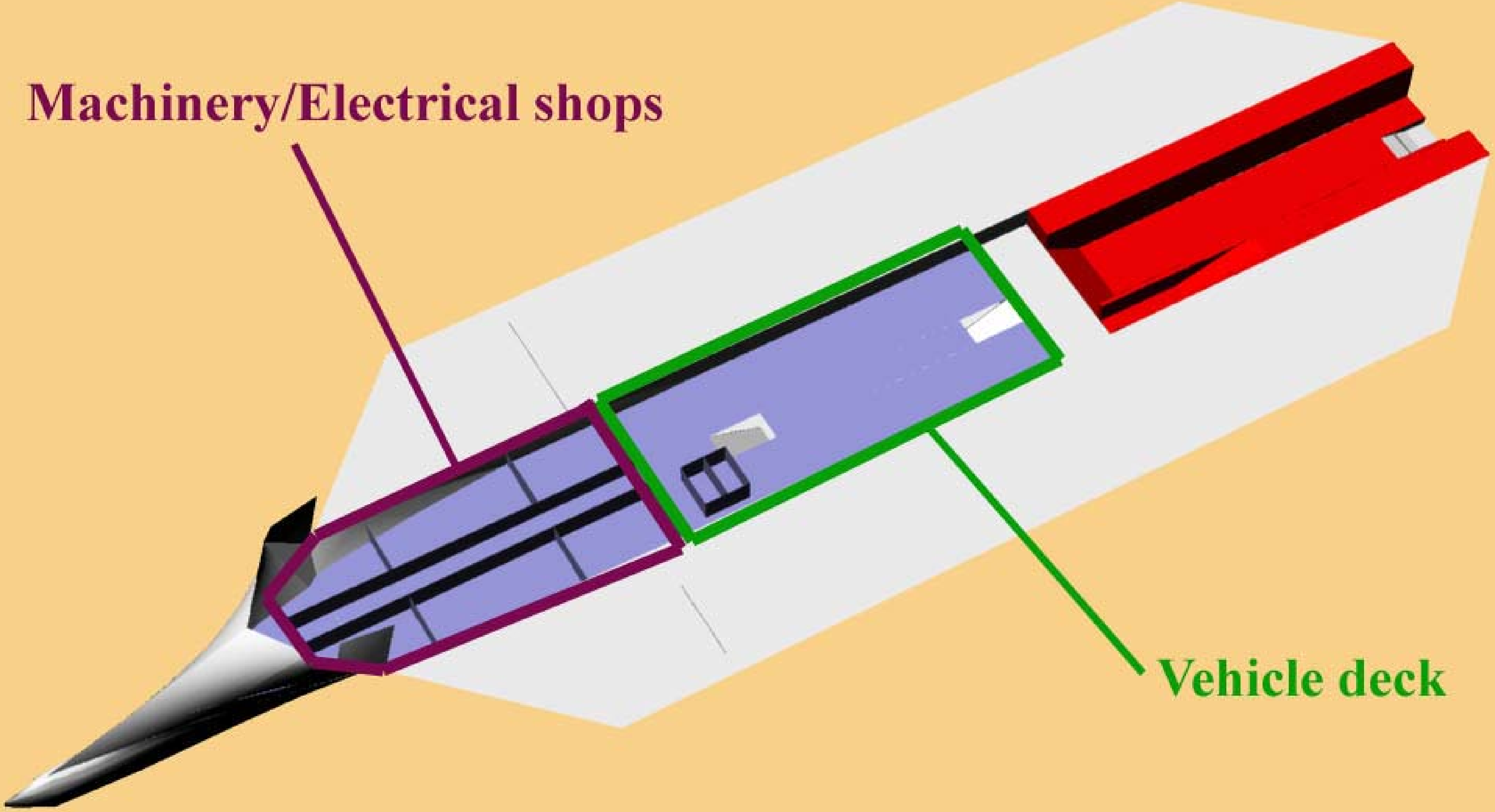
Below the Waterline



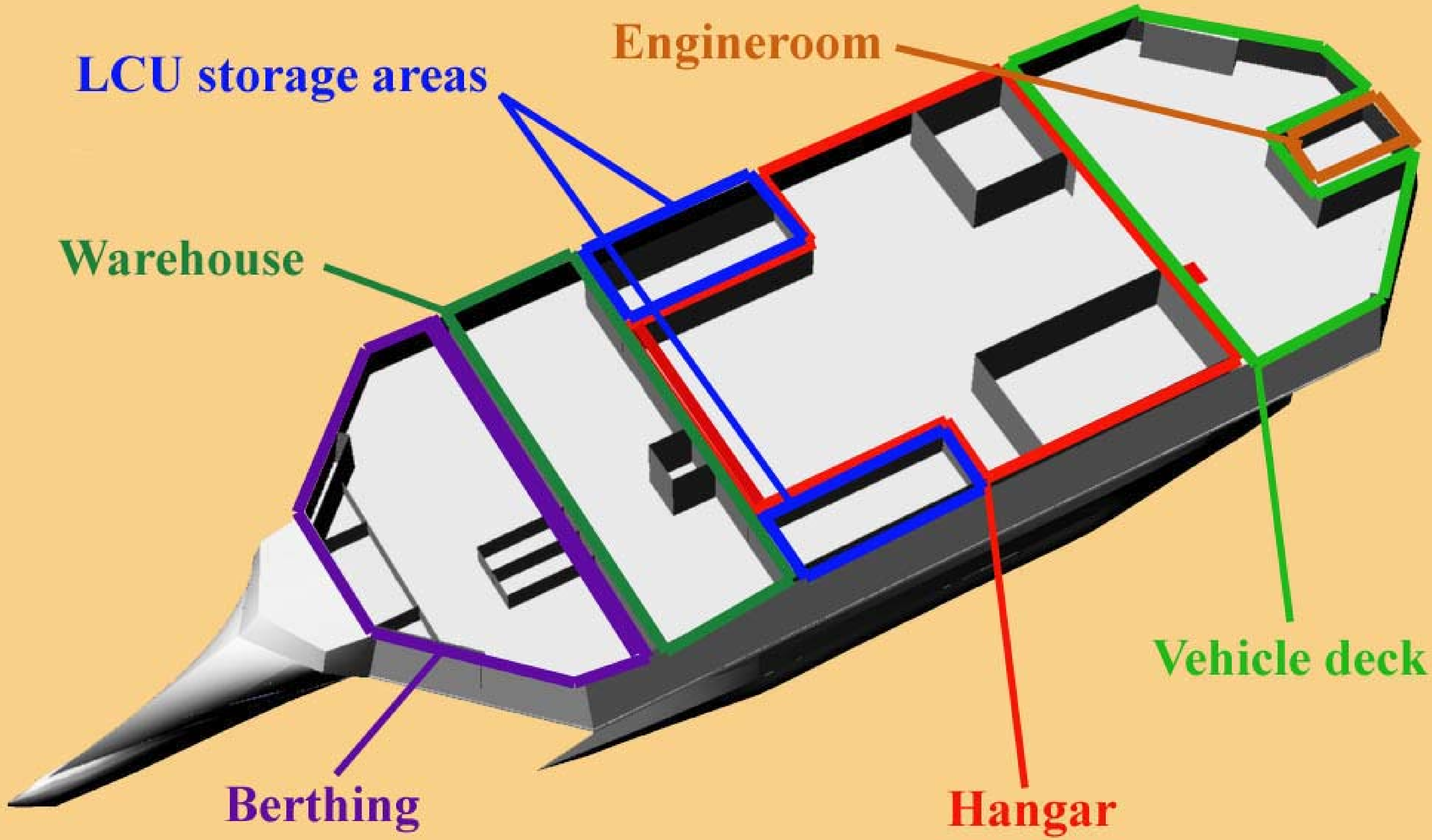
Second Deck



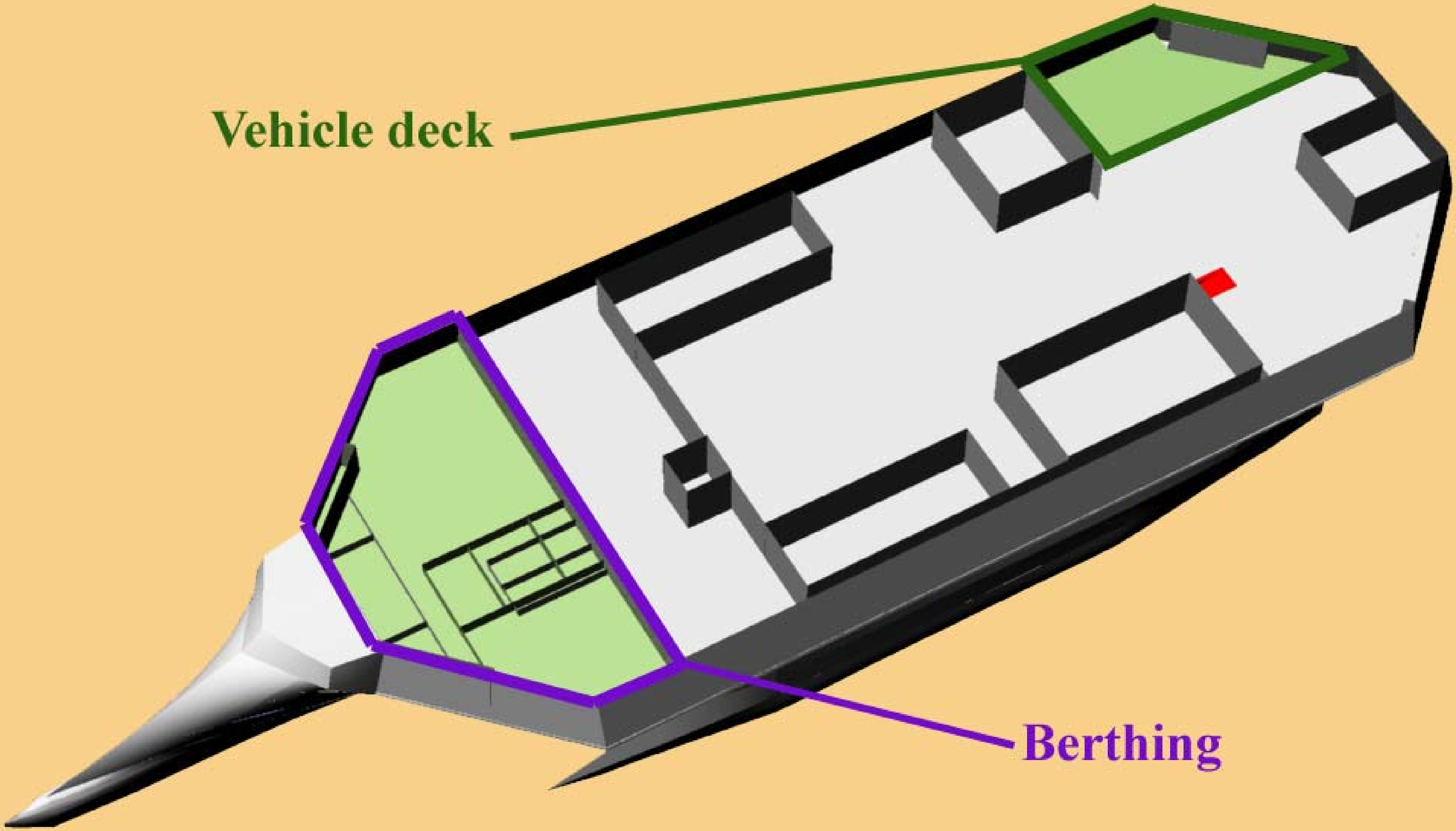
First Deck



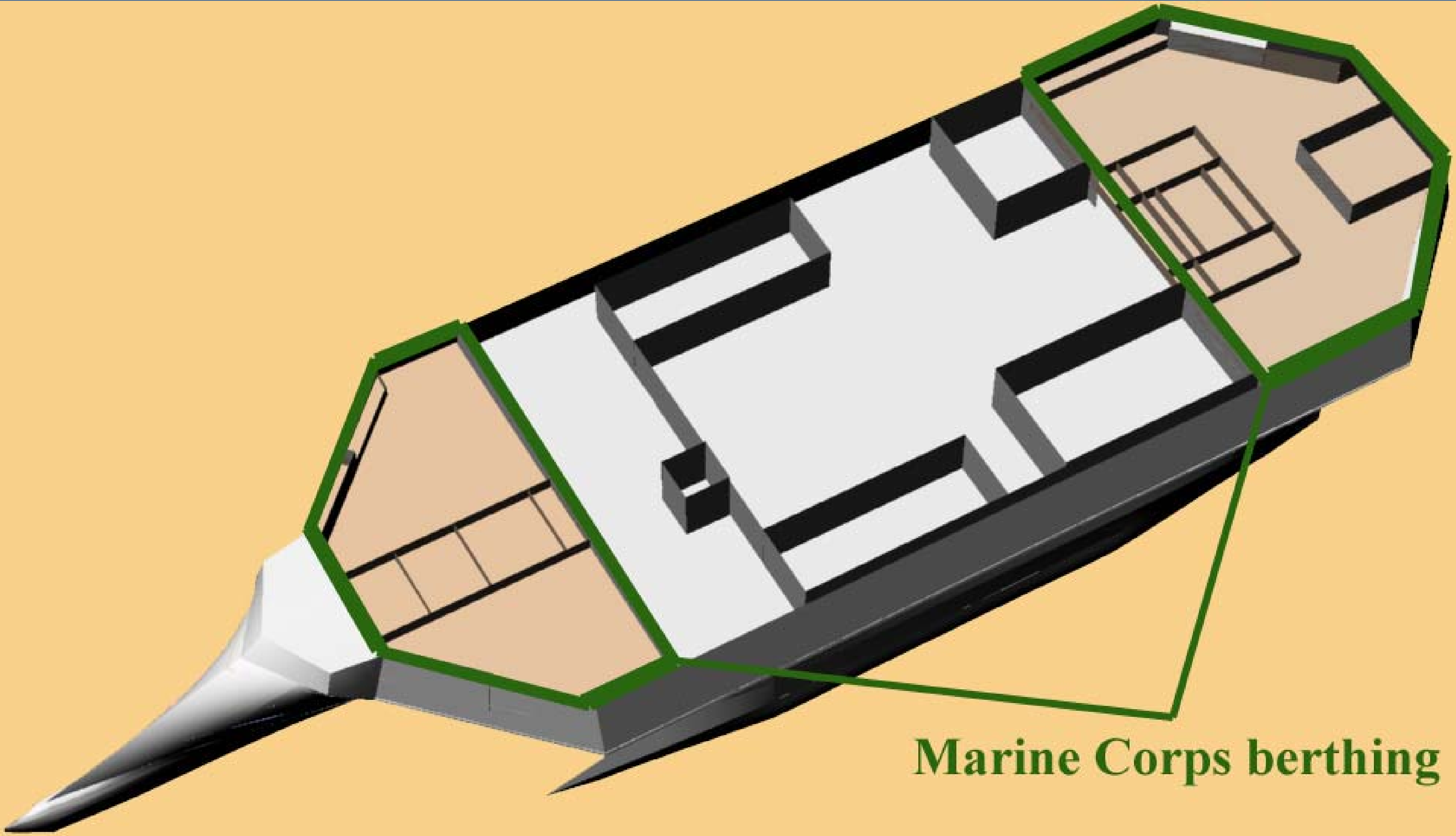
Main Deck


Engineroom
LCU storage areas
Warehouse
Vehicle deck
Berthing
Hangar

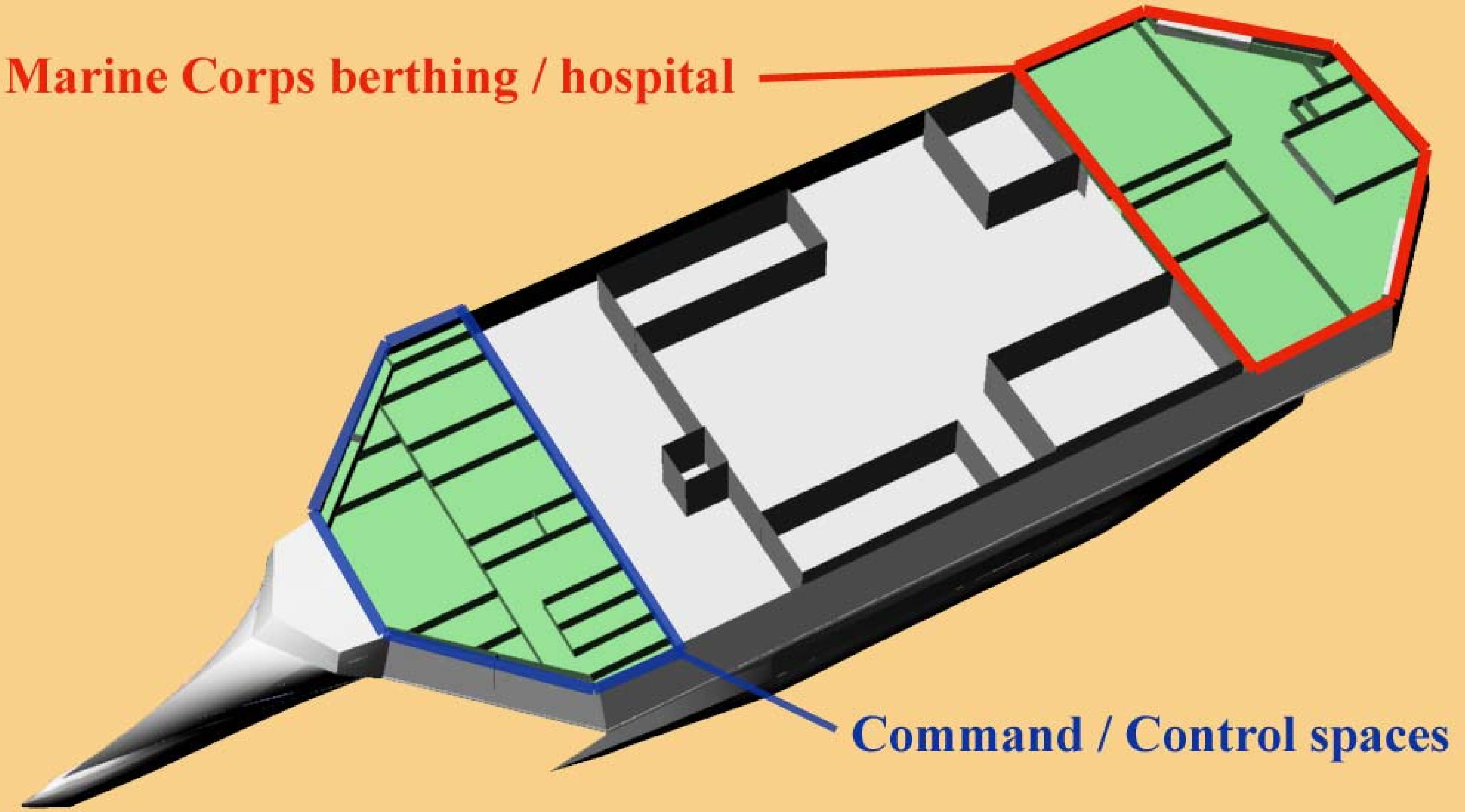
