Virginia Tech
DD-21 Destroyer Concept

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Mission Needs Statement

- Dominance in independent and joint ops
- Mission and Threat Analysis
- Non Material Alternatives
- Material Alternatives
  - Evaluate the impact of speed on concept design

MNS, cont.

- Constraints
  - Sustained speed of at least 40 knots
  - Optimize effectiveness vs. cost
  - Reduce manpower
  - Minimize production time
  - Maximize survivability
  - Satisfy pollution laws

Required Operational Capabilities

- Amphibious Readiness Group (ARG) Escort
- Carrier Battle Group (CBG)
- Mine Counter Measures (MCM)
- Non-Combatant Ops / Humanitarian (NCO)

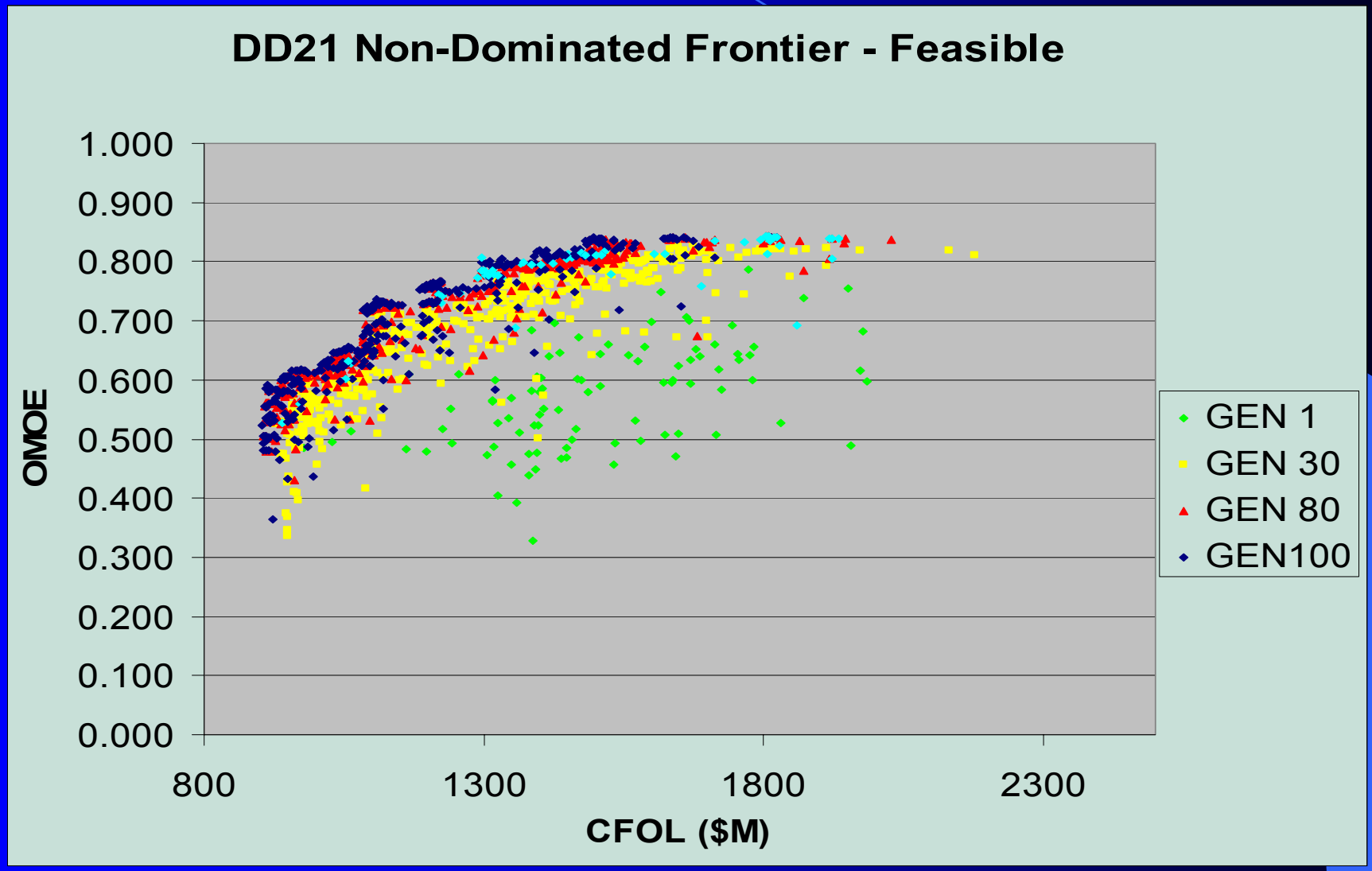
Concept Exploration Model

- Three Hulls
  - Transport Factor used in choices
    - Evaluate hull forms in terms of load capacity vs. speed
  - Mercier-Savitsky
    - Regression formulas produced for resistance data
  - FastShip Atlantic
    - Resistance from existing data of model testing
  - SS United States
    - Resistance from existing data of ship

Concept Exploration Model, cont.

- Propulsion Choices
  - Waterjets
  - Surface piercing propeller
  - Conventional propeller
- Weapons and Missions Options

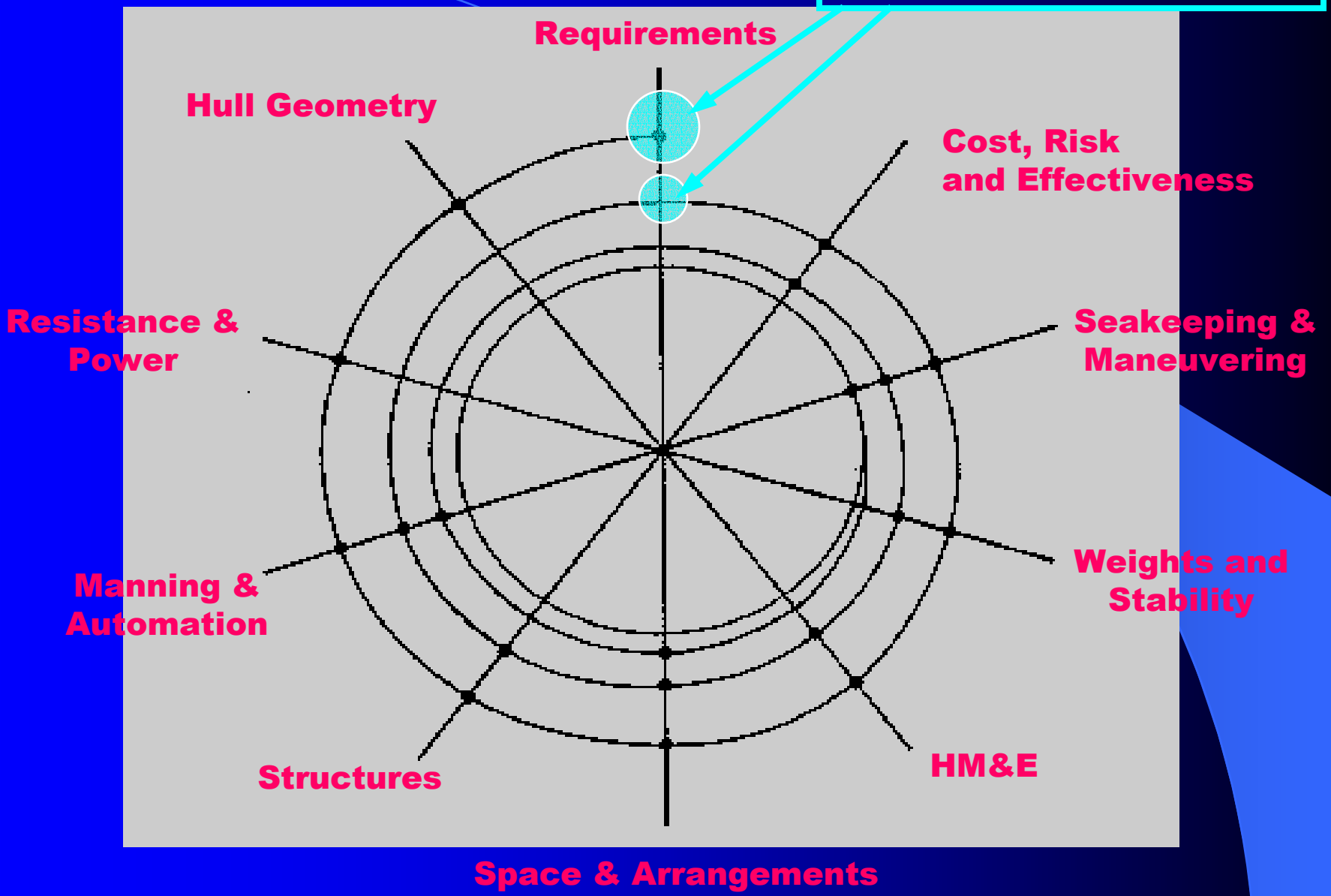
Non-Dominated Frontier



Baseline Concept Design

	HI	BBH	BCD	BBL	LO
LBP[ft]	598.48	537.83	437.4	414.21	404.41
Beam [ft]	103.74	93.22	67.7	64.02	62.51
Draft [ft]	26.33	23.66	19.09	18.23	17.79
D10 [ft]	49.87	44.82	35.02	34.52	35.17
Lightship [LT]	9683.8	7200.8	3841	3577.5	3278
Full load displacement	16164.6	11750.9	5870	5357.8	4998.1
FL Vertical CG [ft]	30.47	27.72	24.68	21.23	20.97
Np	6	4	4	4	4
Ve	35	35	35	35	35
Nhelo	2	2	2	0	0
Range	10000	8000	4000	4000	4000
Manning	128	125	73	66	50
Sustained speed	42.87	40.11	41.96	42.28	42.44
Maximum speed	45.03	42.22	43.8	44.23	44.38
C fola [$M]	1803.9	1450.4	1297	1057.2	971.8
OMOE	0.842	0.813	0.807	0.631	0.559

