



# Team YETI

## Yukon Equipment Transport Initiative

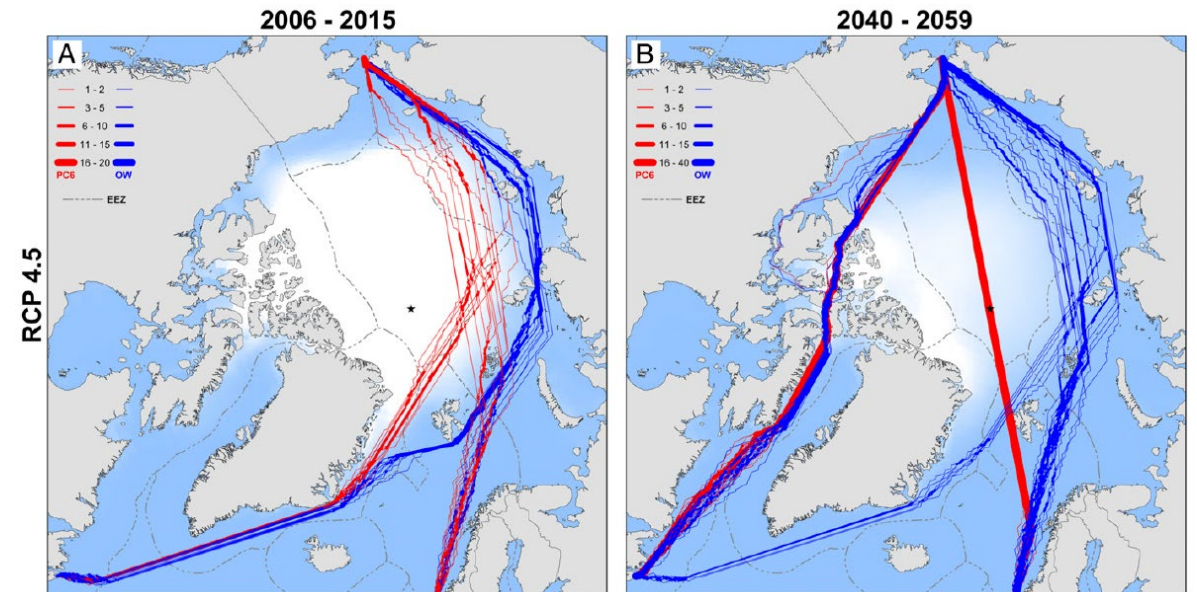
2.705 Projects in New Concept Naval Ship Design

LT Brady Hammond

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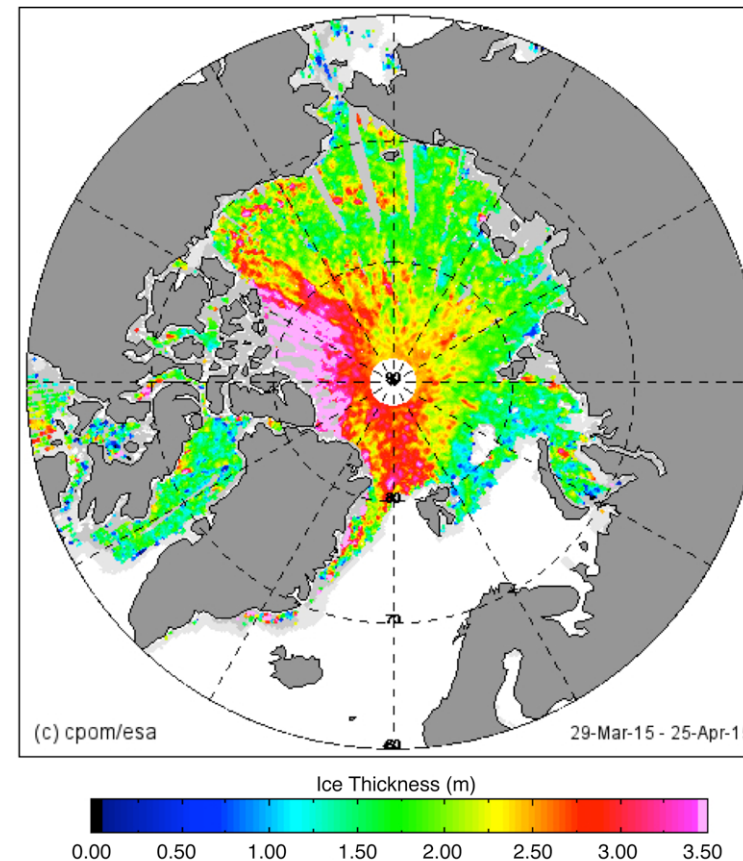
- Receding ice coverage
- Natural resources
- Shipping routes
- Strategic passageways and chokepoints
- Advances and proliferation in unmanned technology
- Lack of dedicated Arctic vessels