01 Deck



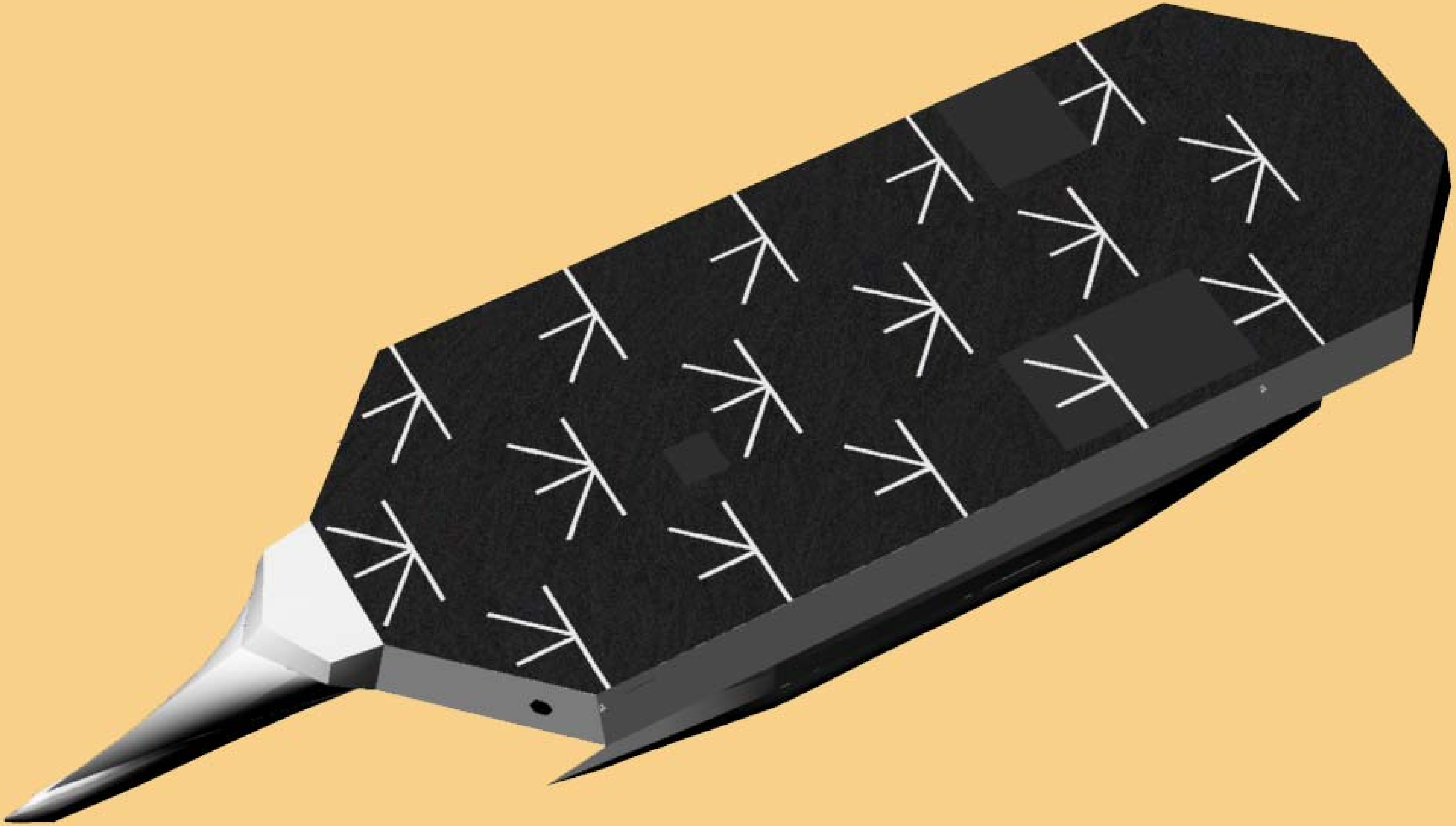
02 Deck



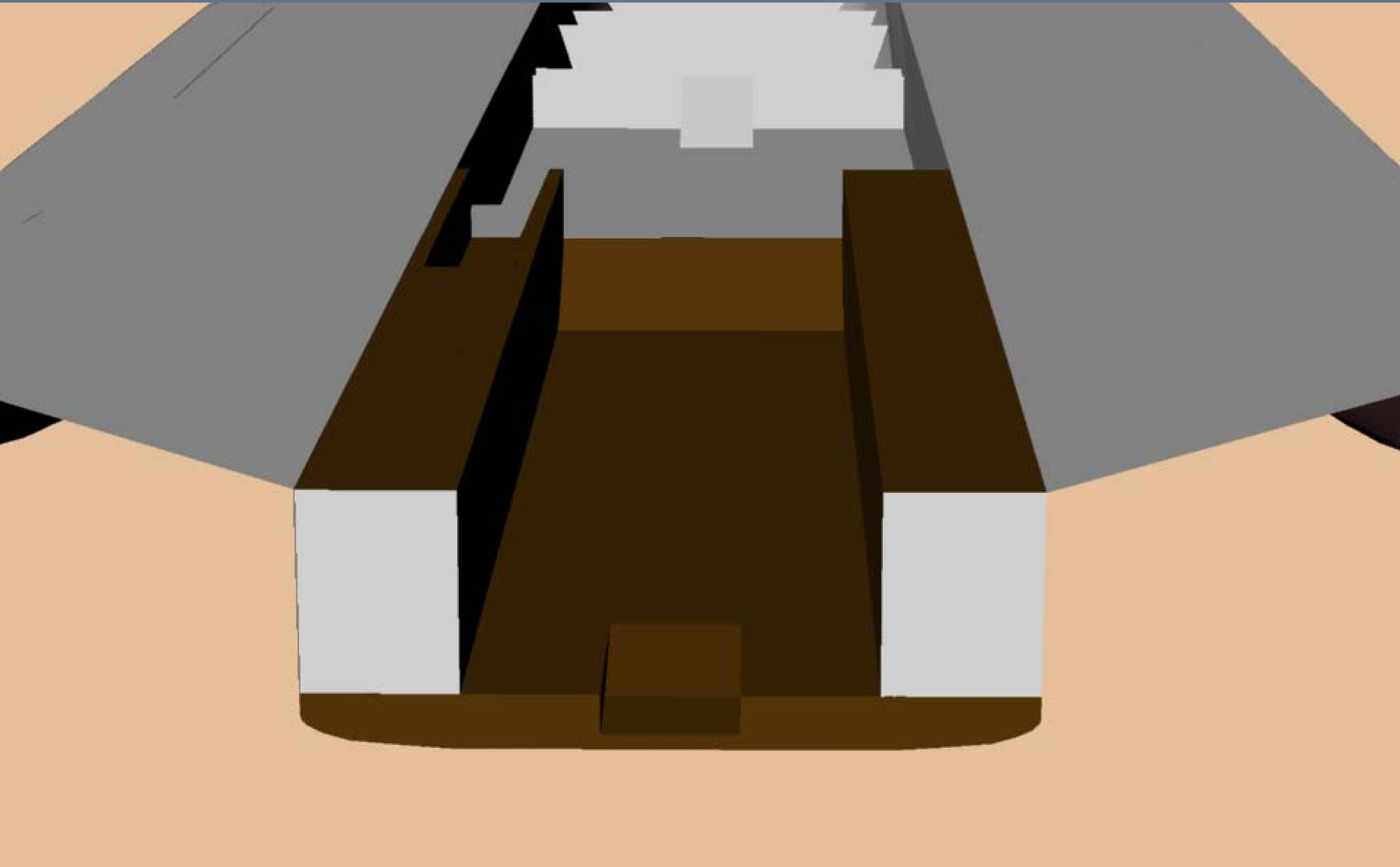
03 Deck



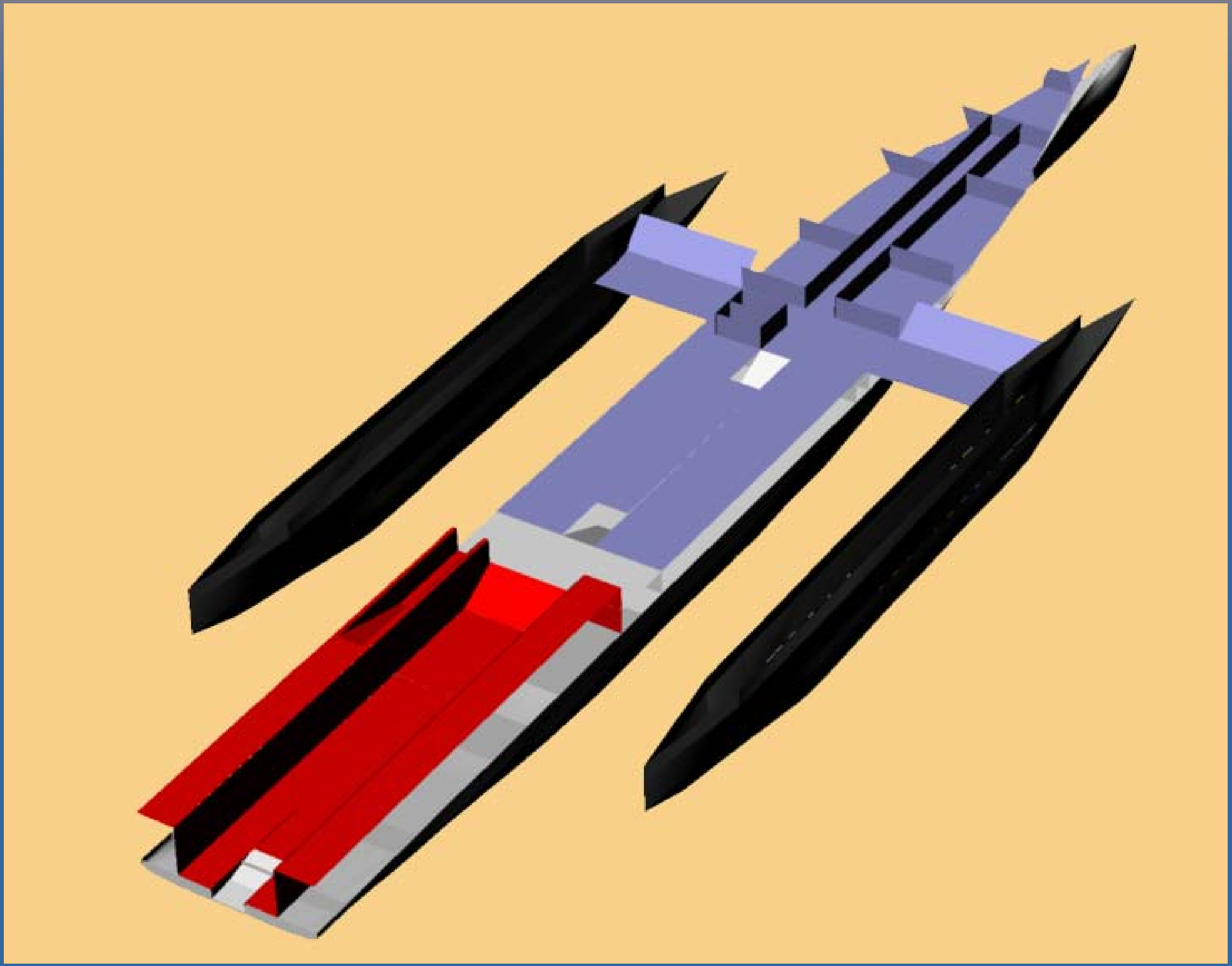
Flight Deck



Well Deck



Side Well Description



- Rail system transfers vehicles / containers between Sea Force and LCUs.