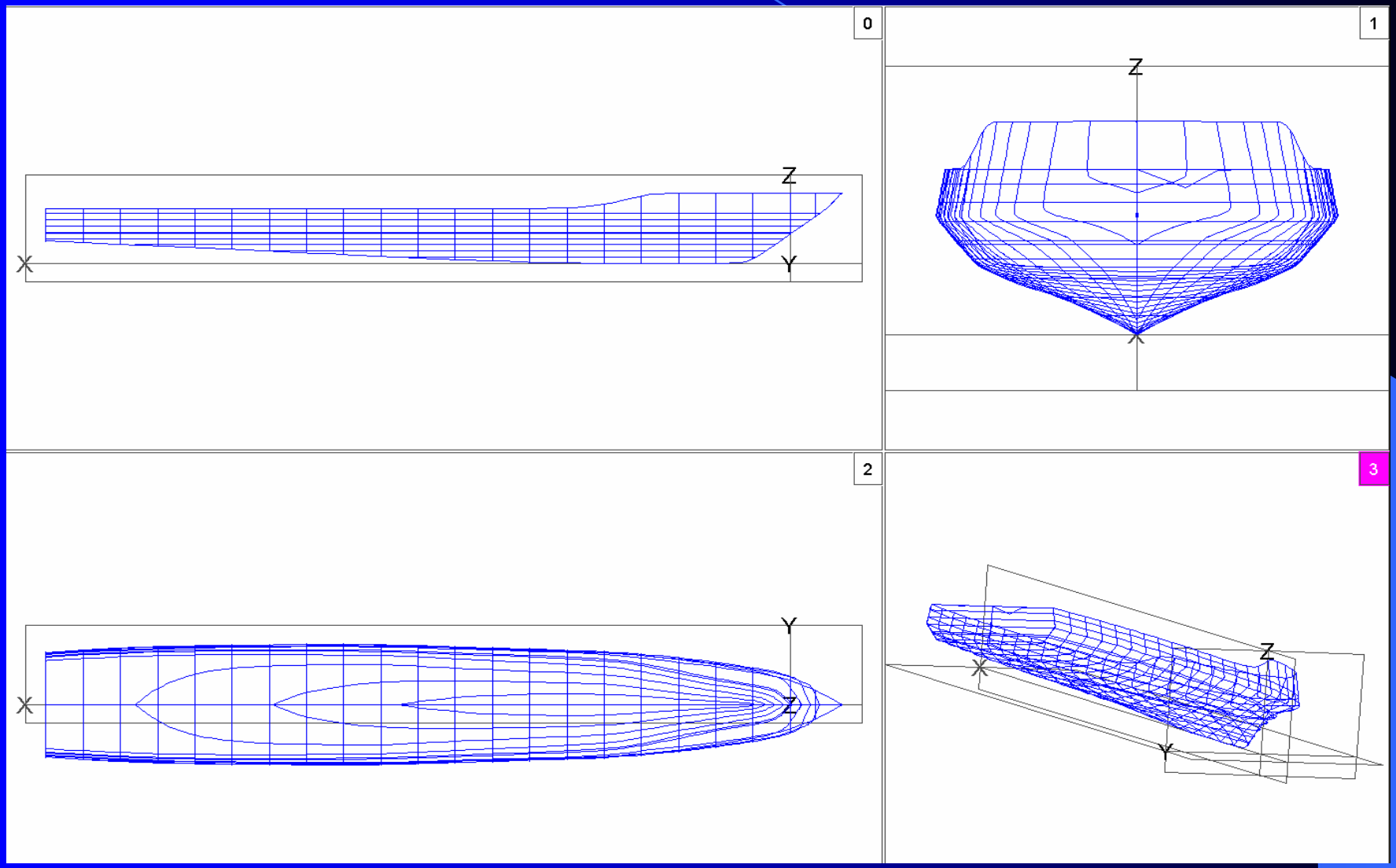
Hull Form and Structure


Concept & Requirements Exploration
Requirements
Hull Geometry
Cost, Risk and Effectiveness
Resistance & Power
Seakeeping & Maneuvering
Manning & Automation
Weights and Stability
Structures
HM&E
Space & Arrangements

Hull Form Development

- FastShip Atlantic Offsets
- Scaled in HECSALV
- Read offsets into Fastship program
- Surface fit to offsets

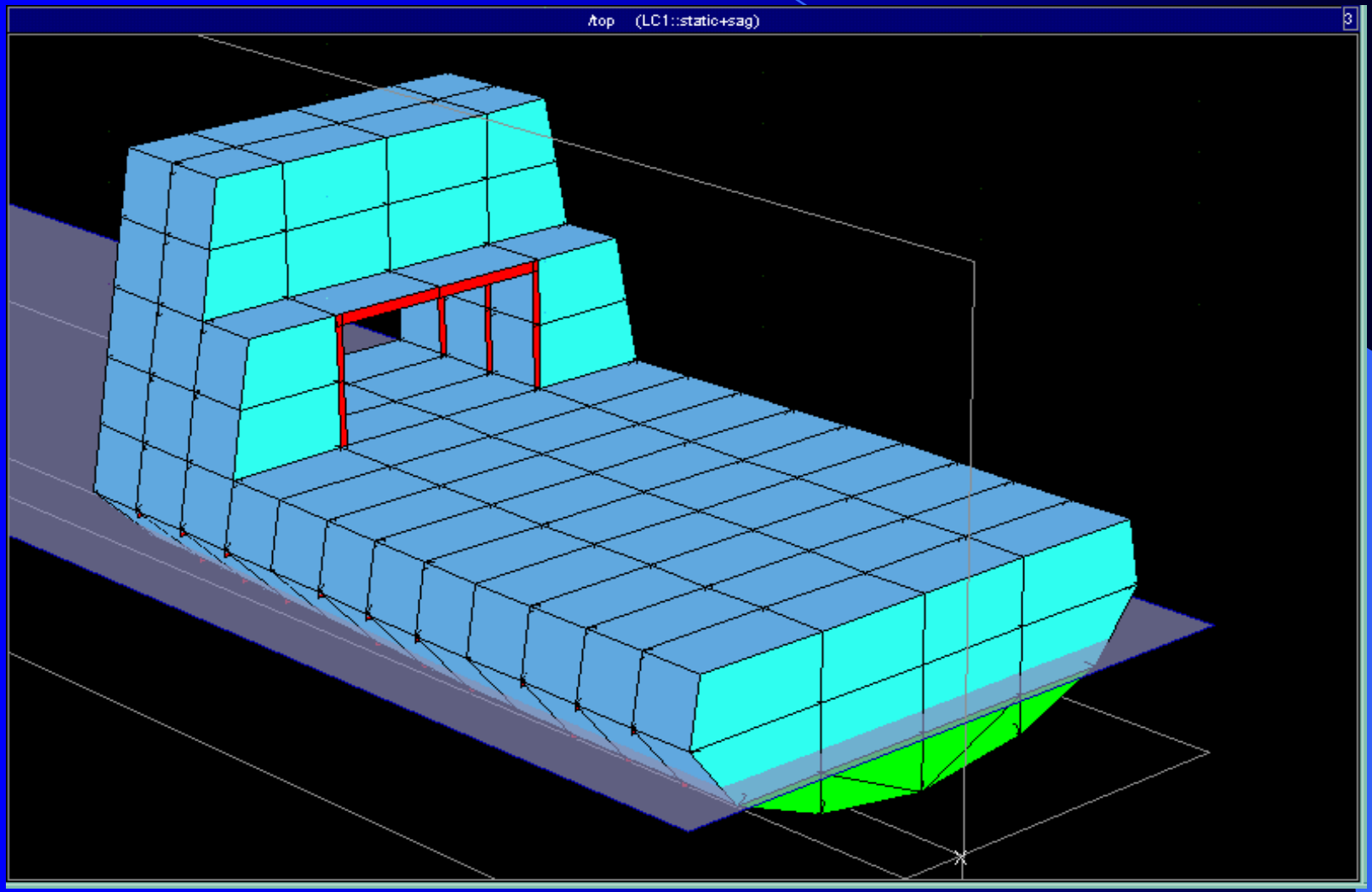
Hull Form



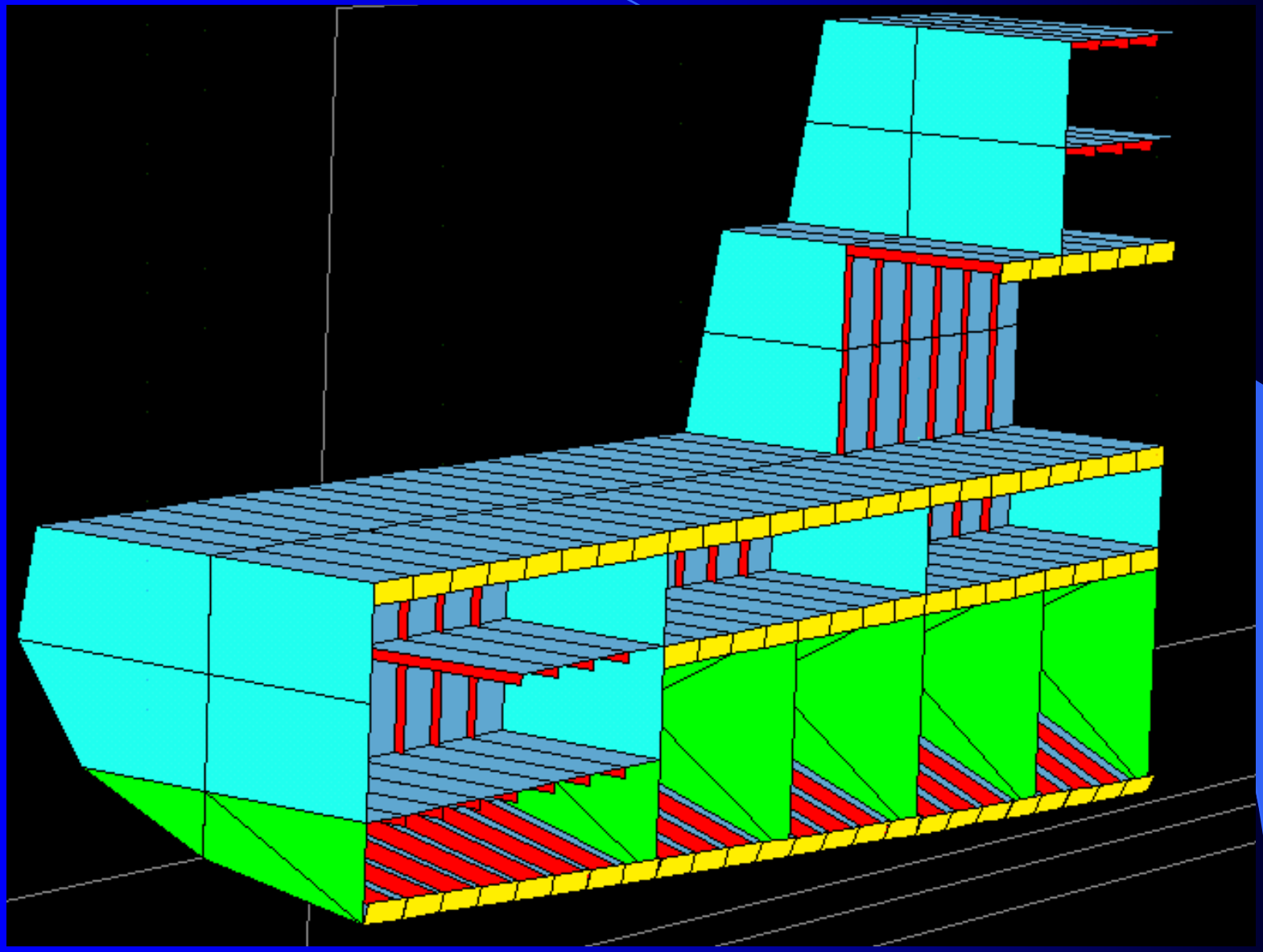
Structural Design and Analysis

- Three watertight sections of the hull
  - One centered at midships
  - One section forward and one aft of midships
- Tested in Maestro
  - Moments and Shear Forces from HECSALV
- Materials
  - Composite deckhouse to reduce weight
  - Standard steel construction for hull