- Homeport and Operating Area
- Seasonal ice coverage
- Deployment rotation
- First-year ice
- UXV Operations



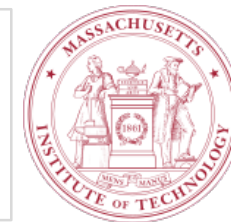
## Arctic Sea Ice Thickness



Center for Polar Observation and Modelling, University College London



# Customer Requirements



	Threshold	Objective
Range	One refueling required on deployment	No refueling required
Station Time	3 months	6 months
UXV Capability	UUV, USV	UUV, USV, UAV
UUV Capability	Man-Portable, LWV, HWV	Man-Portable, LWV, HWV, Large
USV Capability	Very Small	Very Small, Small
UAV Capability	No UAV Capability	Up to Group 3
UXV Capacity	Group 1/2 UAV – 0 Group 3 UAV – 0 Small UUV – 20 Medium UUV – 10 Large UUV – 0 Very Small USV – 1 Small USV – 0	Group 1/2 UAV – 20 Group 3 UAV – 3 Small UUV – 40 Medium UUV – 40 Large UUV – 6 Very Small USV – 2 Small USV – 2
UXV Onload	In Port	In Port and At Sea
Ice Hardening	PC7	PC6



# Assumptions and Derived Requirements



- Assumptions

- C2
- UXV Detachment
- Ship Crew
- UXV Classification
- Class Size

- Derived Requirements

- Endurance
- Range
- Embarkation
- Aviation
- Classification
- UAV launch and recovery
- Non-combatant

# Baseline Ship Description



- San Antonio Landing Platform Dock (LPD 17)
- Flight deck and well deck directly support the sponsor and derived requirements.
- Weight at full load: 22,951 metric tons.

Selection Criteria	Weights	Value			
		DDG 51	CG 47	LPD 17	LCS
Initial Volume and Area	0.35	2	2	5	2
Hull Adaptability	0.30	2	3	5	3
Complexity	0.25	3	3	4	2
Seakeeping	0.10	4	4	3	3
<b>Overall Score</b>		<b>2.75</b>	<b>3.00</b>	<b>4.25</b>	<b>2.50</b>



# Design Parameters



- Variables

- Propulsion System: Small/Large Diesel/IPS
- Electrical System: Small/Large DG/IPS
- Fuel Tank Capacity: Small/Large
- Food Storage Capacity: Small/Large
- Ice Hardening: PC7/PC6
- UXV Loadout: Low/Low-Med/Med/Med-High/High
- UXV Onloading: At Port/At Sea
- Refuel and Restock: Required/Not Required

- Constraints

- Non-Combatant
- Single Hullform
- UXV Handling System
- Embarkation/VERTREP



# UXV Loadout

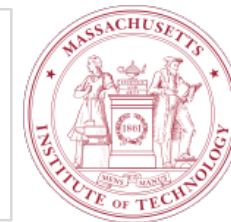


Name	UXV Loadout	Weight (MT)	Area (m <sup>2</sup> )	Power (kW)	Manning
Low	Group 1/2 UAV – 0, Group 3 UAV – 0 Small UUV – 20, Medium UUV – 10 Large UUV – 0 Very Small USV – 1, Small USV – 0	22.0	90.4	7.67	10
Low-Medium	Group 1/2 UAV – 10, Group 3 UAV – 0 Small UUV – 40, Medium UUV – 25 Large UUV – 0 Very Small USV – 1, Small USV – 0	51.4	204.4	18.2	10
Medium	Group 1/2 UAV – 20, Group 3 UAV – 1 Small UUV – 40, Medium UUV – 40 Large UUV – 2 Very Small USV – 2, Small USV – 0	110.6	487.3	34.5	15
Medium-High	Group 1/2 UAV – 20, Group 3 UAV – 2 Small UUV – 40, Medium UUV – 40 Large UUV – 4 Very Small USV – 2, Small USV – 1	147.2	696.0	42.2	18
High	Group 1/2 UAV – 20, Group 3 UAV – 3 Small UUV – 40, Medium UUV – 40 Large UUV – 6 Very Small USV – 2, Small USV – 2	183.8	904.7	49.8	20