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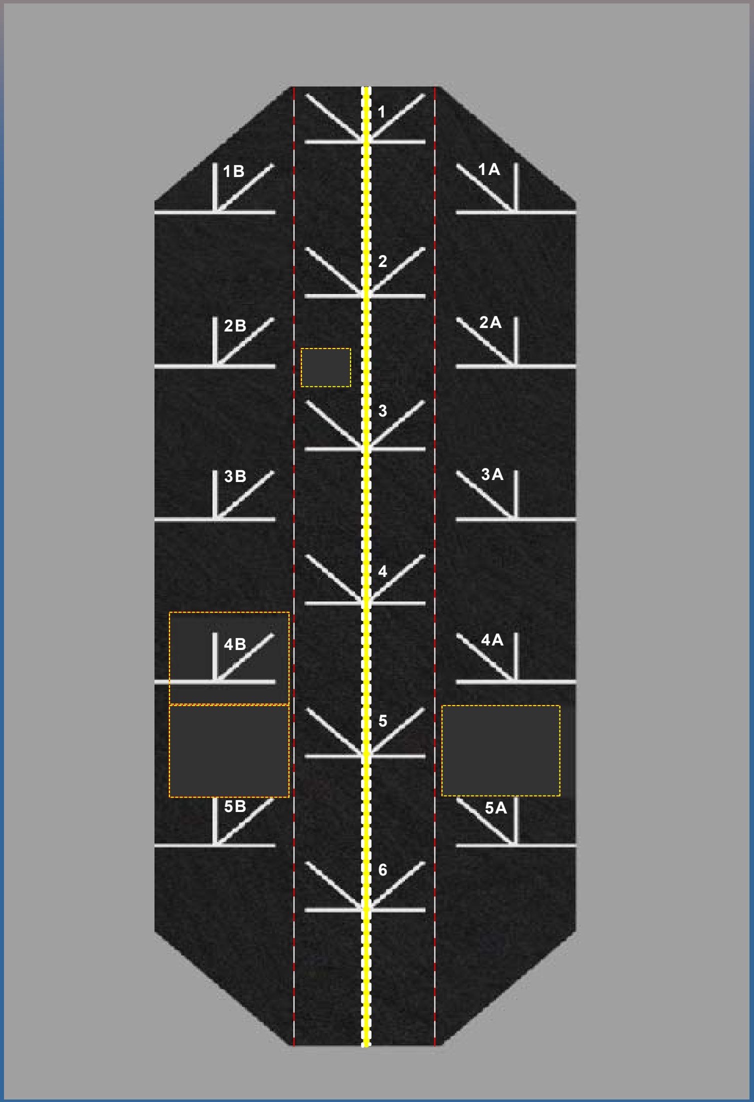
Flight Deck

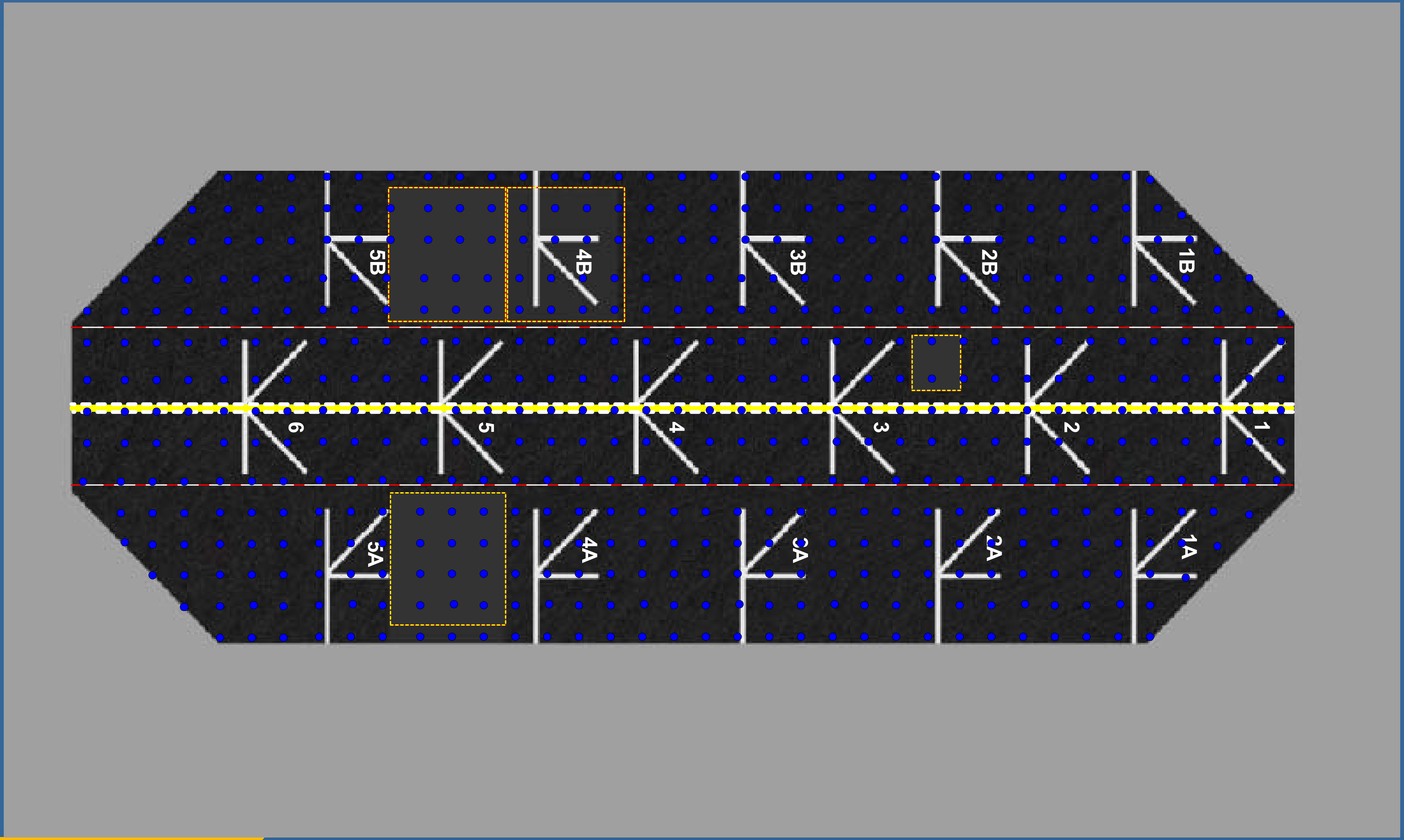
- Description
- Aircraft
- Minimize Manning

Flight Deck

- Triple Tram Line
- Length: 770 ft
- Width: 300 ft
- Area: 230,000 ft^2
- 16 A/C spots
- Centerline Runway
- 3 A/C Elevators