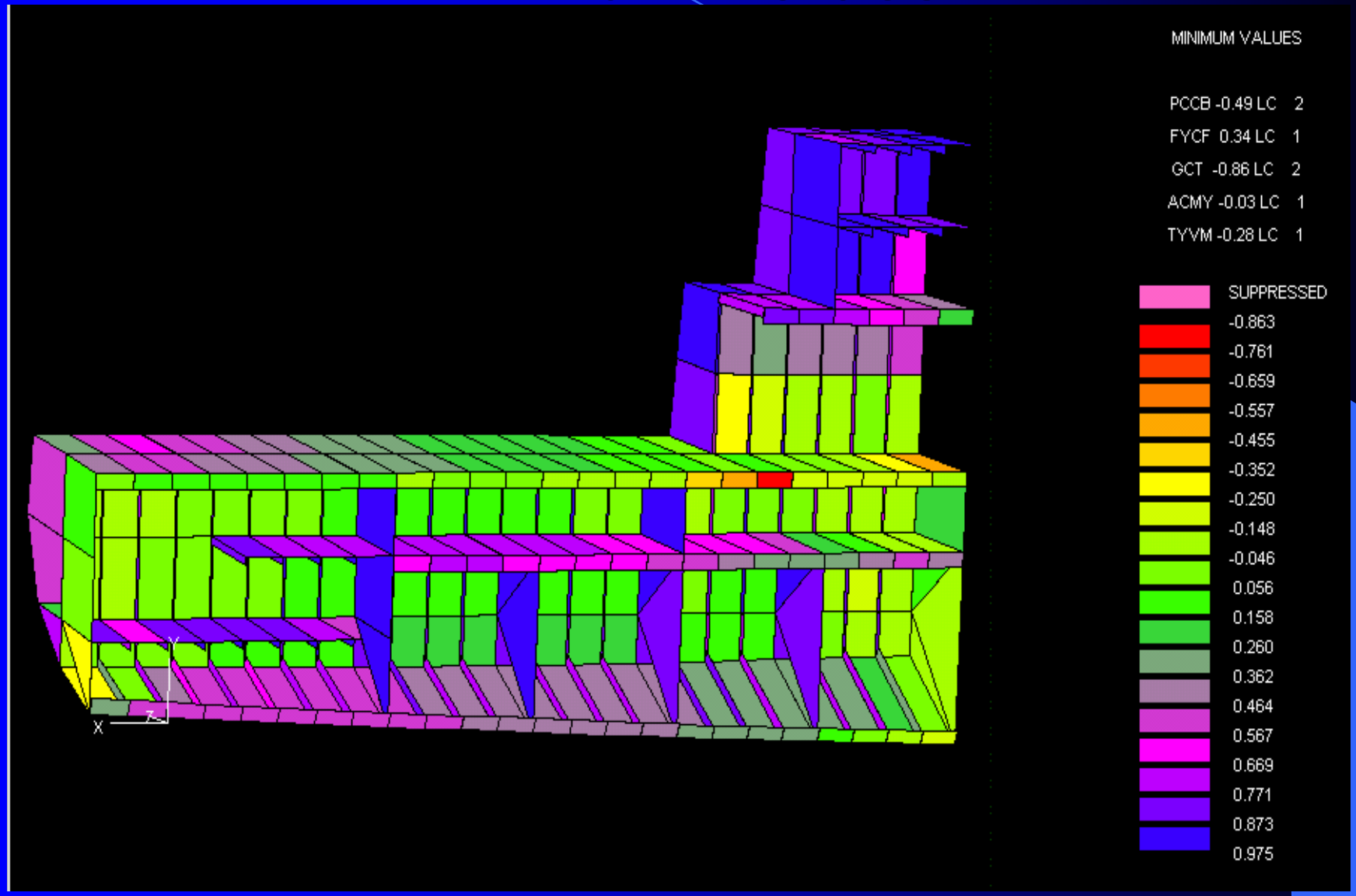
Maestro Model, Stern View



Maestro Model, Internal Structure



Maestro Model, Adequacy Parameter Minimum Values

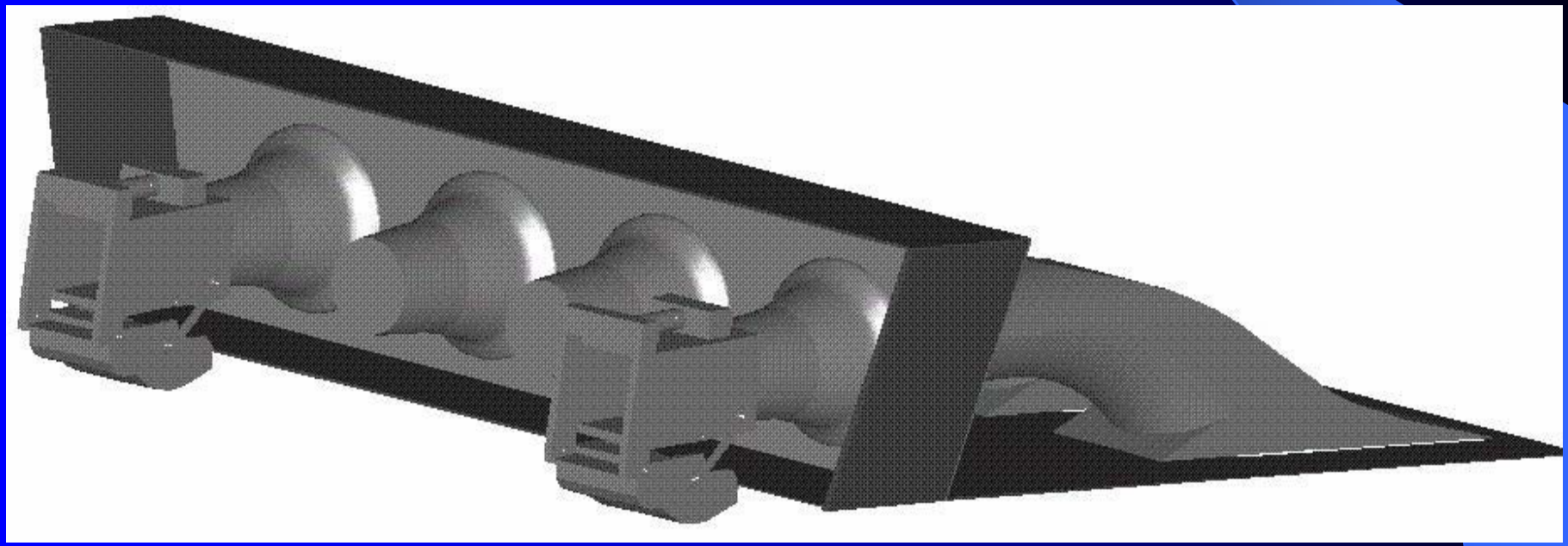


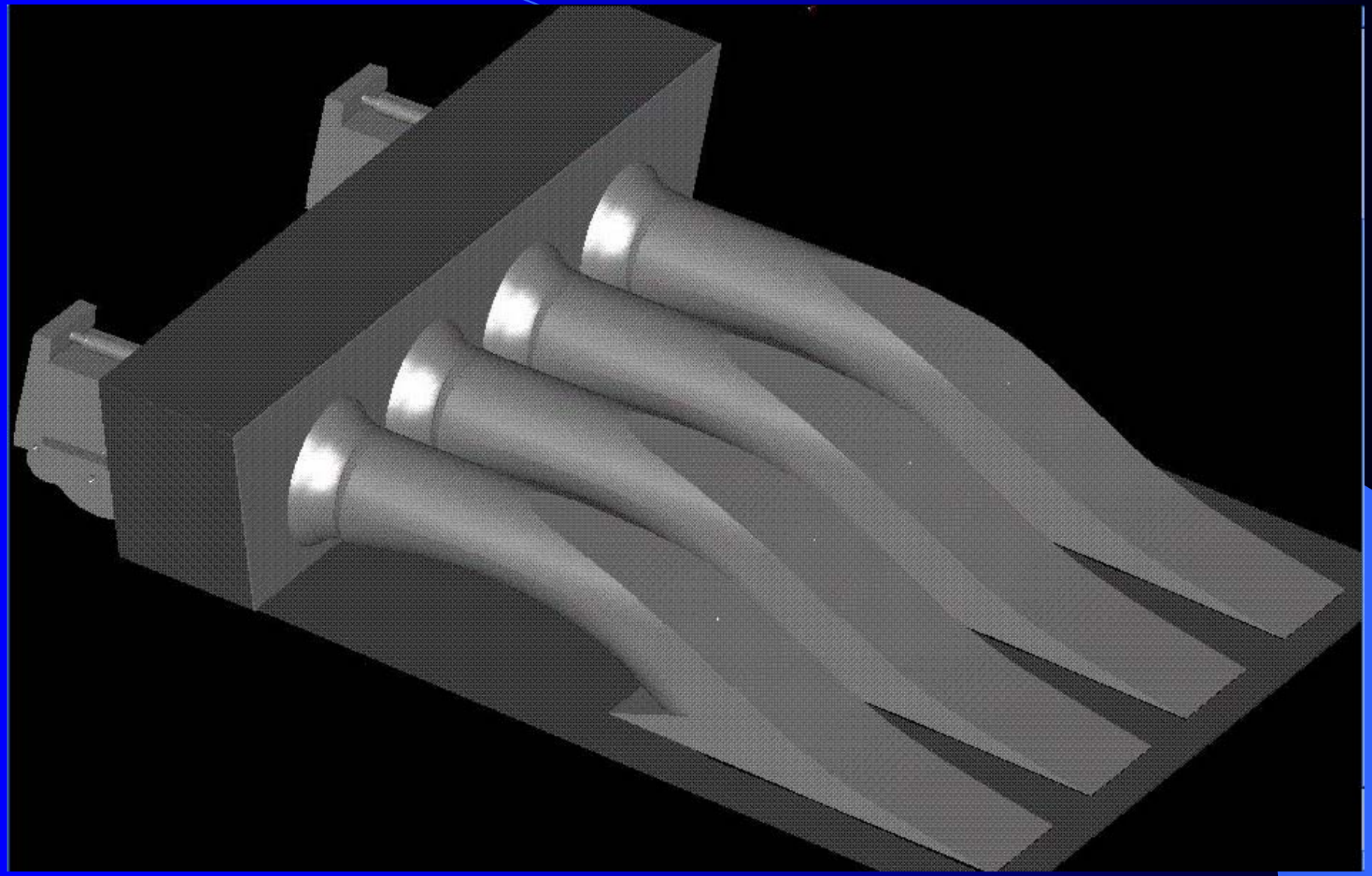
Resistance, Power and Mechanical Arrangements

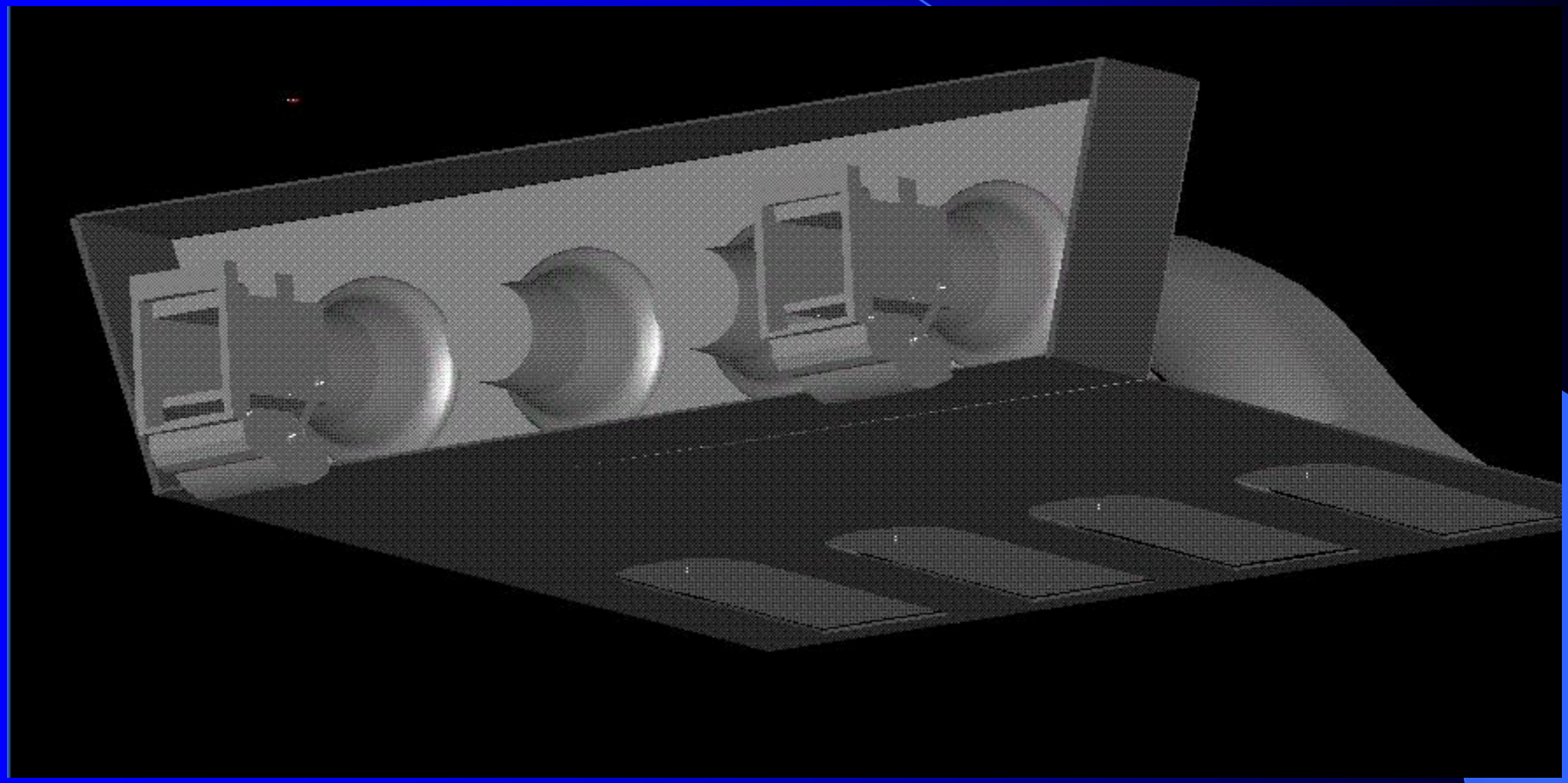
Resistance and Power

- LM-6000
- Waterjets large enough to provide power
  - Not currently available
  - Scaled by inlet diameter vs. kilowatts