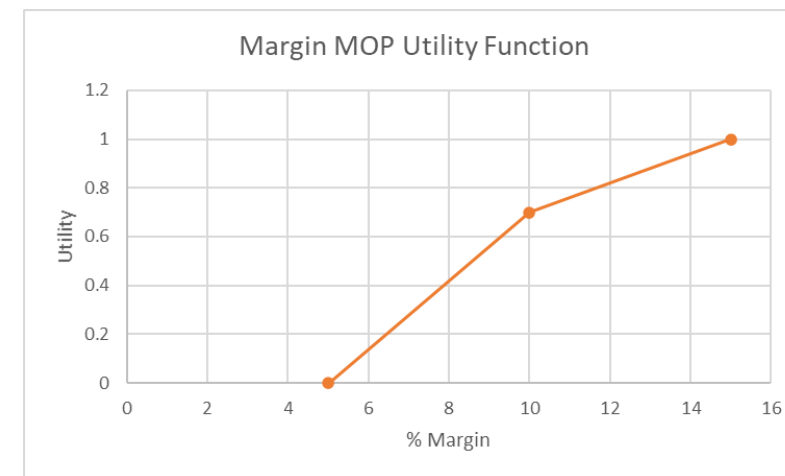
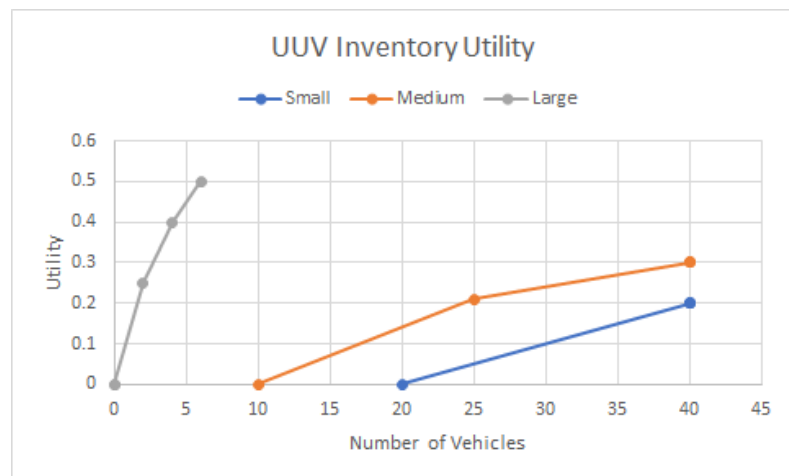




# Evaluation and Decision Framework

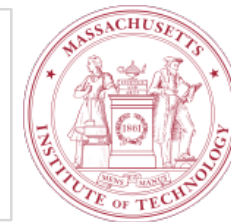


YETI								
<b>Criteria (Weight)</b>	Endurance	0.3	Mobility	0.2	UXV Inventory	0.4	Margins	0.1
<b>Alternatives (Weight)</b>	Range	0.2	Endurance Speed	0.4	UUUV	0.7	Area	0.2
	Station Time	0.3	Ice Rating	0.6	USV	0.2	Weight	0.3
	At-sea UXV loading	0.2			UAV	0.1	Power	0.5
	Required Refueling	0.3						