Flight Deck Sensor Grid



Aircraft

- 16 MV-22
- 4 Heavy Lift Aircraft
- 6 JSF
- 4 UH-1Y
- 4 AH-1Z
- 4 SH-60F

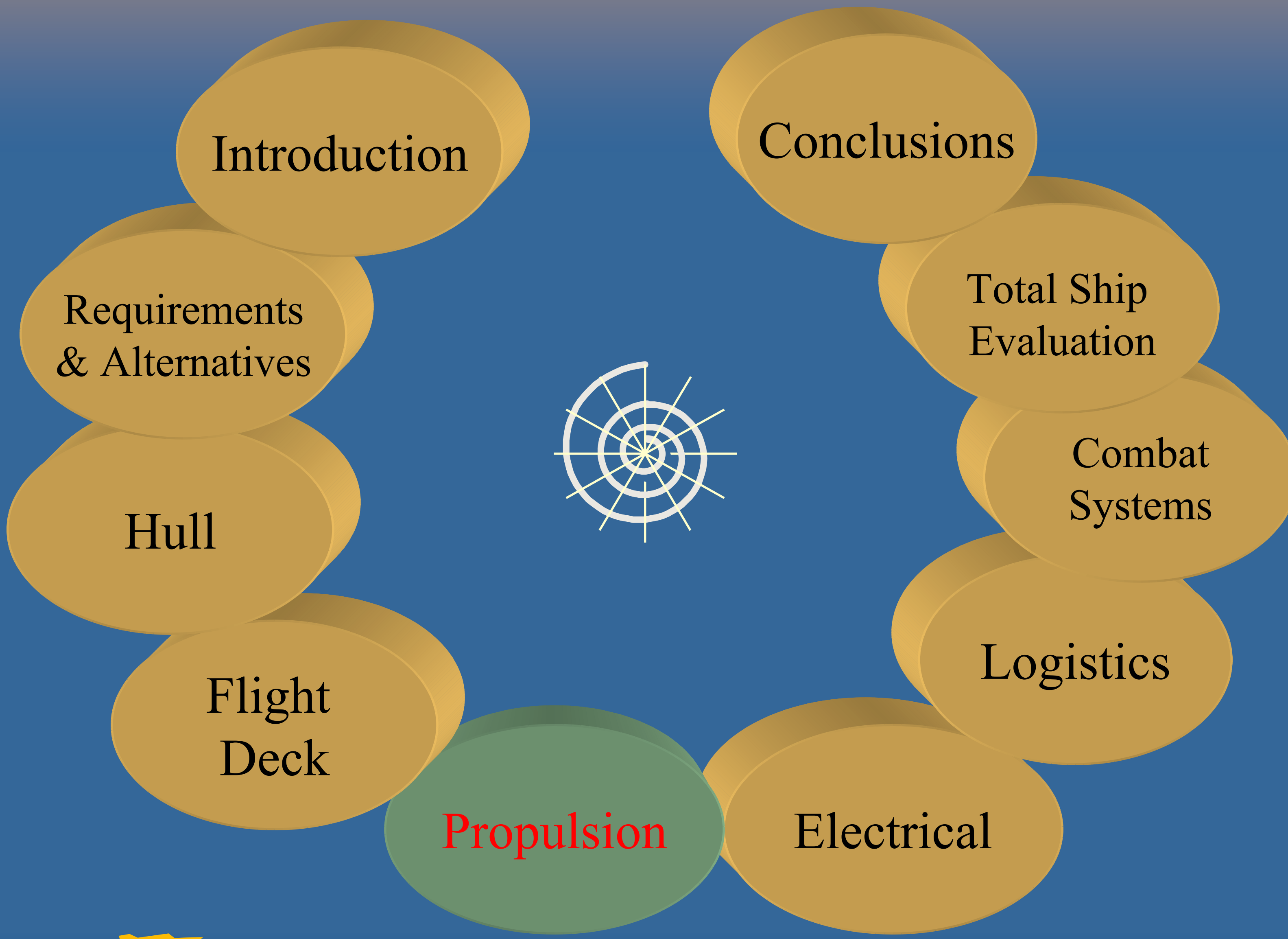





Manning Reduction

- Technologies
  - Robotics
  - Omnidirectional Vehicles
  - Advance Weapons Elevator
- Enhanced functions
  - Firefighting
  - Towing
  - Fueling
  - Aircraft loading

Sea-Force Presentation Outline



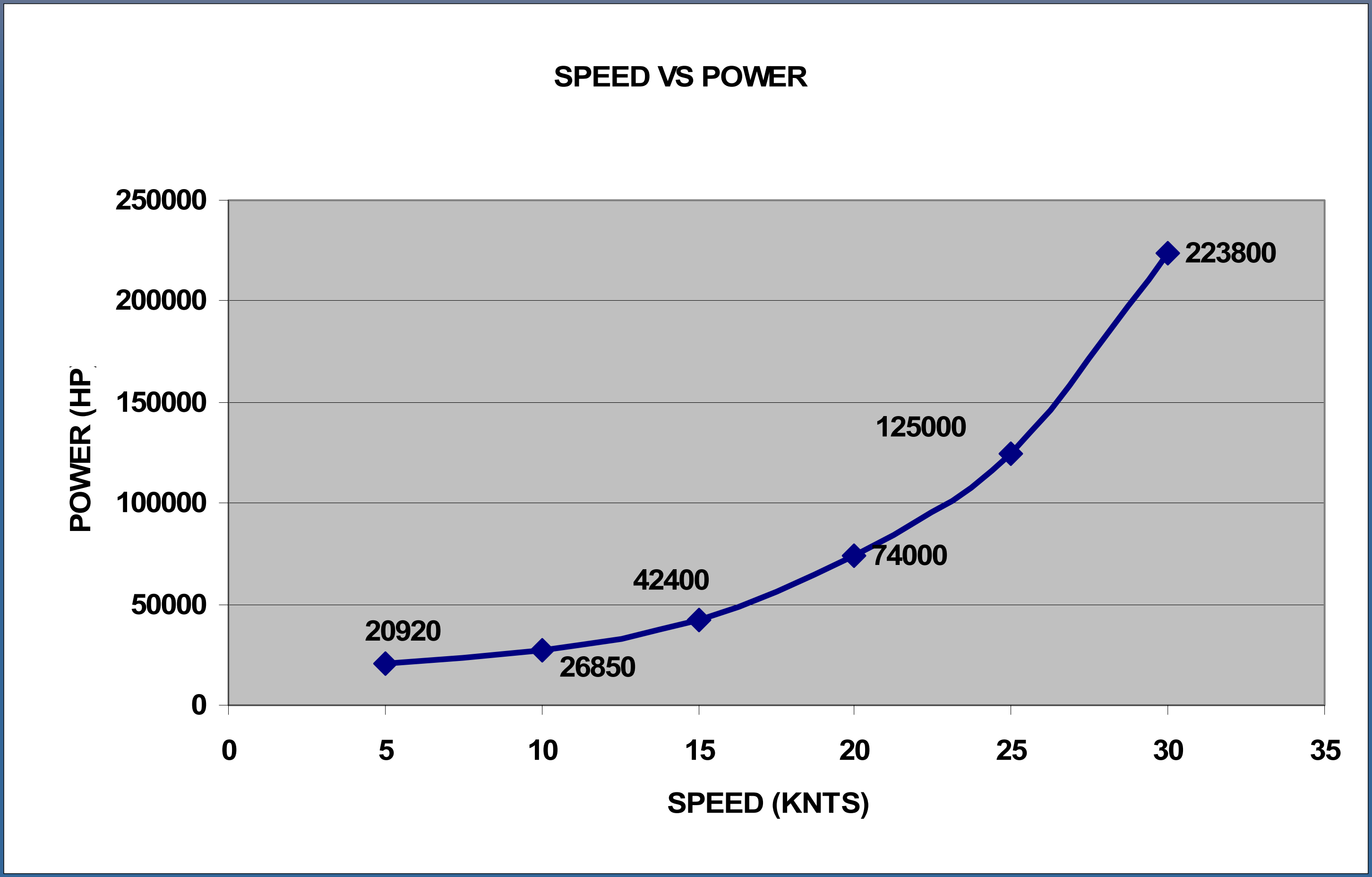
Propulsion

- Resistance Calculations and Power Req.
- Alternatives for Propulsion Plant
- Prime Mover Selection
- Comparison of Gas Turbines
- Propulsor Selection
- Propulsion Motor Selection
- Fuel Consumption comparison
- Lay out plan

Alternatives for Propulsion Plant

- Conventional steam plant
- Nuclear steam plant
- Diesel engines
- Fuel cells
- Gas turbines

Speed versus Power Diagram

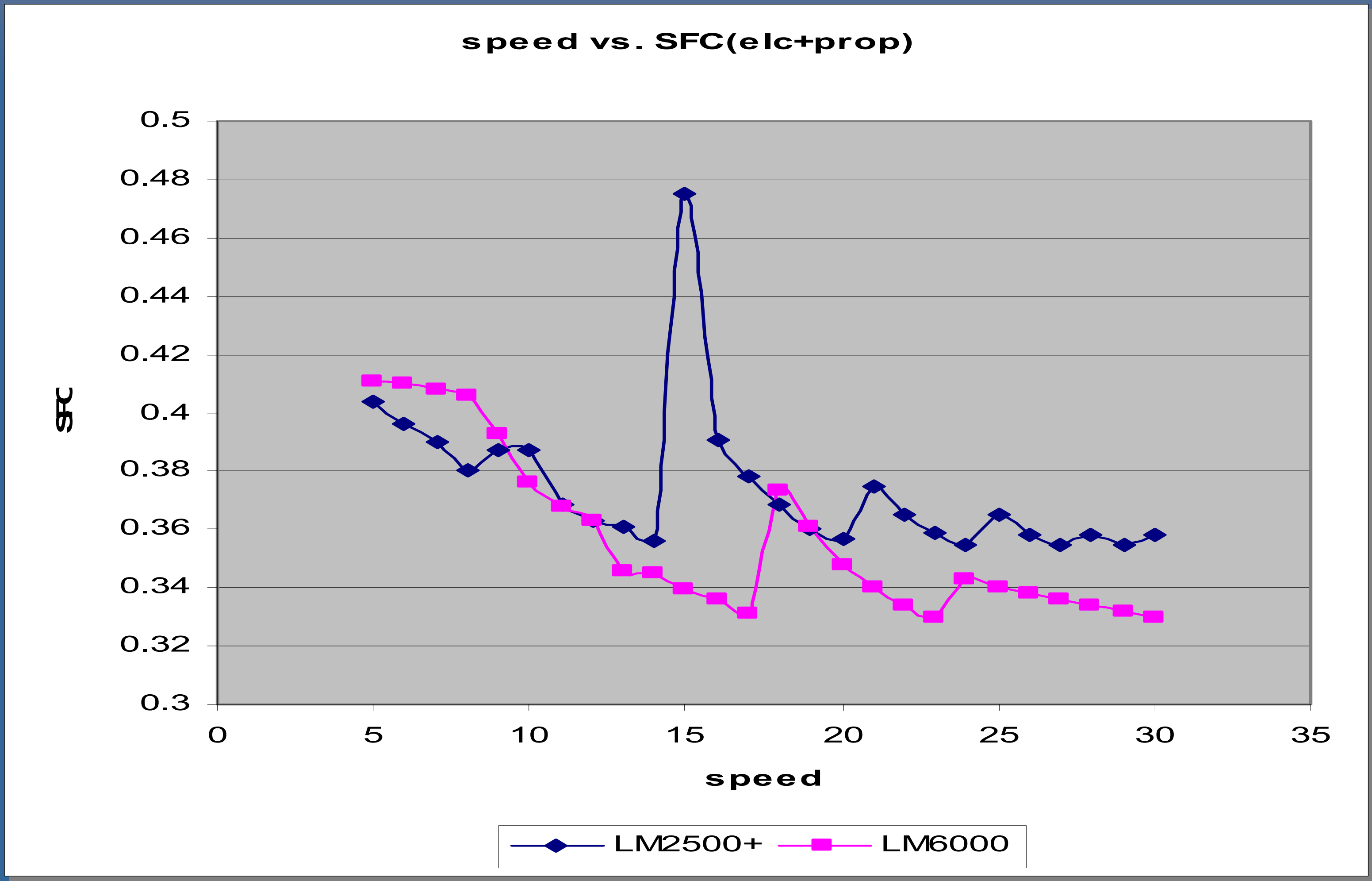


24 Hour Ship Electric Load=>15 Mw (~20 000 Hp)

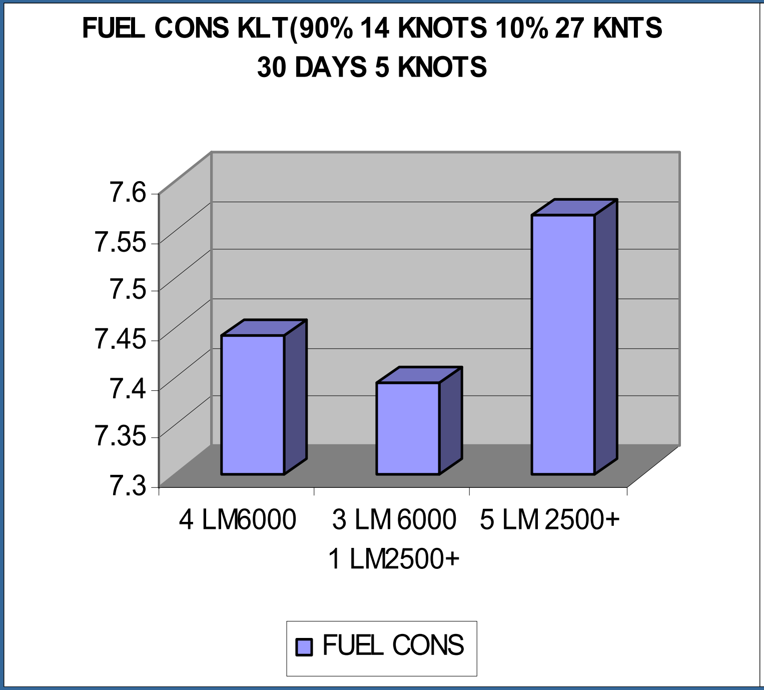
Prime Mover Selection

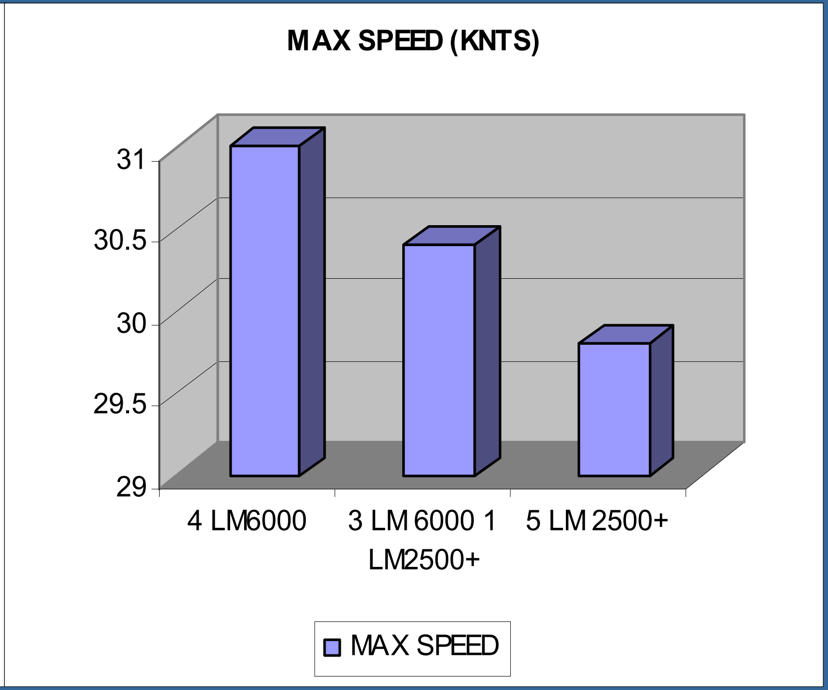
- Gas turbine alternatives
  - Mt 30 TRENT
  - ICR w21
  - LM1600
  - LM2500
  - LM2500(+)
  - LM6000
- Trade off Studies
  - LM1600 and LM2500(+)
  - LM2500(+) and LM6000
- Final Decision: 3 LM6000 and 1 LM2500(+)