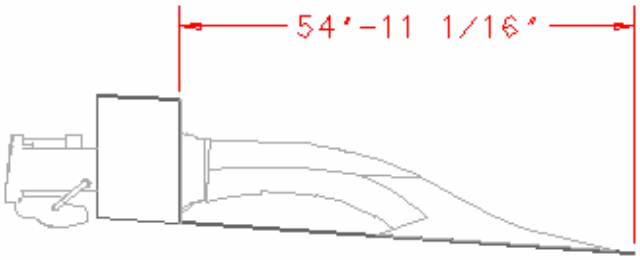
Waterjet Arrangement



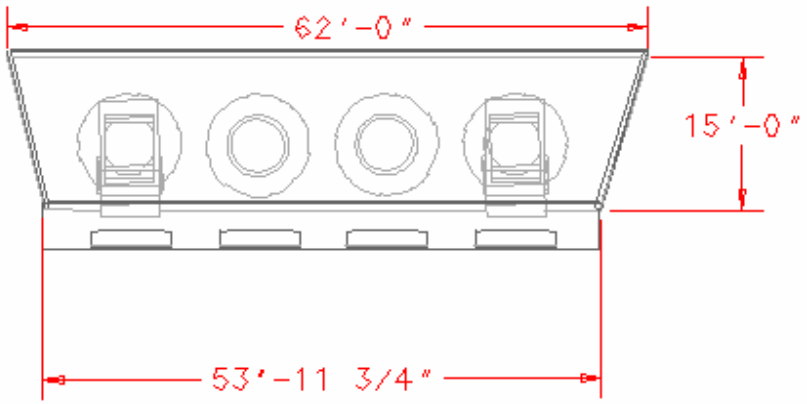




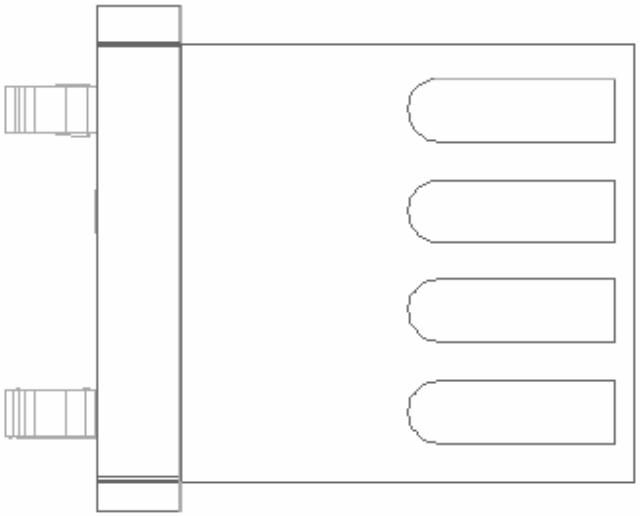
WATERLINE IS
4.9 FEET FROM
TRANSOM BASELINE



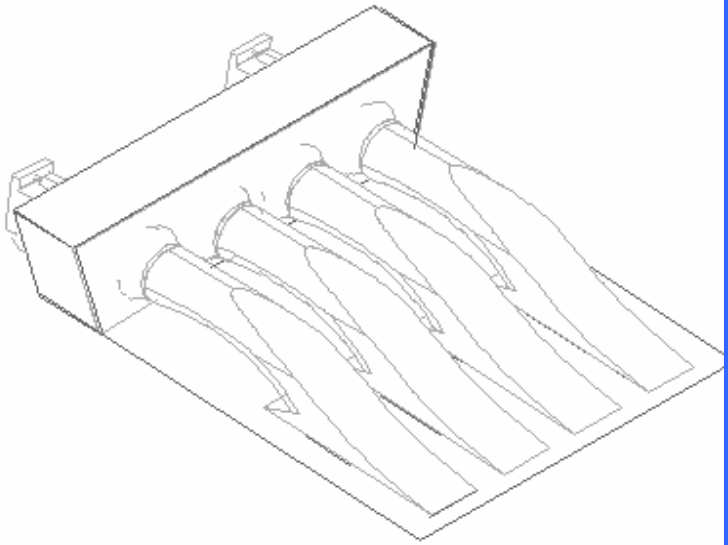
FRONT



LEFT



BOTTOM



ISOMETRIC

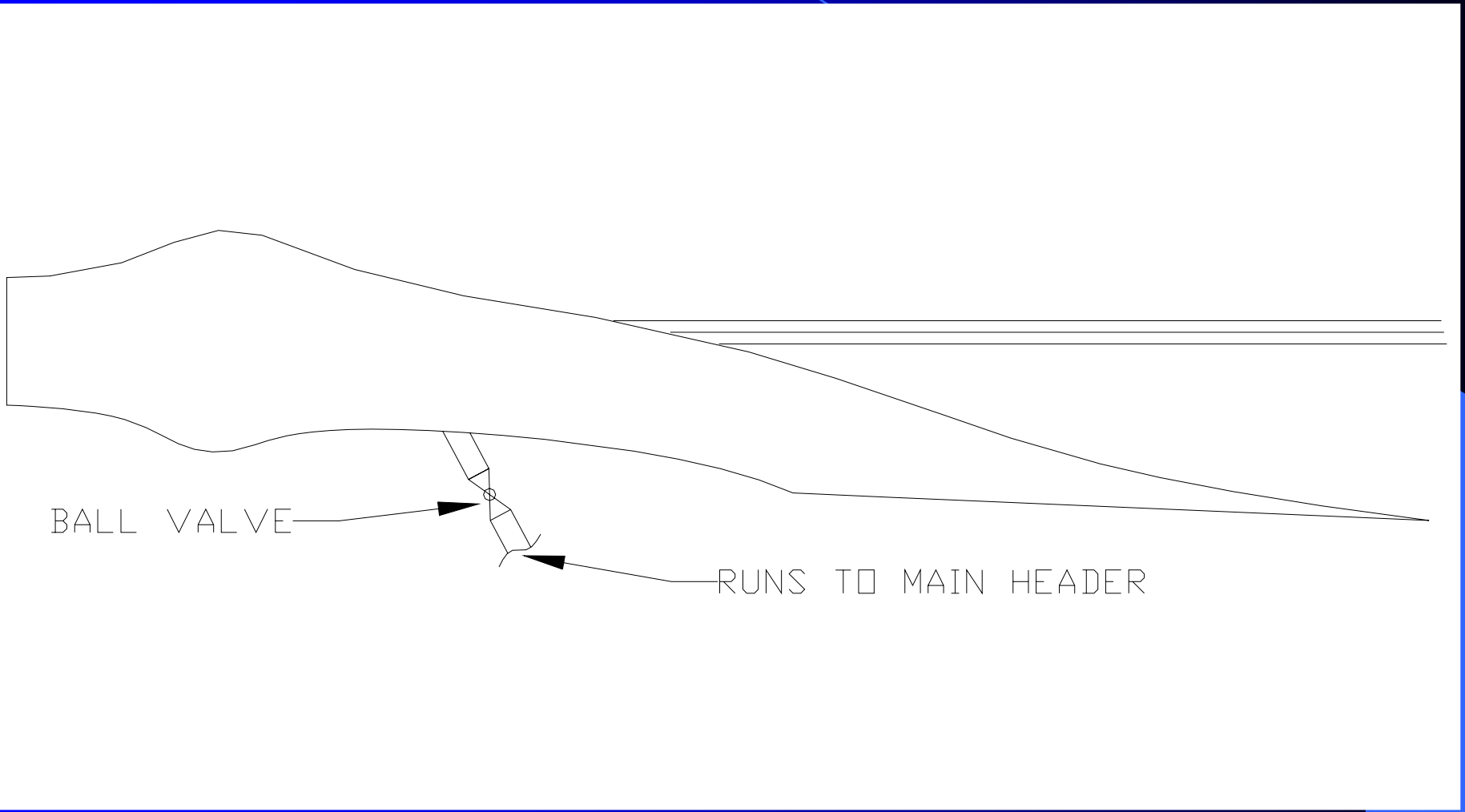
Resistance and Power Requirements

- NAVCAD software used to calculate Resistance, P_E, Fuel Consumption, and Efficiency
- Fuel Consumption at endurance speed of 35knts: 2554.78 gph
- Propulsive Efficiency at 35knts: 69.75%
- P_E at 35knts: 83362.41 hp
- P_E at top speed: 149616.54 hp

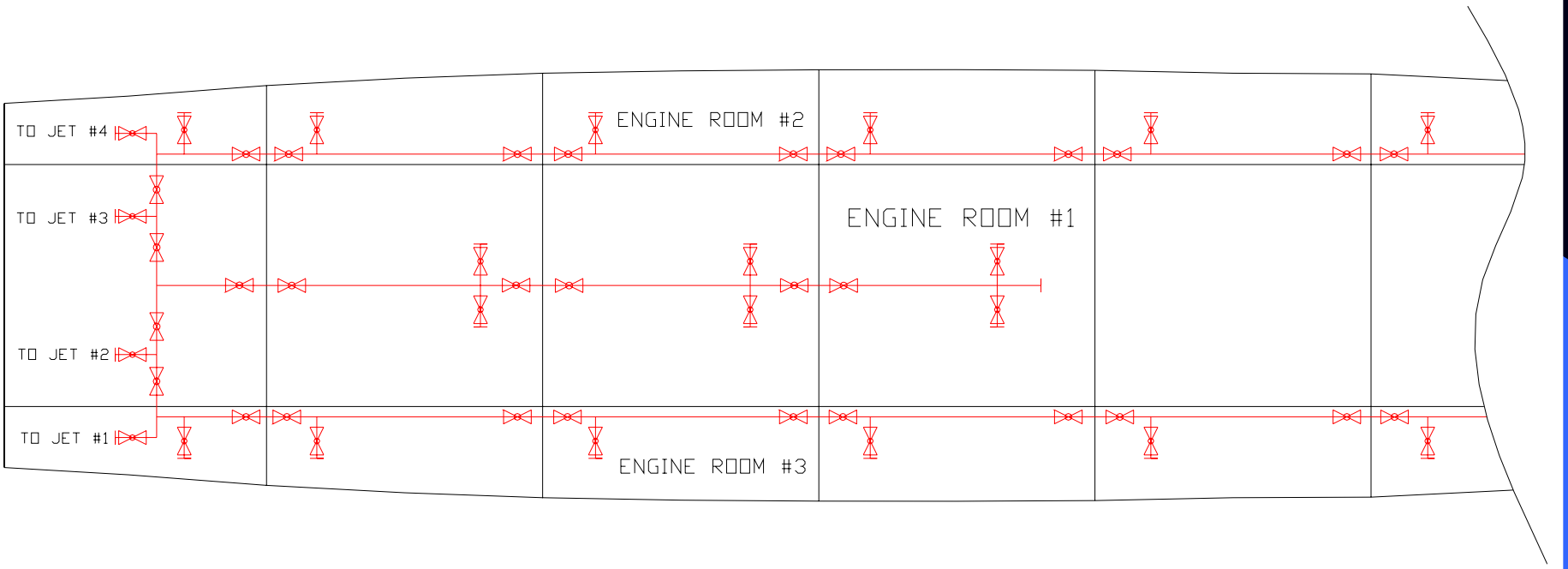
Mechanical and Electrical

- Dewatering systems of waterjets
- Forward Emergency Generator
- PDSS generators
- Smart Ship Technology to enhance survivability