Trade off Study Between LM6000 and LM2500(+)



Fuel Consumption Calculations for Different Speeds





Propulsor Choices

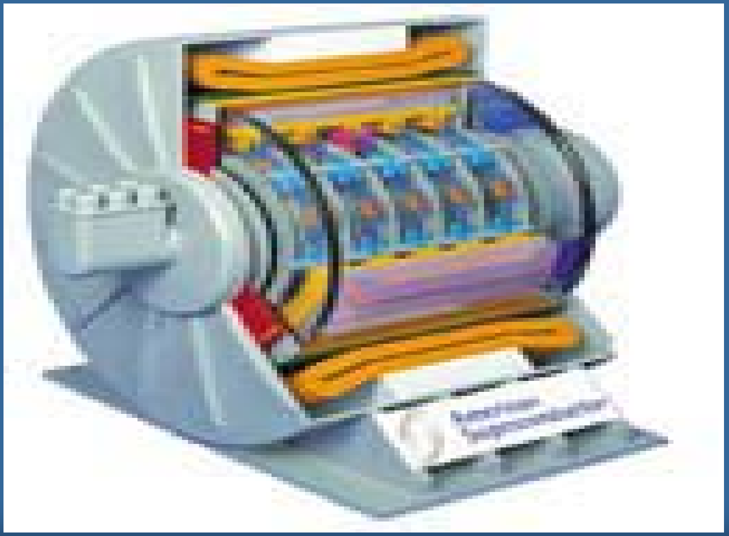
- Water jets and hydro drive
- Conventional propeller
- Pods

*The most feasible propulsor is electrical pods due to weight, volume, location flexibility and maneuverability.

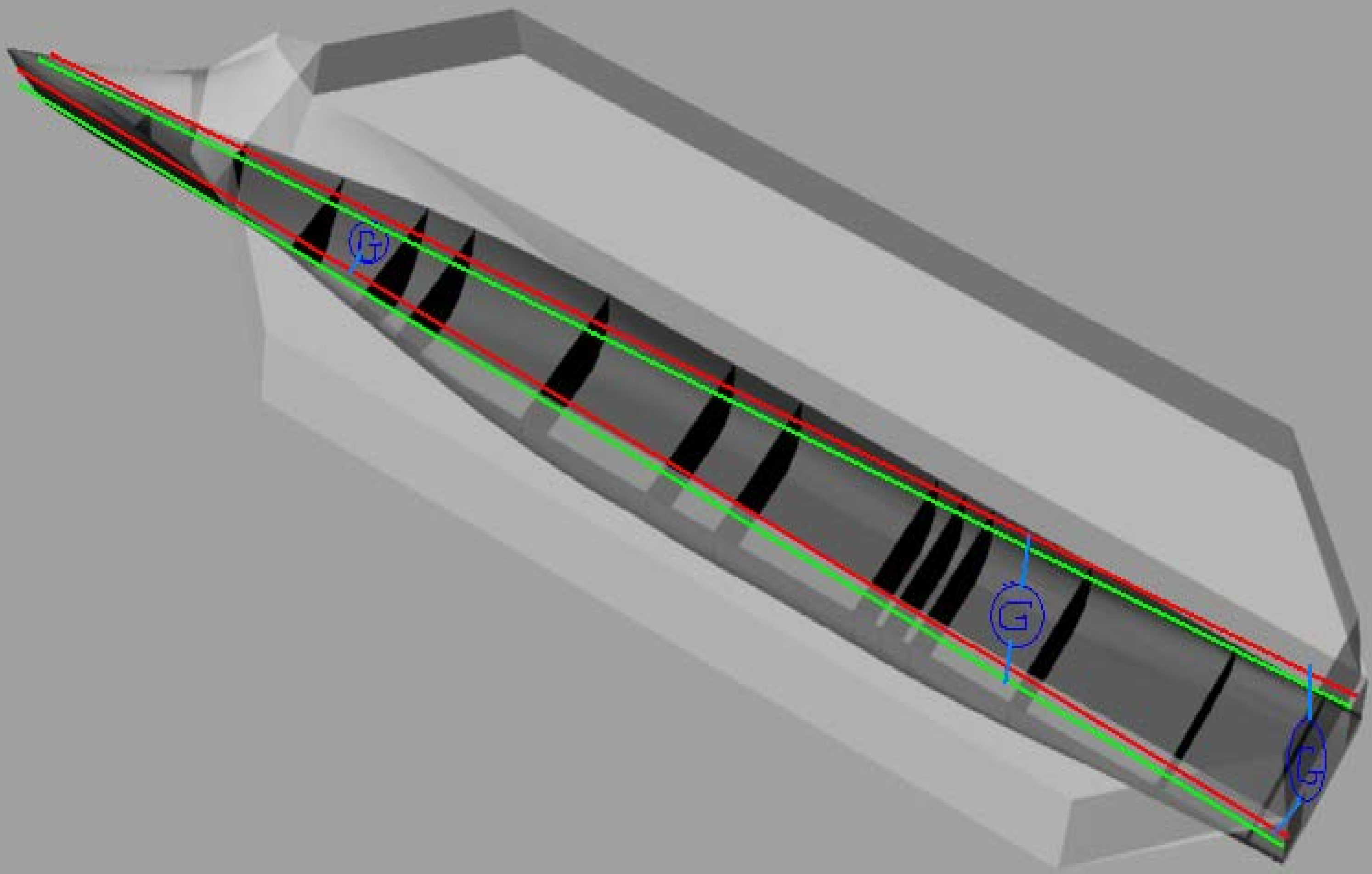
Propulsion Motor Selection

- Conventional motors
- HTS Superconducting AC synchronous motors
- DC Superconducting Homopolar motors

SELECTION: 40 MW HTS SUPERCONDUCTING AC MOTOR WITH THE PROMISING TECHNOLOGY



Schematic



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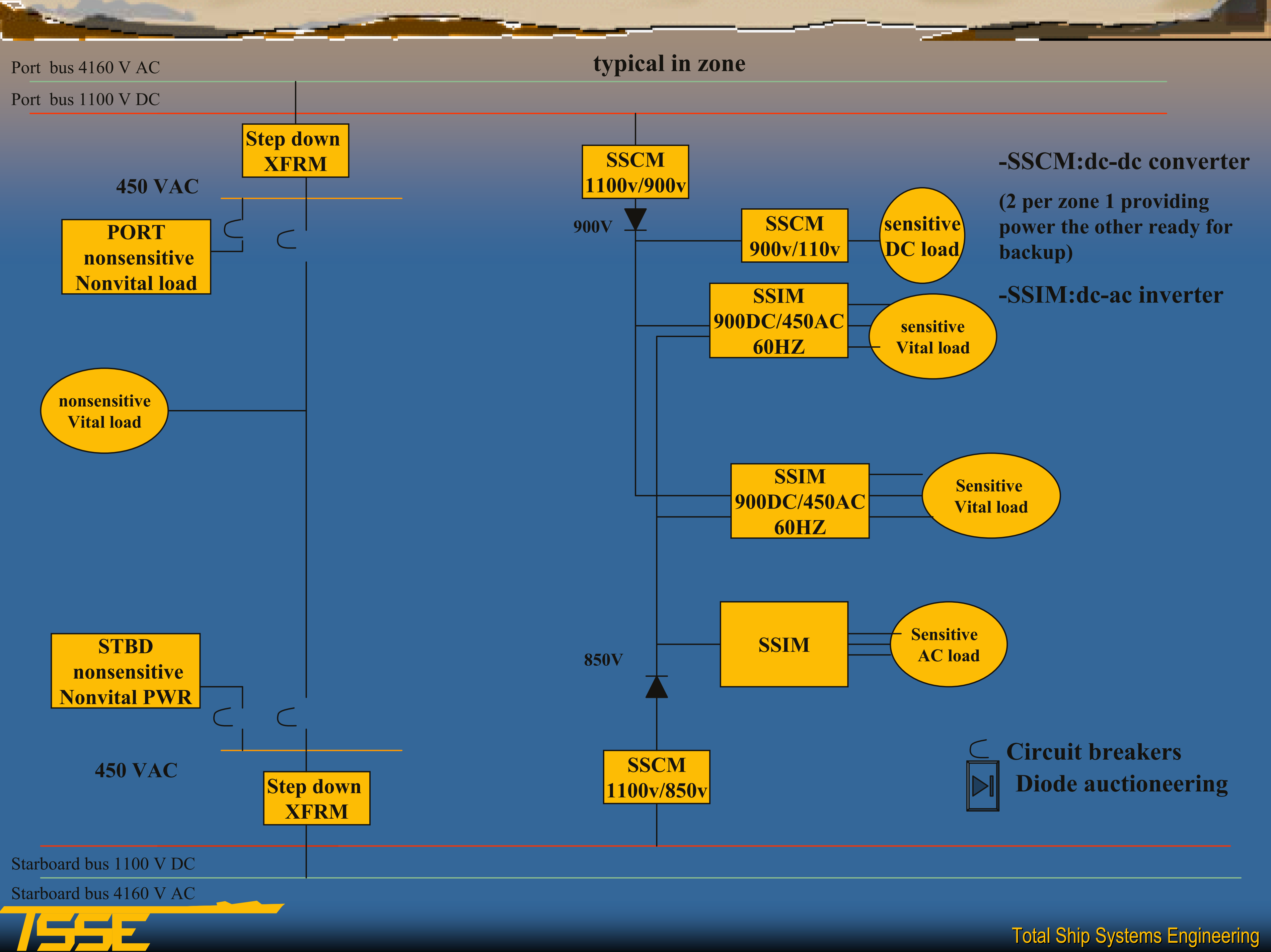
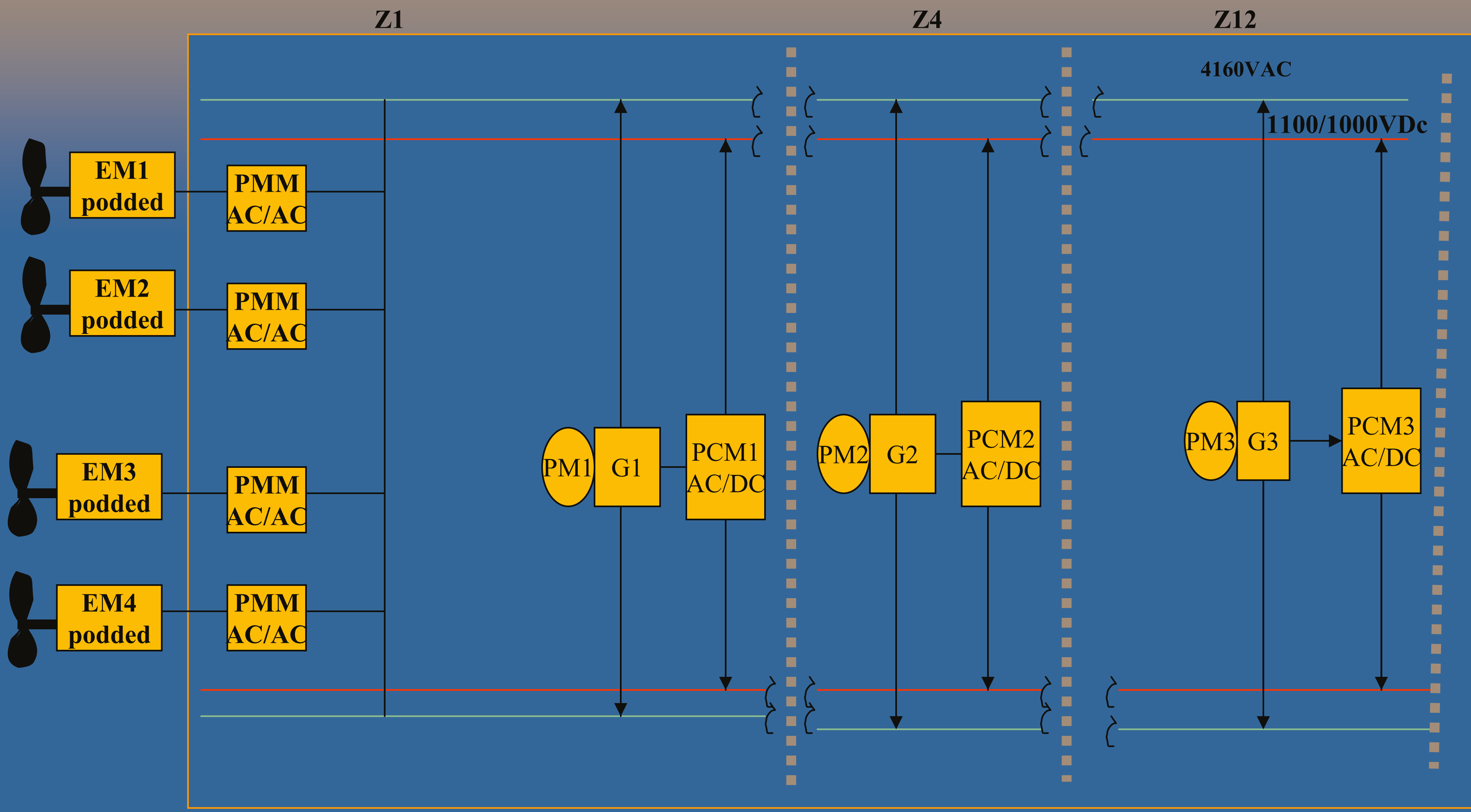
Installed Electrical Power

- Total installed electrical power **159 MW**
  - 3 LM6000 → **43MW each**
  - 1 LM2500+ → **30MW**
- Electrical load
  - At a speed of 30 knots **15MW** of power is available for ship's service.
  - Up to **120 MW** available at reduced speed of **20knots** for FEL and rail gun operations.
- Fly-wheel and capacitors are used to store energy for FEL and rail gun.

Electrical Distribution

- IPS architecture
  - Ship divided to 15 zones
  - Combined AC and DC zonal electrical distribution system
  - 4 buses (2) 4160V AC and (2) 1100V DC
  - 2 above the water line and 2 below the waterline
  - 2 in the port and 2 in the starboard.


typical in zone
Port bus 4160 V AC
Port bus 1100 V DC
Step down XFRM
450 VAC
PORT nonsensitive Nonvital load
nonsensitive Vital load
STBD nonsensitive Nonvital PWR
450 VAC
Step down XFRM
SSCM 1100v/900v
900V
SSCM 900v/110v
sensitive DC load
SSIM 900DC/450AC 60HZ
sensitive Vital load
SSIM 900DC/450AC 60HZ
Sensitive Vital load
SSIM
Sensitive AC load
850V
SSCM 1100v/850v
-SSCM:dc-dc converter
(2 per zone 1 providing power the other ready for backup)
-SSIM:dc-ac inverter
Circuit breakers
Diode auctioneering
Starboard bus 1100 V DC
Starboard bus 4160 V AC
Total Ship Systems Engineering



EM: electric motor podded
PM: prime movers
Z1:1LM6000&1LM2500+
Z5&Z11 :1LM6000
G: generator 4160VAC

PCM:power converter module4160VAC/1100VDC(transformer +rectifier)
PMM:propulsion motor module (transformer + cycloconverter)
EM :propulsion electric motor

IPS Advantages

- Reduces cost, weight, fuel consumption and manning
- Increases survivability
- Equipment installed and tested prior to zone interconnection
- Faster and simpler fault detection and zone isolation
- Only main buses cross watertight compartment bulkheads

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Derived Logistics Requirements

- Distribution and logistics hub
- Interface with existing and future supply assets
- Increase inter & intra ship material handling efficiency in a robust environment
- Leverage on technology & automation to meet reduce manning requirements for logistical functions

Sustainment Requirements

•Loading Requirement Per Ship : First 30 Days of Sustainment of a MEB

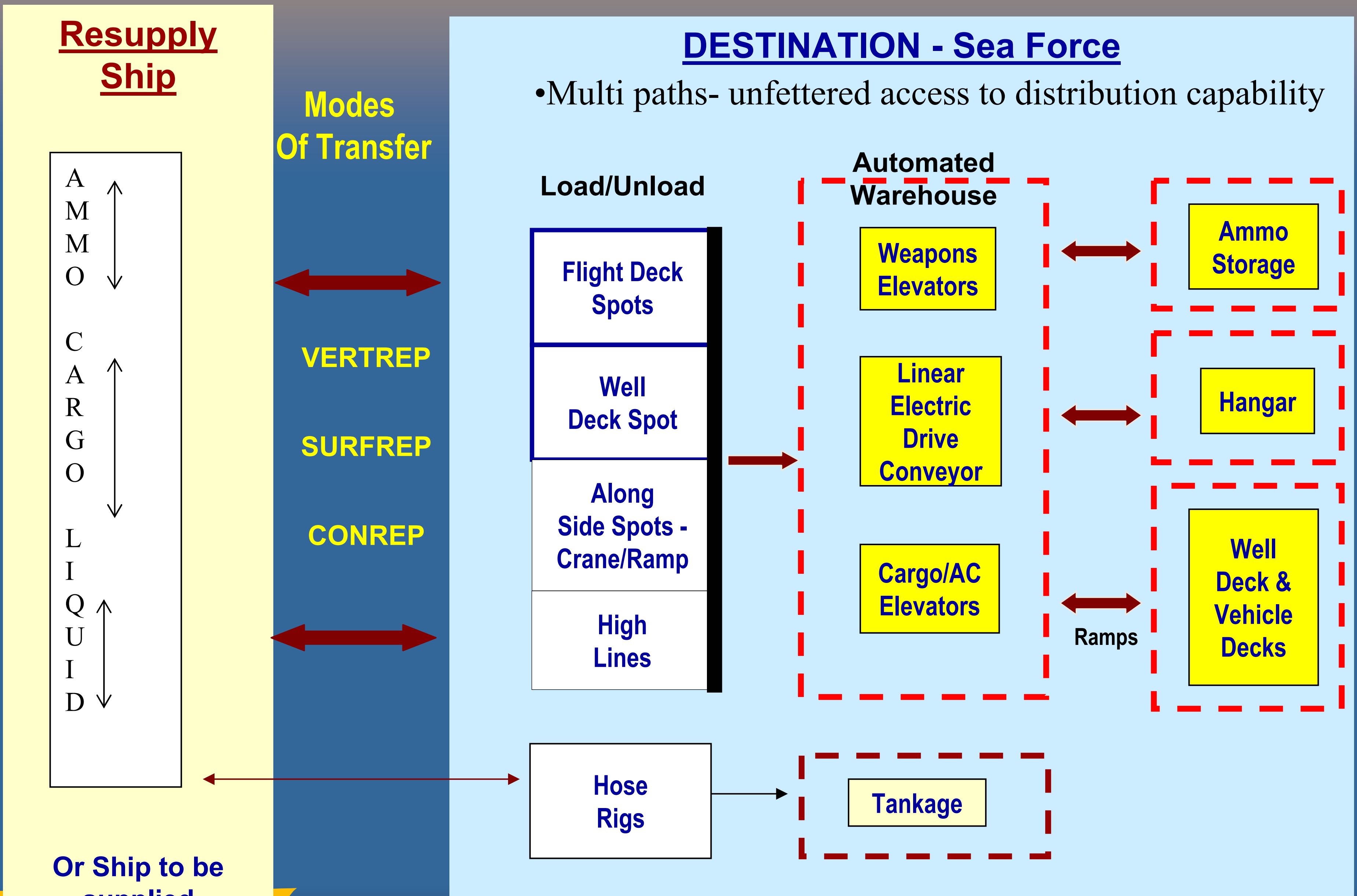
Commodity	TEUs	Pallets per ship	Total Pallets MEB
Provisions	40	800	4800
Ordnance	144	2880	17280

Commodity	Weight per Ship (LT)	Volume per Ship (ft^3)
Provisions	425	51200
Ordnance	3069	184320
Total	**~3500**	**235520**

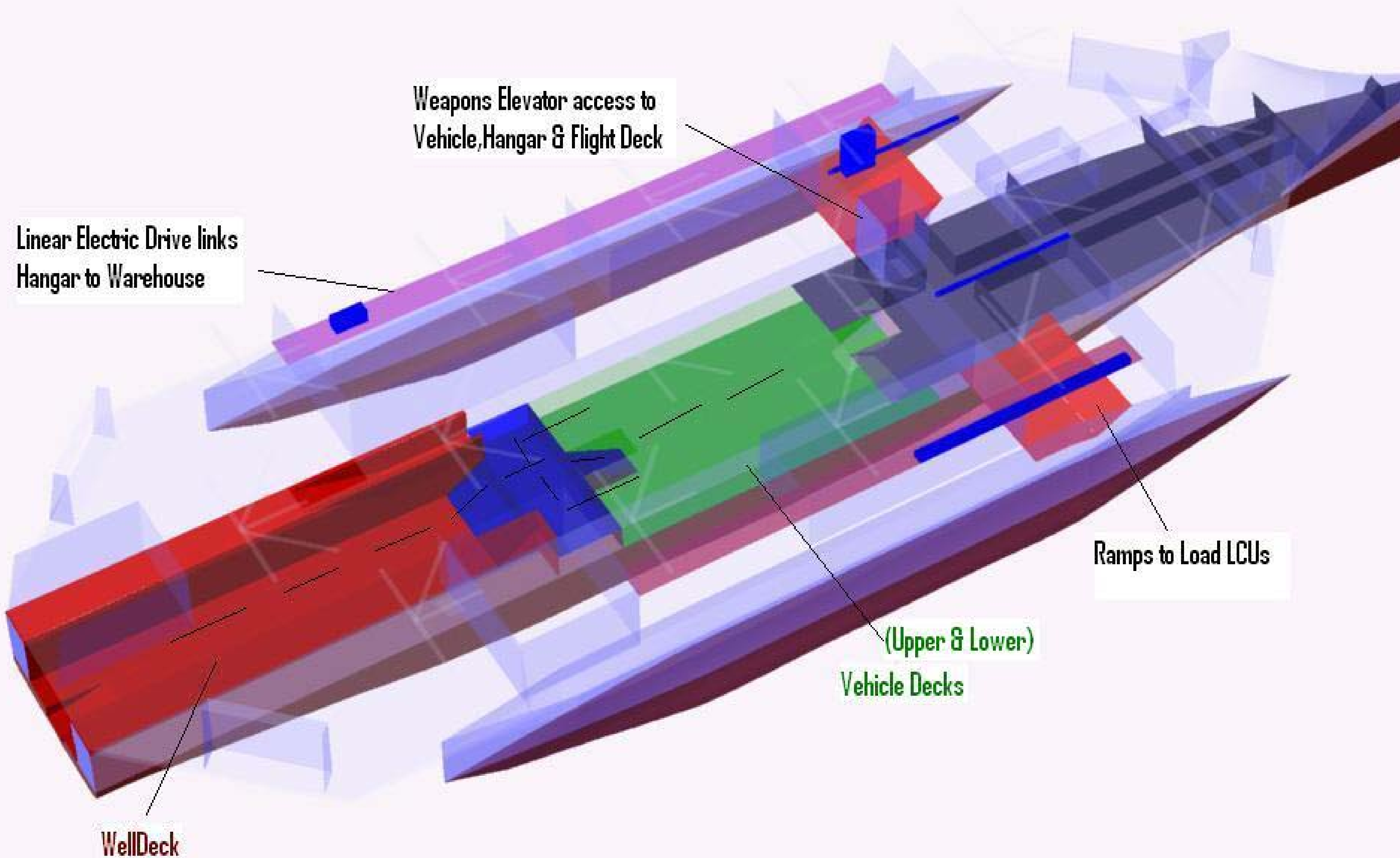
•Fuel Requirements Per Ship for 30 Day Sustainment : 2,103,300 gallons(7835LT) for Surfrep assets : 400,000 gallons for GCE(1360LT)

•Subsequent Transfer Requirements : 15 TEUs per day per ship (from day 30 onwards)