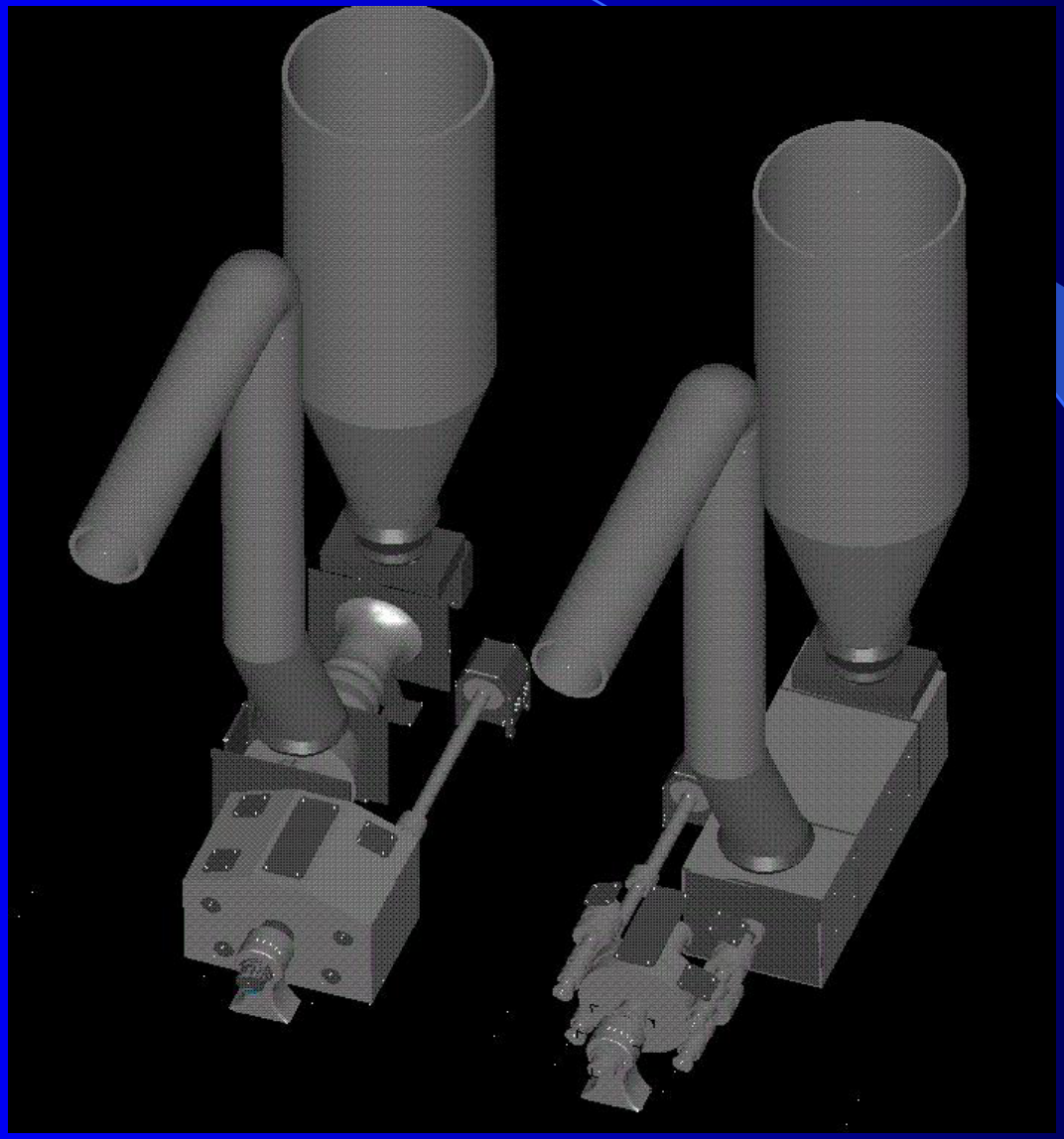
Dewatering Concept Design



Dewatering System



Machinery Room

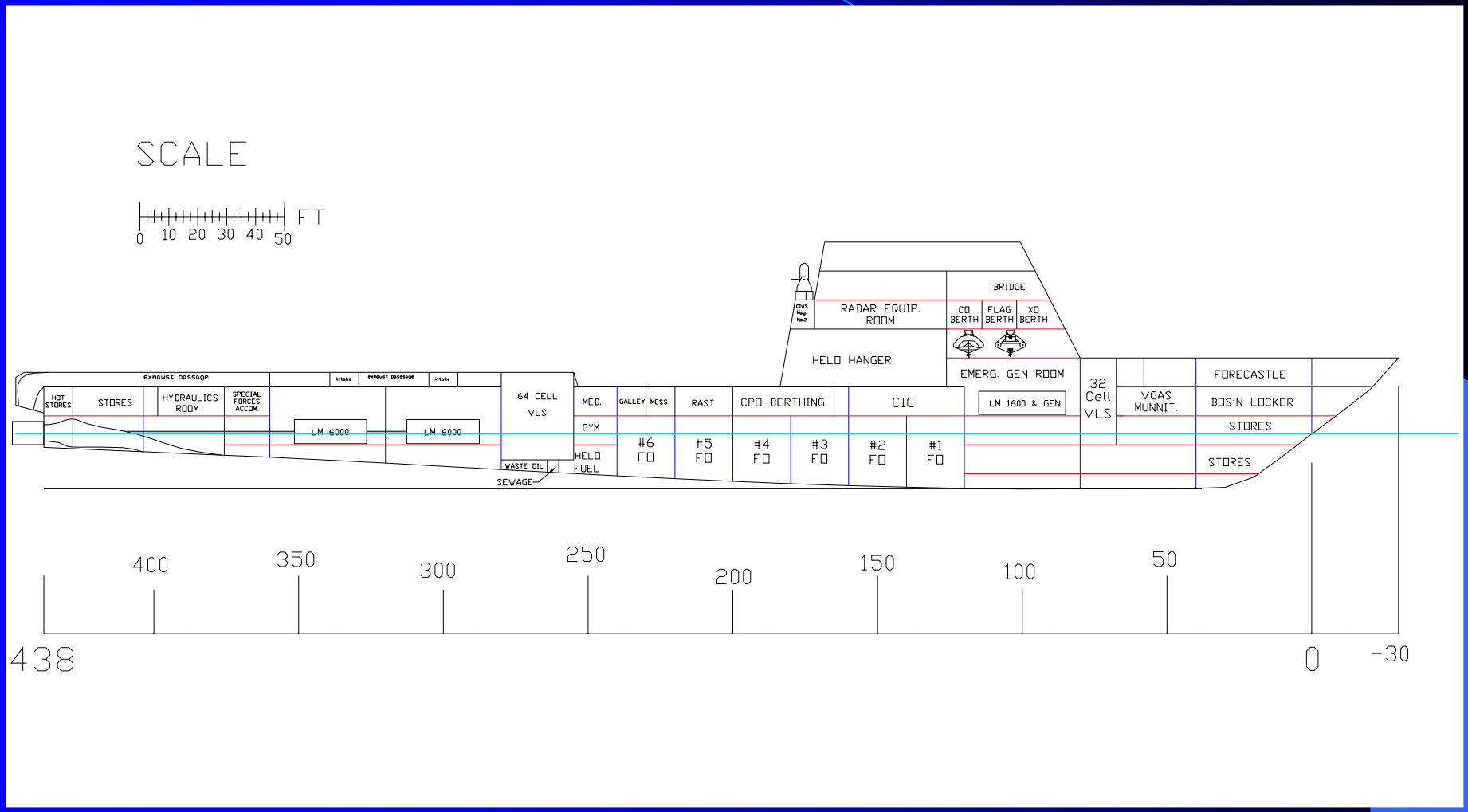


Space, Arrangements and Manning

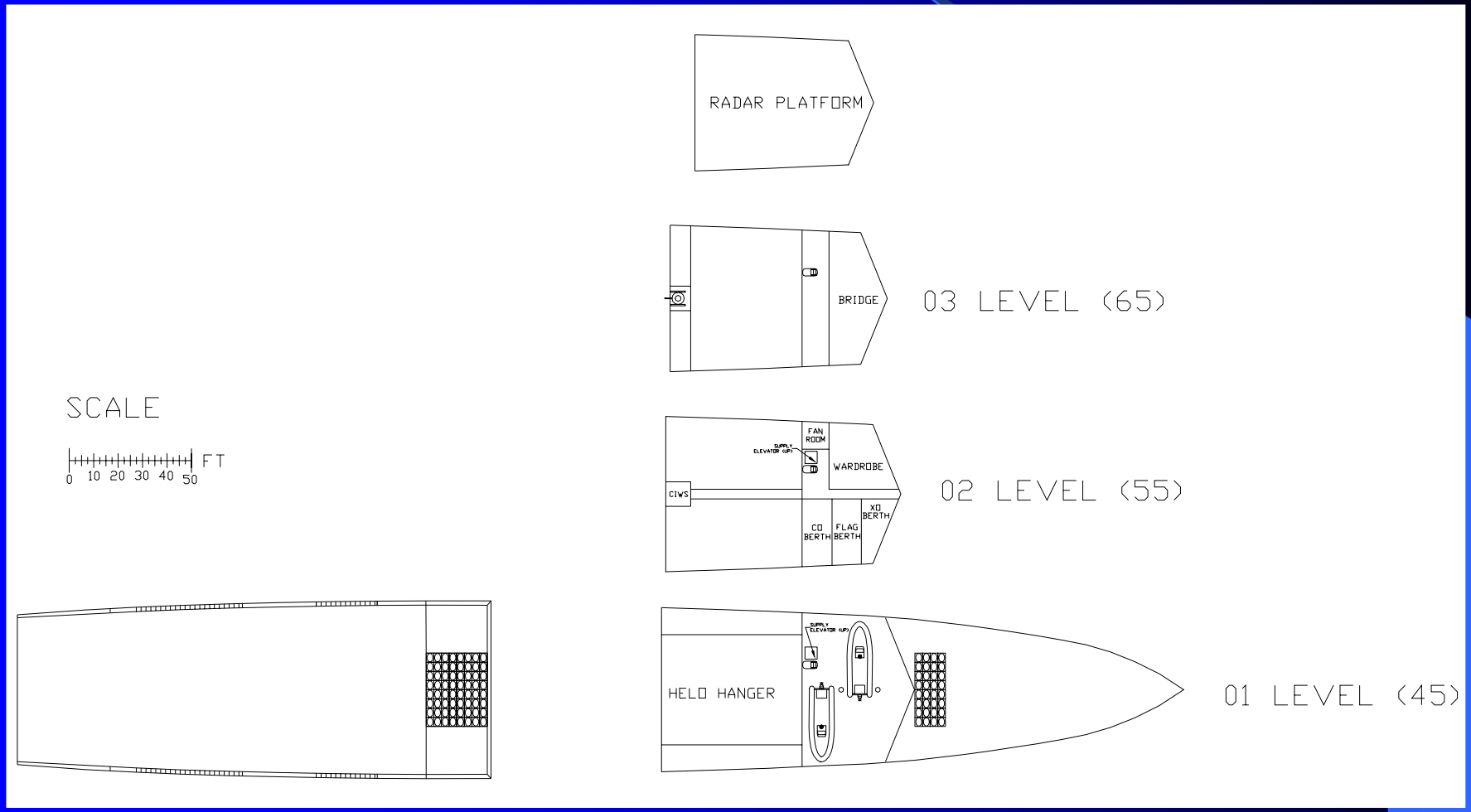
Space and Arrangements

- Radar Cross Section
  - Every surface at 10 degrees
- Heat Signature
  - Exhaust system
- Deckhouse placement
- Helo deck placement
- Internal module arrangements