Intra/Inter-Ship Material Handling Concept

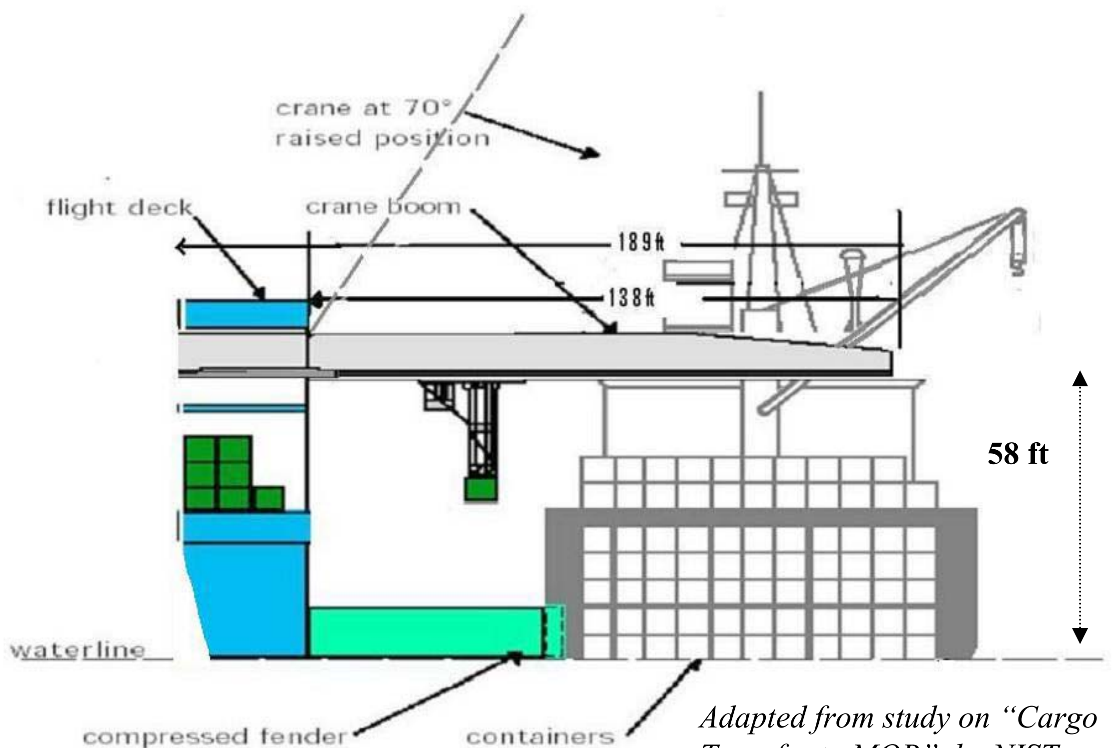


Ref: *Sea-Base Sustainment Conference 02 NSWC Port Hueneme Division*


Weapons Elevator access to
Vehicle,Hangar & Flight Deck
Linear Electric Drive links
Hangar to Warehouse
Ramps to Load LCUs
(Upper & Lower)
Vehicle Decks
WellDeck

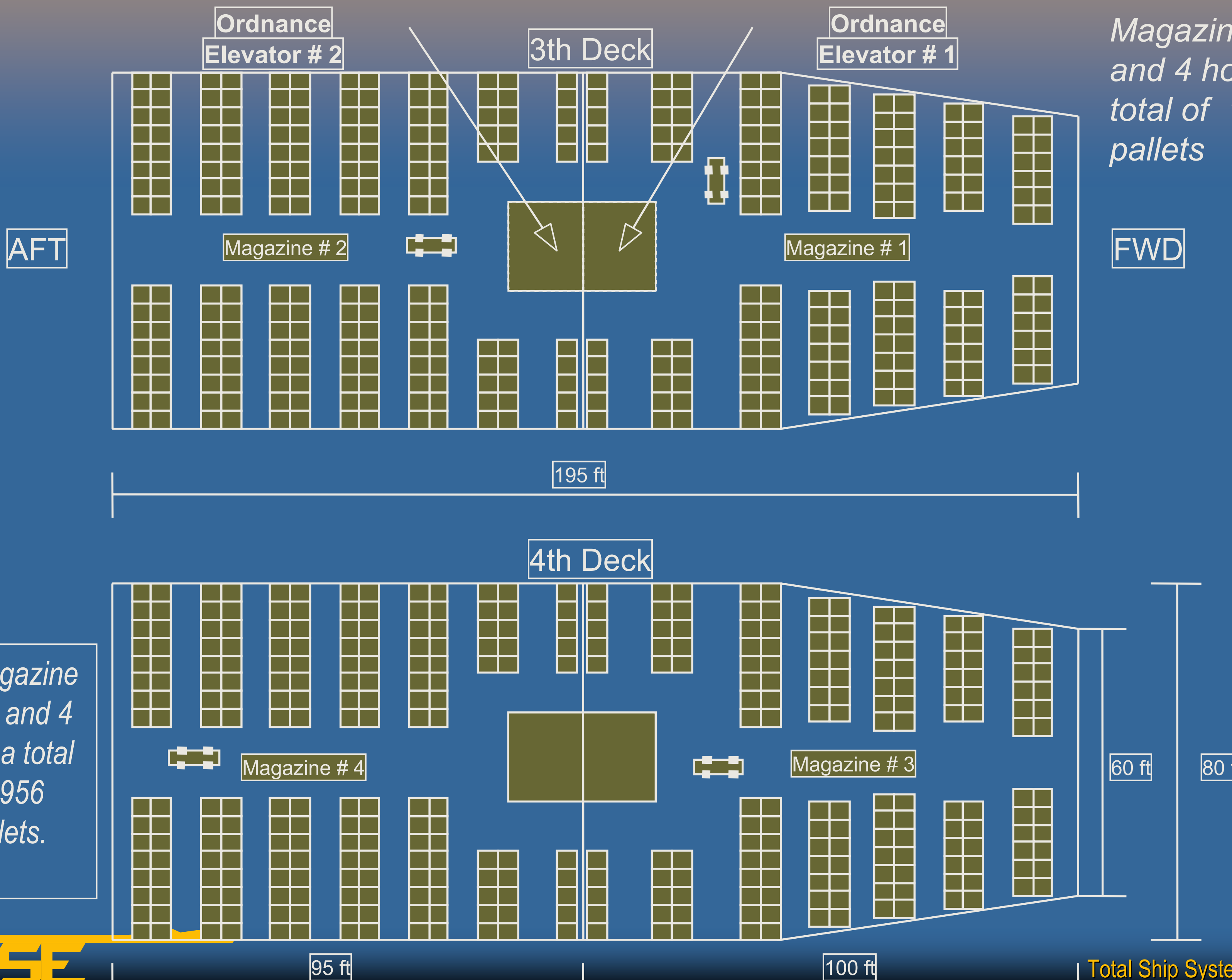
Motion Compensated Crane

- Able to recess into the warehouse
- Minimal obstruction to flight operations
- Motion compensated – handle TEU loads @ SS 4



Adapted from study on "Cargo Transfer to MOB" by NIST submitted to ONR in 1998

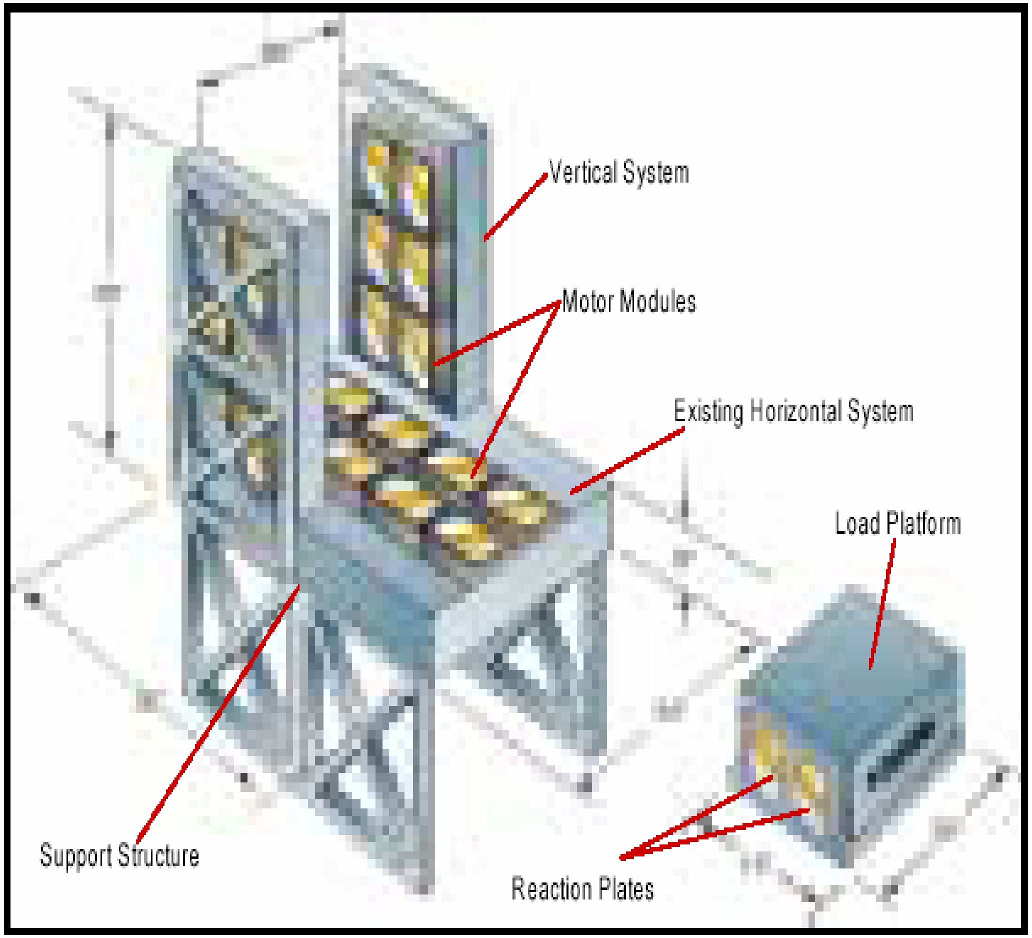
Magazine Layout



Magazines 2 and 4 holds a total of 1100 pallets

Magazines 3 and 4 for a total of 956 pallets.

Hybrid Linear Electric Drive

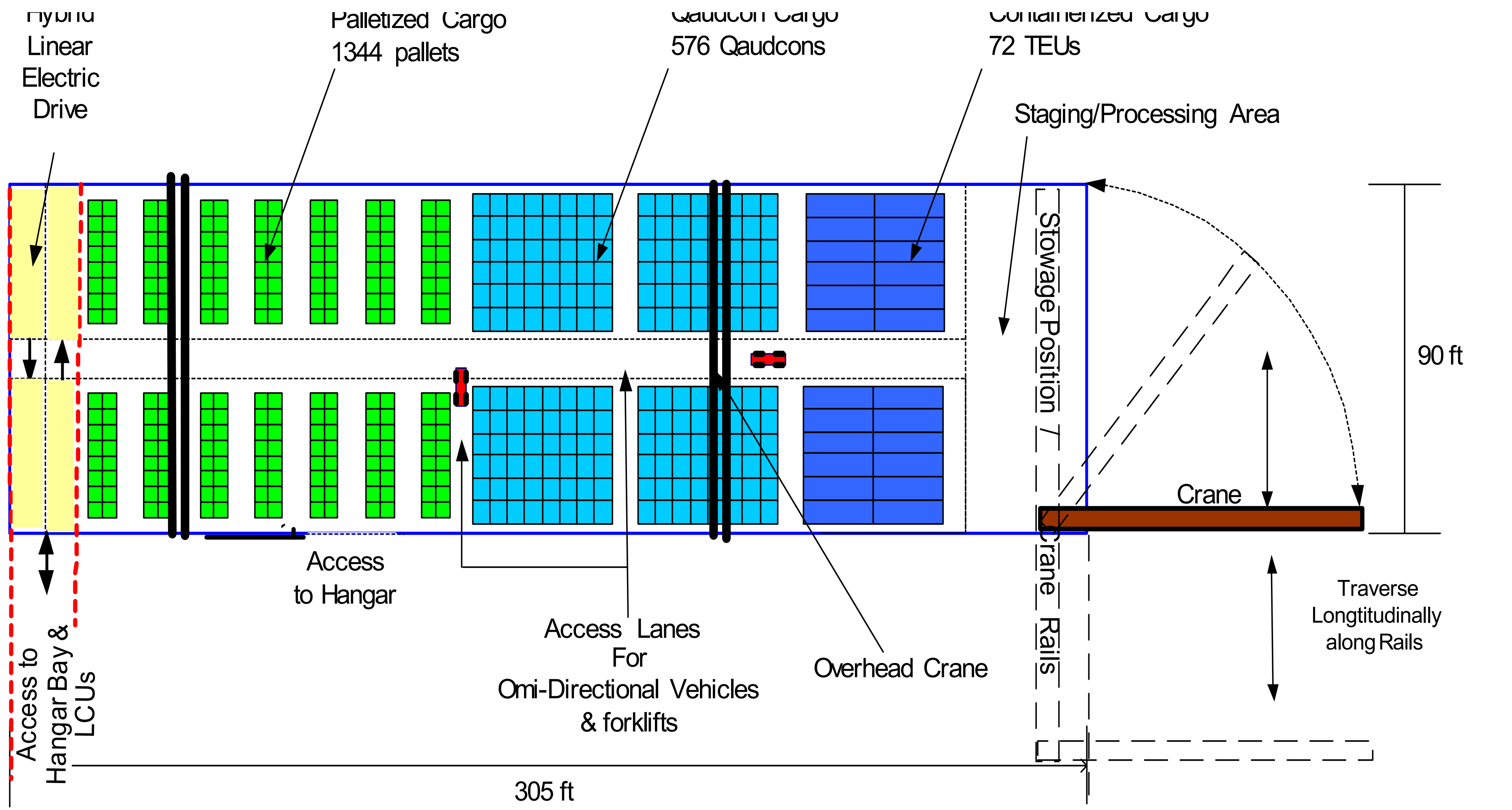


Vertical/Horizontal LIM Conveyor Belt (Source: ONR)

- 30 % workload reduction over current systems.
- 20 % weight reduction.
- 20 % power consumption reduction.