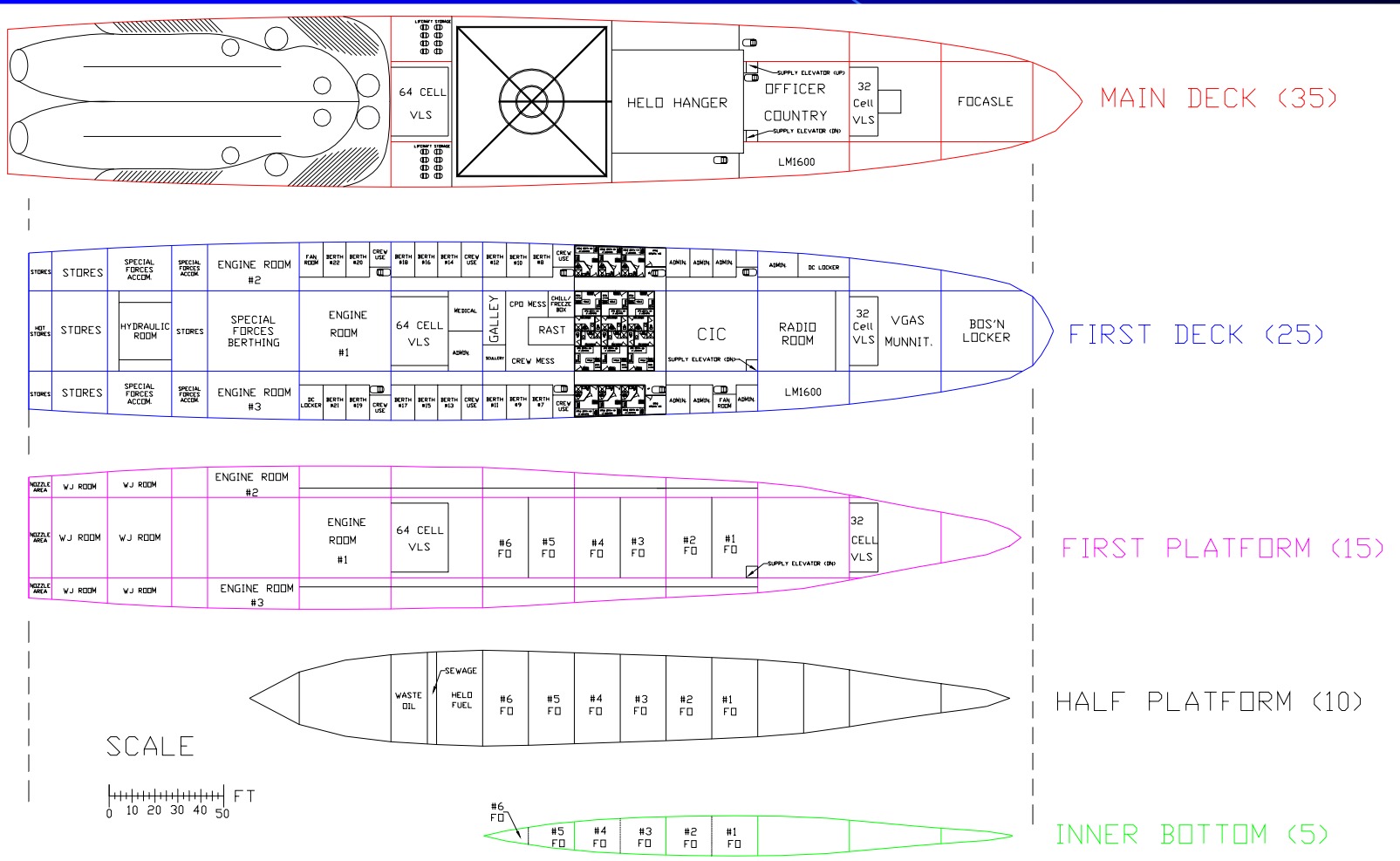
Arrangements: Profile View



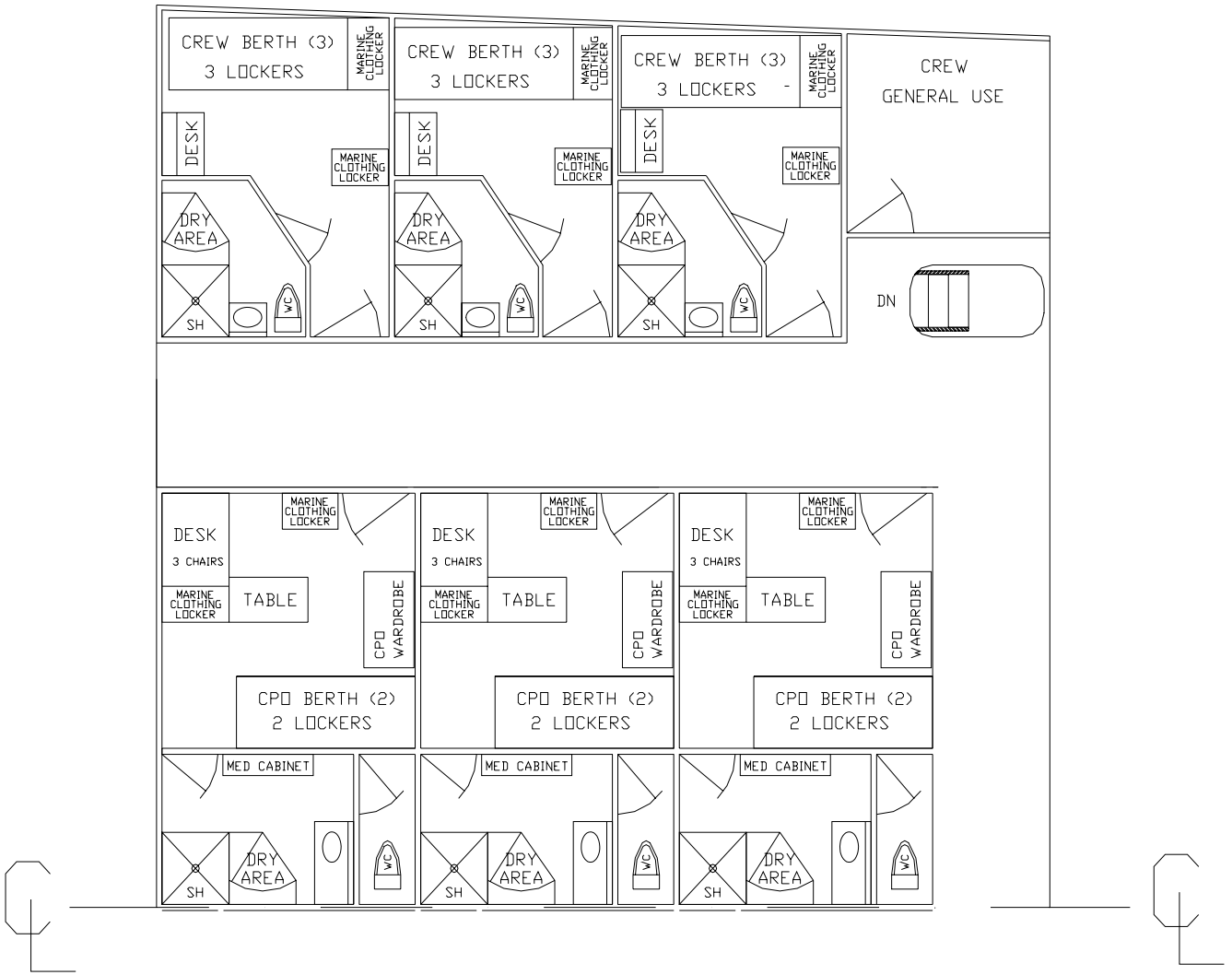
Arrangements: Deckhouse Plan



Arrangements: Hull Plan



Arrangements: Berthing

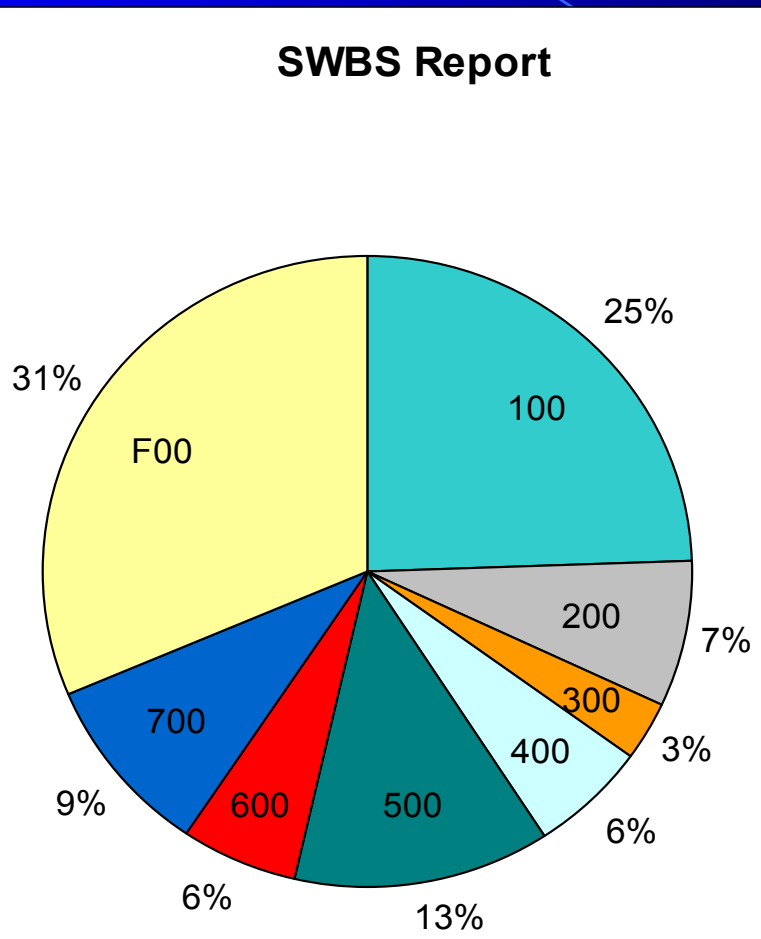


Weights, Centers and Seakeeping Analysis

Loading and Centers

- Total Weight = 6223 LT
- LCG = 215 feet aft of FP
- VCG = 22.1 feet above BL
- TCG = 0.06 feet (Port)

SWBS Report



Seakeeping Limit Criteria by Subsystem

- Helo
  - Vertical velocity = 6.5 ft/sec at landing spot
  - Roll = 5 degrees
- Personnel
  - Vertical acceleration = 0.4g at bridge
  - Transverse acceleration = 0.2g at bridge
  - Roll = 8 degrees

Seakeeping Limit Criteria, cont.