Warehouse Layout

- Total warehouse volume : 960,750 ft^3



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Combat Systems Design Requirements

Basic Ship Self-Defense in a Littoral Environment

Major threats include:
High-density missile and small boat attacks
Floating, Bottom and Surface Moored Mines
Coastal Water Submarines

Robust C4ISR Capability

Support for MEB/MEU forces afloat and ashore
Enables ship to function as a Joint Command Center in theater
Compatible with current as well as legacy systems

Overall Architecture

The combat systems and C4ISR suite will be fully integrated to include both organic and non-organic sensor inputs for power projection and ship self-defense to better support Network Centric Warfare

Combat Systems Integration

- Year 2020 Generation Cooperative Engagement Capability (CEC)
- Year 2020 Generation Ship Self-Defense System (SSDS)

Robust C4ISR Capabilities

- Ability to Integrate Battle Group Assets using systems such as Year 2020 CEC, GCCS-M, NTCSS, NAVSSI, and the Expeditionary Sensor Grid (ESG)
- Ability to act as Joint Command Center in Theater providing a full range of communication and information gathering equipment

Layered Self-Defense

Naval Surface Fire Support

The ship will be capable of providing Fire Support for the embarked Expeditionary Forces

Electromagnetic Rail Gun

- Can provide fire support against targets such as enemy personnel and tanks at ranges up to 400 NM
- Four mounts operated NMT two at a time (port or starboard) due to power requirements

Embarked Aircraft

- Joint Strike Fighter could be utilized

Battle Group Assets

- Escort Ships and Aircraft

Air Warfare Sensors

The Air Warfare suite will consist of sensors and weapons optimized for defense against high density missile attacks

Year 2020 Generation Digital Array Radar (Volume Search Radar)

- Provides High Volume Air Tracking and Fire Control Capability
- Range: Up to 250 km
- 4 Array Panels Provide 360 Degree Coverage

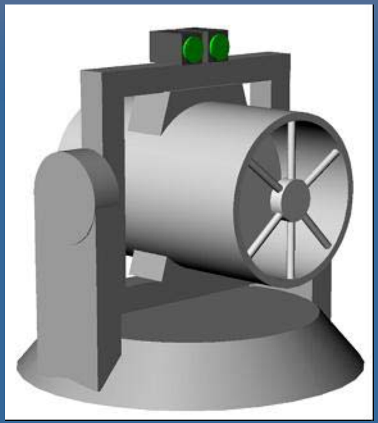
Year 2020 Generation Infrared Search and Track / Electro-Optical Systems

- Detects anti-ship cruise missile thermal heat plumes or signatures
- Range: Minimum of 10 km
- Four Sensors with 360 Degree Coverage

Air Warfare Weapons

Free Electron Laser

- Counters Magazine Saturation Attacks
- Range: Up to 10 km
- 5 Beam Directors (2 Port, 2 Starboard and 1 Astern)



Year 2020 Generation SEA RAM

- Counters Temporal Saturation Attacks
- Range: Up to 4 km
- 3 Mounts (Port, Starboard and Bow)

Embarked Aircraft/Other Battle Group Assets

- Joint Strike Fighters, Year 2020 Generation Standard Missiles

Mine Interdiction Warfare

The Mine Interdiction Suite will be capable of only Basic Mine Detection and Avoidance

Unmanned Undersea Vehicles

- Perform remote mine detection, reconnaissance and clearance operations
- Systems for employment include (Year 2020 Generation): Long Term Mine Reconnaissance System (LMRS), Remote Mine Hunting System (RMS), Enhanced Mine Neutralization System (EMNS)

Aircraft Mounted Mine Detection and Removal Equipment

- Equipment is easily mounted into embarked assets such as the SH-60 or MV-22 configured aircraft
- Systems for employment include (Year 2020 Generation): Airborne Laser Mine Detection System (ALMDS), Rapid Airborne Mine Clearance Systems (RAMICS)

Surface Warfare Sensors

The ship will be configured to defend primarily against small boat attacks

Year 2020 Generation SPS-73 Surface Search/Navigation Radar

- Primary Surface Search/Navigation Radar

Year 2020 Generation Digital Array Radar

- Primary Fire Control Radar

Year 2020 Generation Electro-Optical Systems

- Infrared Search and Track/FLIR and/or TISS System
- Primary/Secondary Fire Control Systems

Surface Warfare Weapons

Year 2020 Generation SEA RAM

- Current System is air defense only and would require a surface mode similar to CIWS Block 1B
- Range: 4 km utilizing four mounts (Two Fwd and Two Aft)

Electromagnetic Rail Gun

- Primarily for Targeting small to medium sized vessels
- Range: 10 km utilizing four mounts NMT two at a time (Two Port and Two Stbd)

Free Electron Laser

- Targeting of small boats only
- Range: 10 km utilizing any 3 of 5 beam directors simultaneously (Two Port, Two Stbd and 1 Astern)

Battle Group Assets / Embarked Aircraft (i.e. JSF)

Undersea Warfare Sensors/Weapons

The Undersea Warfare Suite will be limited to basic Undersea Warfare capabilities using embarked Air, Undersea Vehicle and other Battle Group Assets

Utilize Unmanned Undersea Vehicles (UUV's) and dipping sonar from embarked SH-60F or MV-22 configured aircraft.

Utilize year 2020 generation MK50 torpedoes launched from SH-60 or MV-22 configured aircraft.

Other Battle Group assets will be required for any other operation than basic self-defense (i.e. ships, aircraft and submarines).

Electronic Warfare

The Electronic Warfare suite will integrate a full array of Electronic Warfare capabilities into its Combat Systems Suite

Year 2020 Generation Integrated Electronic Warfare System

- System will incorporate Year 2020 Generation Electronic Support (ES), Electronic Attack (EA), an Infrared Search and Track System (IRST), as well as an Infrared Jamming and decoy system.

Provide Active and Passive Electronic Warfare capabilities similar to AN/SLQ-32(V).

Provide decoy system such as Mk 53 NULKA Decoy Launching System

Sea-Force Presentation Outline

Introduction

Requirements & Alternatives

Hull

Flight Deck

Propulsion

Electrical

Logistics

Combat Systems

Total Ship Evaluation

Conclusions

Total Ship Evaluation Areas

- Operational Functionality and Flexibility
- Modularity
- Survivability
- Manning
- Damage Control
- Cost

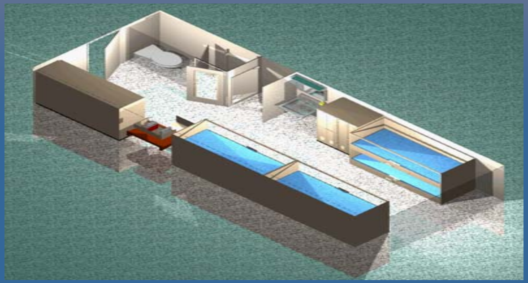
Operational Functionality/Flexibility

- Access/Reroute/Resupply Methods
  - Well Deck
  - Flight Deck
  - LCU Decks
  - Crane
- Layout
  - Berthing for GCE near Med/Hospital
  - Joint Support spaces co-located:
    - CO/Flag/CS/C4I and Bridge

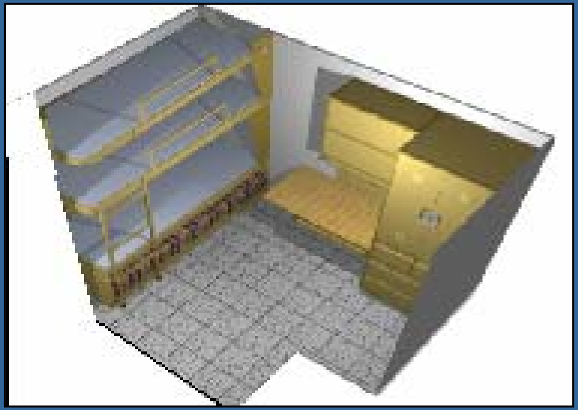
Operational Functionality/Flexibility

- Ports of Access
  - Norfolk
  - San Diego
  - Everett
  - Rota
- Ports Requiring Access
  - Blount Island

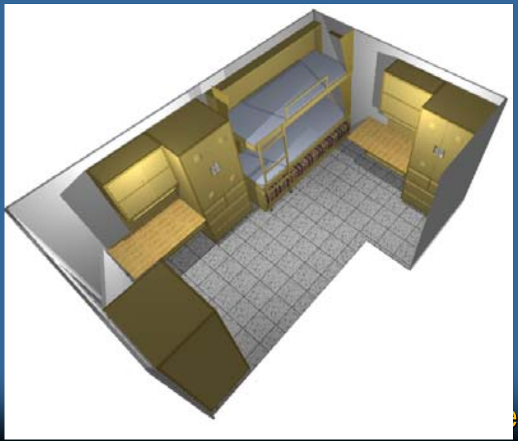
Modularity



- Berthing Modules
  - 80 total
  - 30 Navy Ofcr/Enl
  - 50 USMC Ofcr/Enl



- Medical/Third echelon afloat care
  - 500 bed hospital
  - 6 operating rooms
  - 1 pharmacy.



Modularity

- Space Conversion from Combatant to Supply Configuration
  - C4I/CS/Weapons
    - Retain SEARAM, DAR, SPS-73, Comms, Flight Deck control, and Countermeasures
    - Total Converted Volume – 201,000 ft^3
  - Berthing – All USMC and a percentage of Navy
    - Total Converted Volume – 1,540,000 ft^3
  - Hospital/Medical – 219,000 ft^3
- Available for containers/pallets/ammo – ~ 5.7 million ft^3
    - Includes Half the Hangar, Vehicle Decks, Warehouse

Supply Configuration

- Weight limited vice volume limited design:
  - More room for containers than weight allowed
  - Allows for 25 days of sustainment load
- Areas Reduced–
  - Maintenance (IMA), Food Preparation, Aviation, Admin, Flight Deck, and Engineering

Survivability

- Signature Reduction
  - Exhausts expended between hulls and water misted
  - Carbon Composite covering steel hull structure
  - Radar absorbent paint
- Redundant systems/Distributed C4I
  - Elevator
  - Combat Systems Weapons and Sensors
- CBR Protective Measures

Manning

- Manning levels determined based on
  - Watch Stations - 50
  - Maintenance - 146
  - Logistics Operations - 242

Manning - Summary

- Manning reduction – Combat Variant
  - 35% (based on LHD)
  - 50% (based on displacement of US Warship)
- Total Ship Manning (Combat Ship) - 724
  - 51 Officers, 41 CPOs and 632 Enlisted
- Total Ship Manning (Supply Ship) – 145
  - Civilian and Military Mix
    - 30 Civilians, 115 Military

Low Maintenance Design

- Conditioned Based Maintenance
- Integrated Electric Drive
- Electrical Distribution System - Power Electronic Building Blocks
- SWAN
    - Automated Identification Technology

Damage Control

- Integrated into the shipboard SWAN
  - Advance Real-Time Sensing
  - Pre-emptive (“flinch”) capability
- Intelligent distributed control architecture – robust DC-ARM Supervisory Control System
  - Display sensory information
  - Isolate/recover zones as a result of attack
- Optimized the distribution and separation of redundant vital systems and control stations

Fire Suppression Systems Onboard

Compartment	FM 200	CO_2	Water Mist	AFFF
Machinery spaces	--	--	X	X
Engine enclosures	--	X	--	--
Magazine areas	--	--	--	X
Electronics equipment rooms	X	--	--	--
Hangar	--	--	X	X
Vehicle Deck			X	X
Well Deck				X
Flight deck	--	--	--	X
CIC	X	--	--	--
Bridge	X	--	--	--
Accommodations	X	--	--	--
Kitchens&Galley	X	--	--	--
Offices	X	--	--	--
Passageways	X	--	--	--
Paint lockers	--	X	--	--
Pump rooms	--	X	--	--

The Cost Factor

- Total Acquisition Cost Estimate
  - $3.5 Billion
    - $1.32 Material
    - $1.66 Labor
- Total System Cost Estimate
  - $5.8 Billion
- Cost Breakdown by Percent of Total Cost:
  - Hull – 10% of Material Cost
  - Propulsion/Electrical – 17% of Material Cost
  - Combat Systems – 27.5% of Material Cost
  - Air Wing – 28.7% of Total System Cost

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Areas Requiring Further Analysis

- LCU loading and storage methods.
- Conversion to JCC ship.
- Implementation of a break water area between the main and side hulls

Conclusions

- 2nd Iteration Considerations
  - Port Accessibility.
  - Selective offload of vehicles made more efficient.
  - Further analysis of supply variant loading.

Conclusions

- Key enabler to successful implementation of sea basing concept.
  - Large flight deck to support STOM.
  - Large internal volume for logistics support and selective offload.
  - Supply configured variant capable of supporting troops ashore without transfer to ships in the sea base.
  - Capable of force reconstitution.