- VLS
  - Vertical acceleration = 0.6g at launcher outboard corner
  - Transverse acceleration = 0.7g at launcher outboard corner
  - Roll = 17.5 degrees
- All
  - Pitch = 3 degrees

Mission Systems

- Anti-Aircraft Warefare
- Anti-Surface Warefare
- Anti-Sub Surface Warefare
- Advanced C4-I system
- Mine Countermeasures
- Naval Surface Fire Support
- Sensor and Electronic Warefare
- Strike Warefare

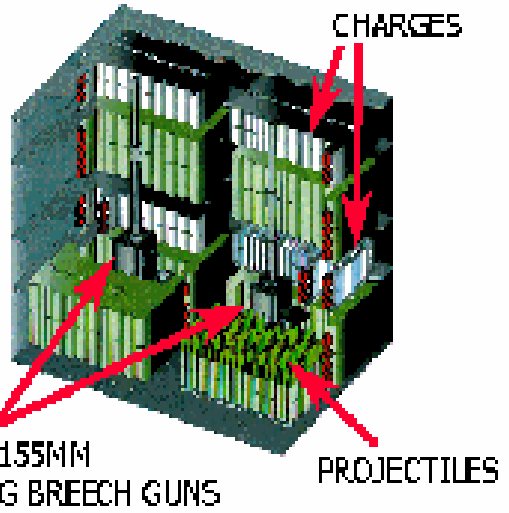
Weapons Systems

- VLS Missiles
- Advanced Gun System
- 2 Lamps MK III Helos
- Phalanx CIWS

Advanced Gun System

- **NEED**
  - VOLUME OF FIRES & SUSTAINABILITY
  - IMPROVED LETHALITY
  - INCREASED RANGE
- **SOLUTION**
  - EXPAND ON USA / USMC 155MM
  - ADVANCED GUN SYSTEM
- **COMPLEMENTARY PROGRAM**
  - LEVERAGES EXISTING ORDNANCE TECHNOLOGIES
    - 5" ERGM
    - ARMY XM982 155MM PROJECTILE
    - SADARM / UNITARY WARHEADS
    - ARMY CRUSADER Program

Vertical Gun Concept



- **Meets DD 21 ORD requirements:**
  - Twin 155MM guns
    750 rounds/barrel
    100NM range
  - Advanced Handling System => reduced manning
  - Flush deck => reduced signature
  - Reduced maintenance

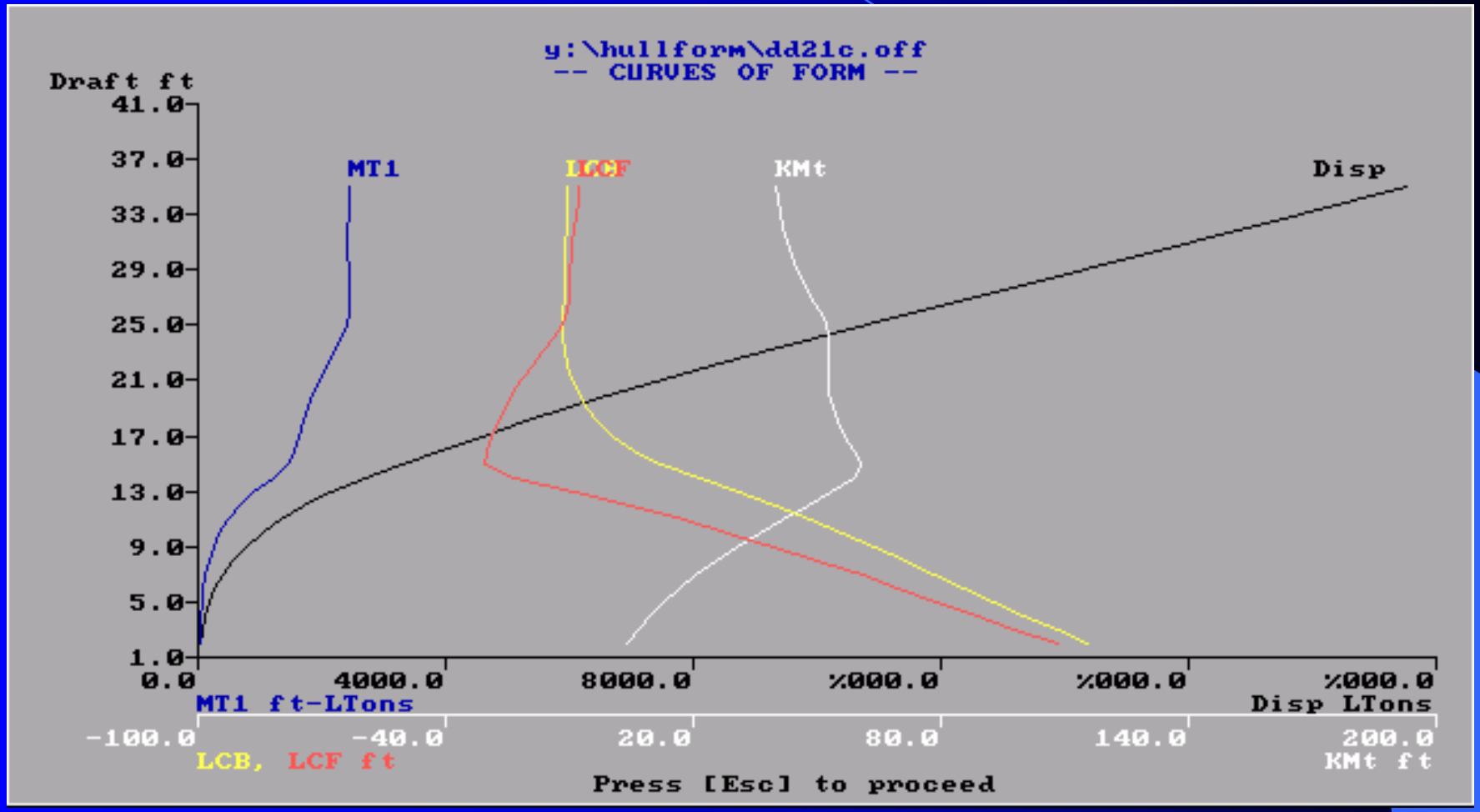
JROC APPROVED

Hydrostatics, Intact and Damage Stability

Hydrostatics and Stability

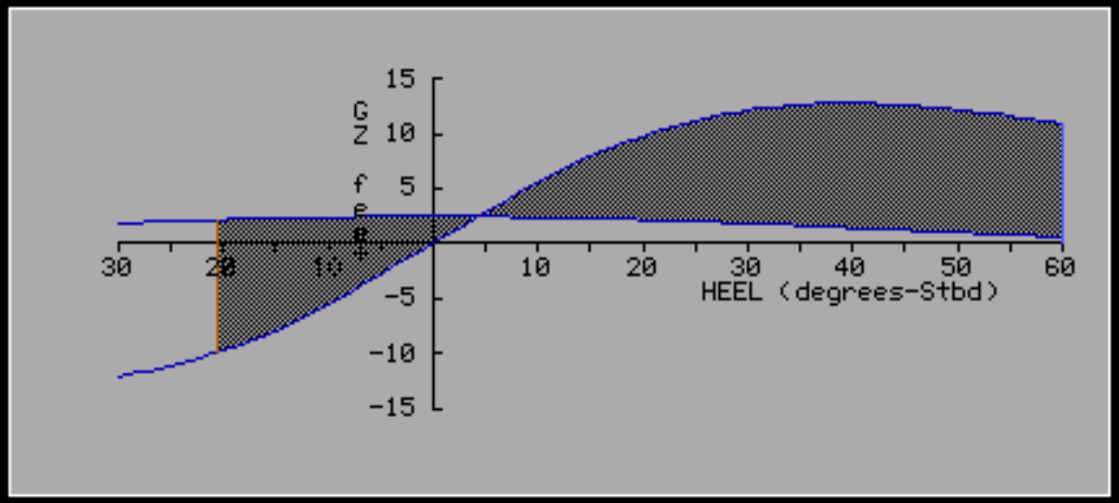
- Intact stability
  - DDS 079-1
  - Two loading cases for each of three stability requirements
    - Beam Seas and Rolling
    - High Speed Turning
    - Topside Icing
- Damage stability
  - DDS 079-1
  - 54.75 foot opening required (12.5% of LBP)

Hydrostatic Curves



Beam Seas and Rolling, Full

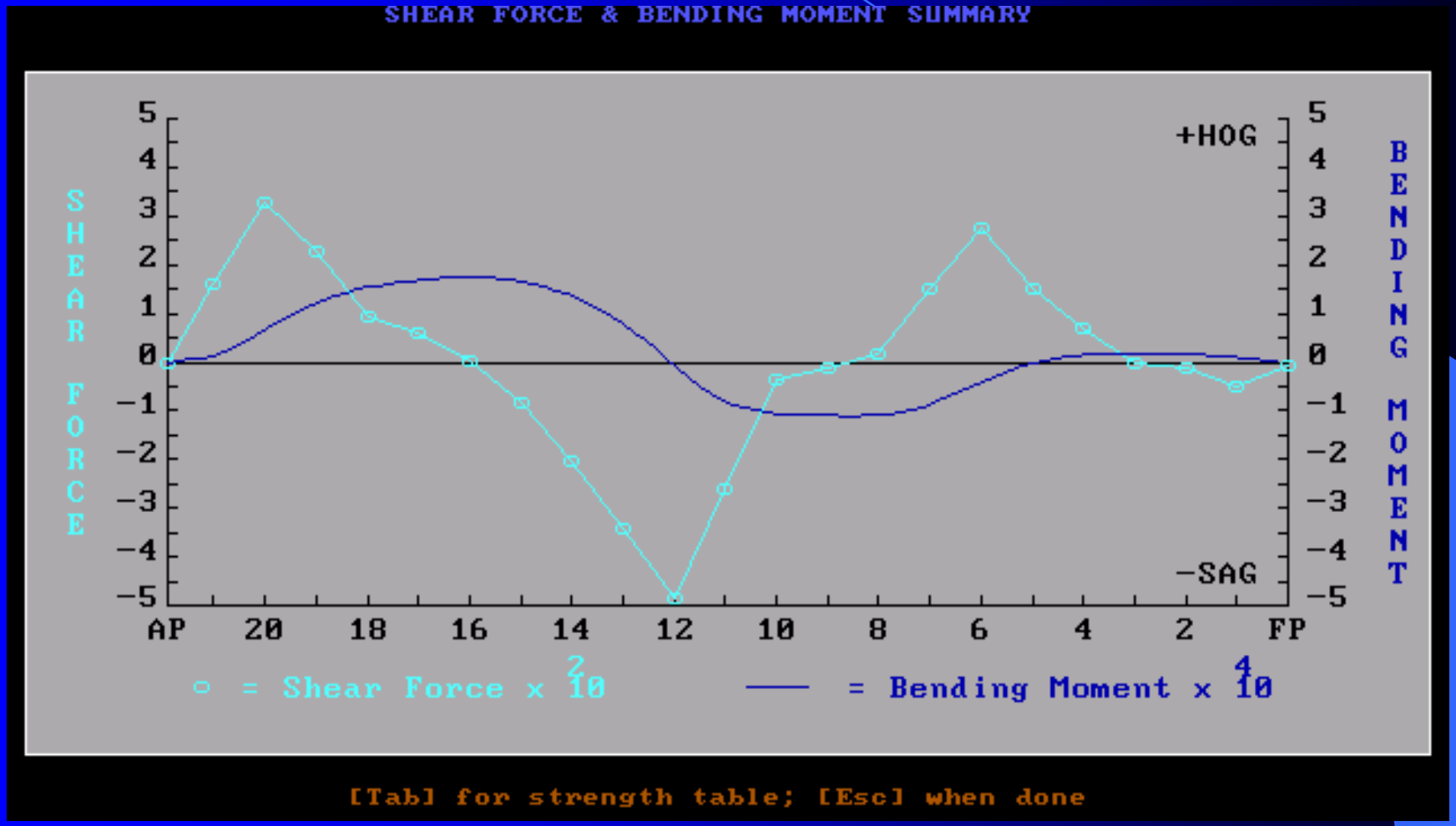
BEAM WIND with ROLLING STABILITY EVALUATION
(per U.S. Navy DDS079-1)



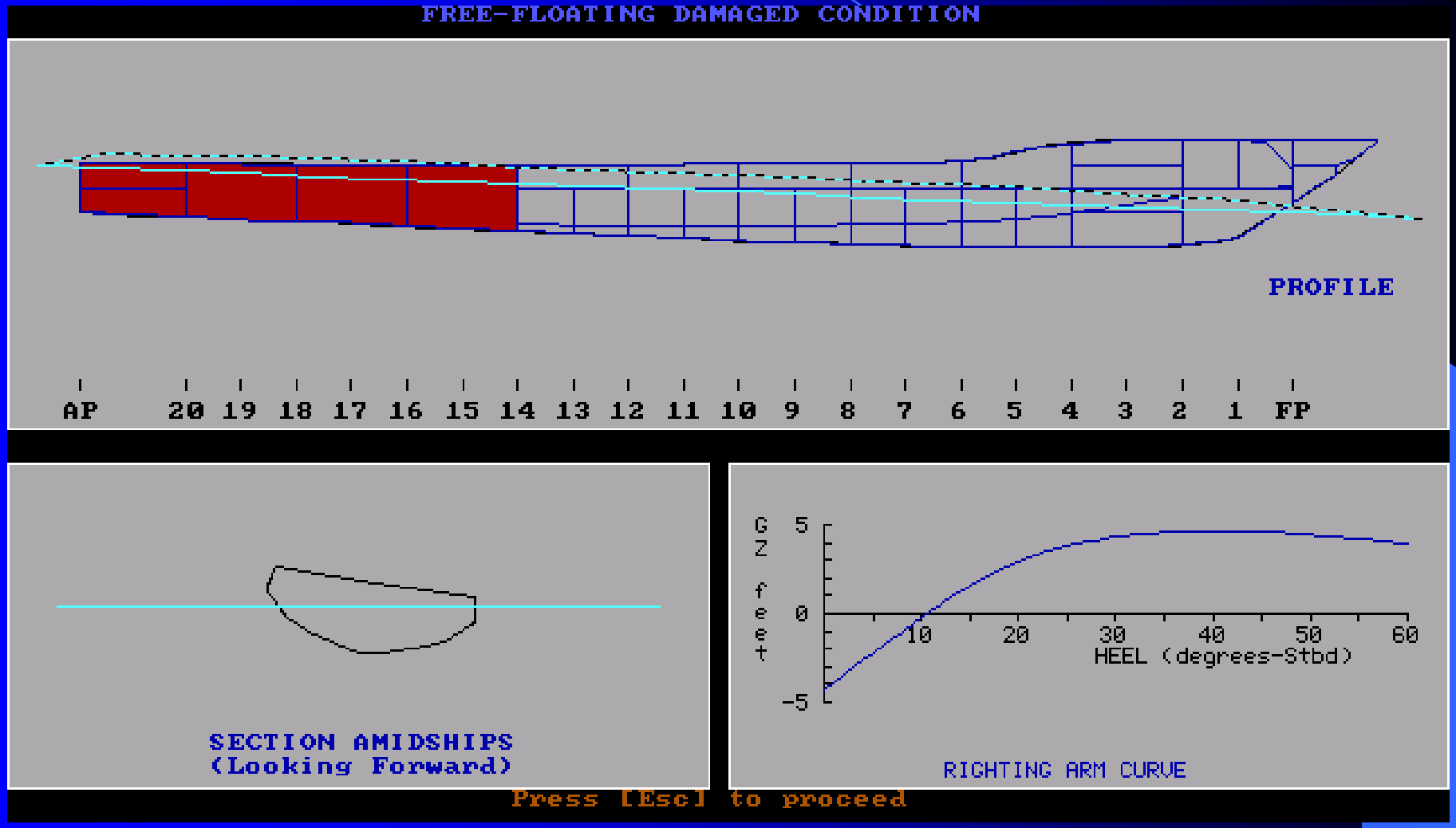
	Available	Required
Wind Heeling Arm Lw	2.458 ft	
Maximum Righting Arm	12.744 ft	4.097 ft
Capsizing Area A2	165.4 ft-deg	
Righting Area A1	483.5 ft-deg	231.5 ft-deg

[Tab] for tabular summary; [Esc] when done

Strength Curves, Full Load



Limiting Case Damage Stability



Final Analysis

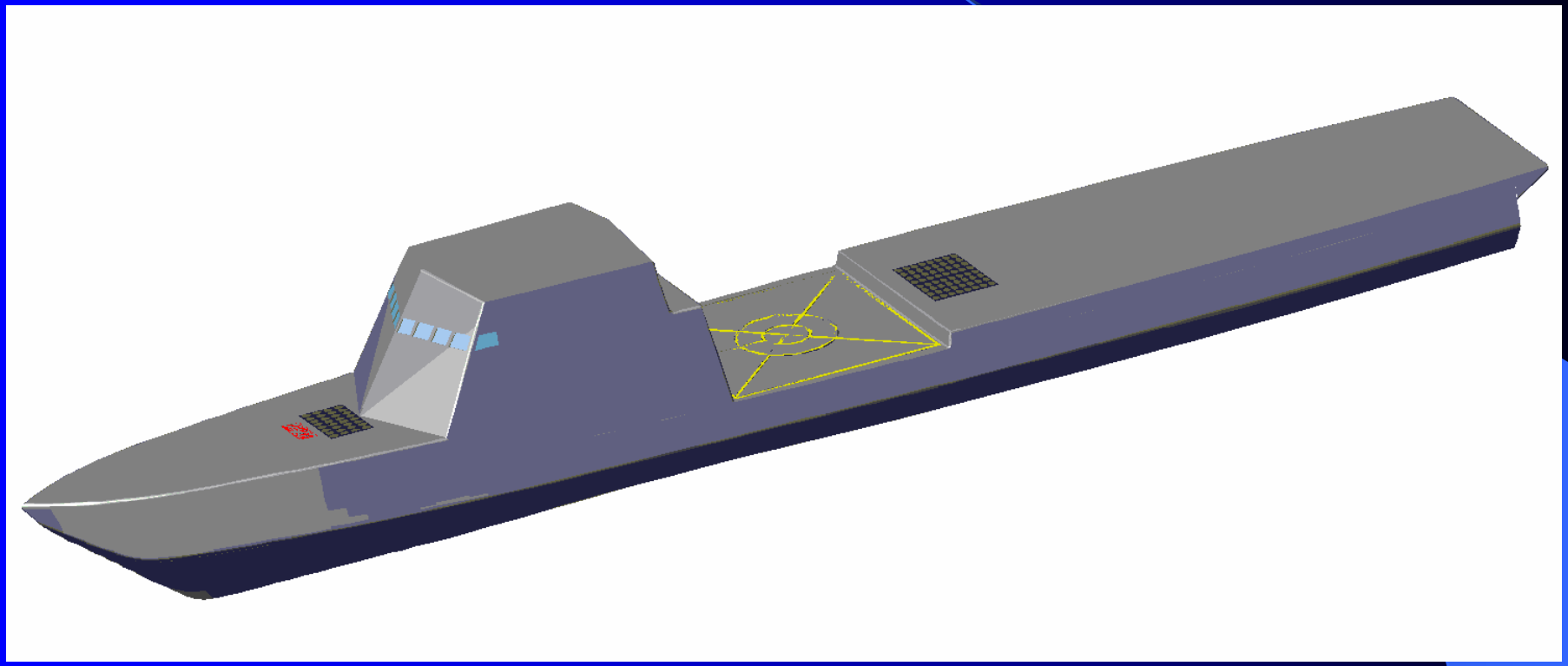
Final Concept Design

- Concept Baseline
  - LBP = 437.4 ft
  - Beam = 67.7 ft
  - Draft = 19.09 ft
  - Disp. = 5870 LT
  - Range = 4000 nm
  - Sustained Speed = 41.96 knots
  - Manning = 73
- Final Concept Design
  - LBP = 438 ft
  - Beam = 67.7 ft
  - Draft = 19.14 ft
  - Disp. = 6223 LT
  - Range = 4000 nm
  - Sustained Speed = 43+ knots
  - Manning = 92
- Cost Estimates
  - Lead Ship = $1.3 Billion
  - Follow Ship = $900 Million

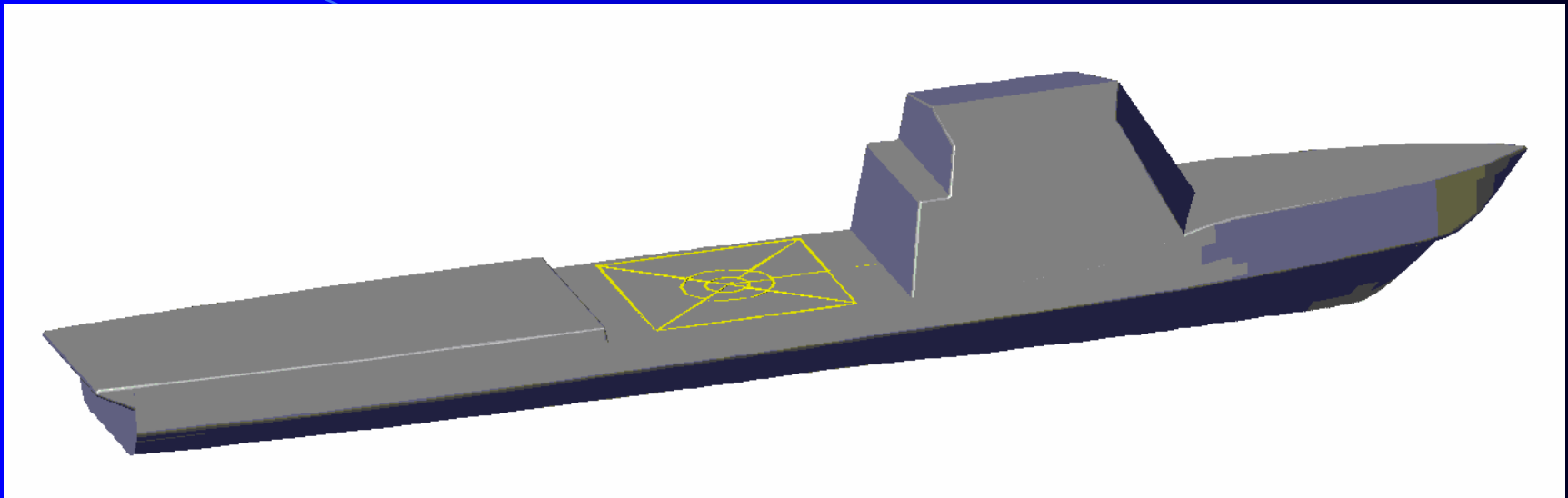
Conclusions and Future Work

- Assessment of DD-21
  - Ship is stable, but stiff
  - Low profile for reduced radar cross-section
  - Can adequately protect the areas assigned
  - Waterjet arrangement will need to be tested
  - Quality of life has been improved
- Recommended improvements
  - Testing of hull type
  - Further research of waterjet technology and improvements
  - Improve weight distribution to improve seakeeping

Final Concept Design



Questions?



Thank you for your time