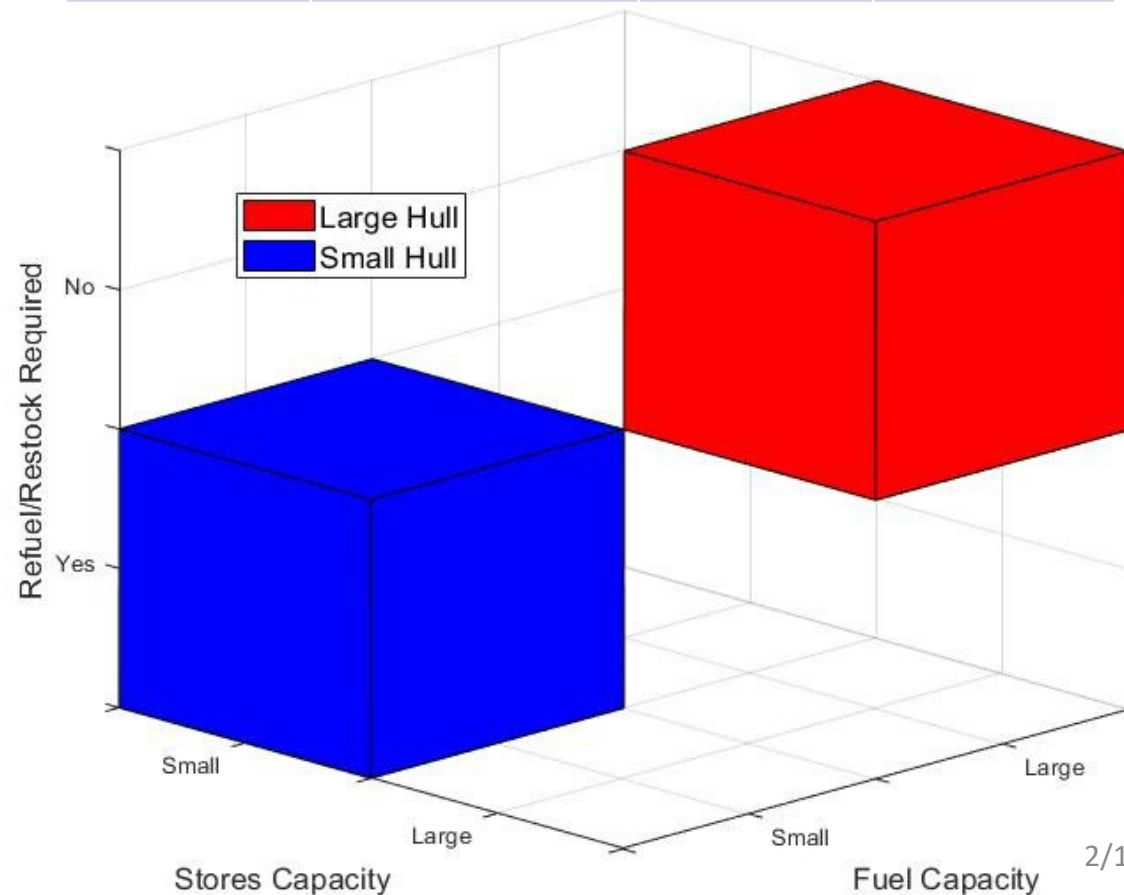


# Concept Exploration and Approach



#	Decision	Option	Description
1	Propulsion	Large Diesel	2x Caterpillar 3608 IL8 (2528 kW each)
		Small Diesel	2x Caterpillar 3516 V16 (1275 kW each)
		IPS	3x Caterpillar 3612 (propulsion/electric, 3750 kW each)
2	Electricity Generation	Large Diesel	2x Caterpillar 3608 IL8 Generators
		Small Diesel	2x Caterpillar 3516 V16 Generators
		IPS	3x Caterpillar 3612
3	Fuel Capacity	Large	Tanks sized to have a range of 14,000 NM
		Small	Tanks sized to have a range of 8,000 NM
4	Stores Capacity	Large	Stores sized to supply 180 days of food
		Small	Stores sized to supply 90 days of food
5	Ice Hardening	PC6	Frame Spacing = 1.4 m, Plate Thickness = 9 mm
		PC7	Frame Spacing = 1.6 m, Plate Thickness = 8 mm
6	UXV Loadout	Low	Weight, Area, Power = 22.0 MT, 90.4 m <sup>2</sup> , 7.67 kW
		Low-Medium	Weight, Area, Power = 51.4 MT, 204.4 m <sup>2</sup> , 18.2 kW
		Medium	Weight, Area, Power = 110.6 MT, 487.3 m <sup>2</sup> , 34.5 kW
		Medium-High	Weight, Area, Power = 147.2 MT, 696.0 m <sup>2</sup> , 42.2 kW
		High	Weight, Area, Power = 183.8 MT, 904.8 m <sup>2</sup> , 49.8 kW
7	UXV Onloading	Yes	Weight, Area = 14.0 MT, 120 m <sup>2</sup>
		No	No additional weight and area requirements
8	Req. Refuel & Restock	Yes	Refuel/restock was required for 6-month deployment
		No	Refuel/restock was not required for 6-month deployment

	Original LPD 17	Large Hull	Small Hull
Length (L)	200 m	150.84 m	136.47 m
Beam (B)	31.9 m	22.19 m	20.65 m
Draft (T)	7 m	6.38 m	5.86 m

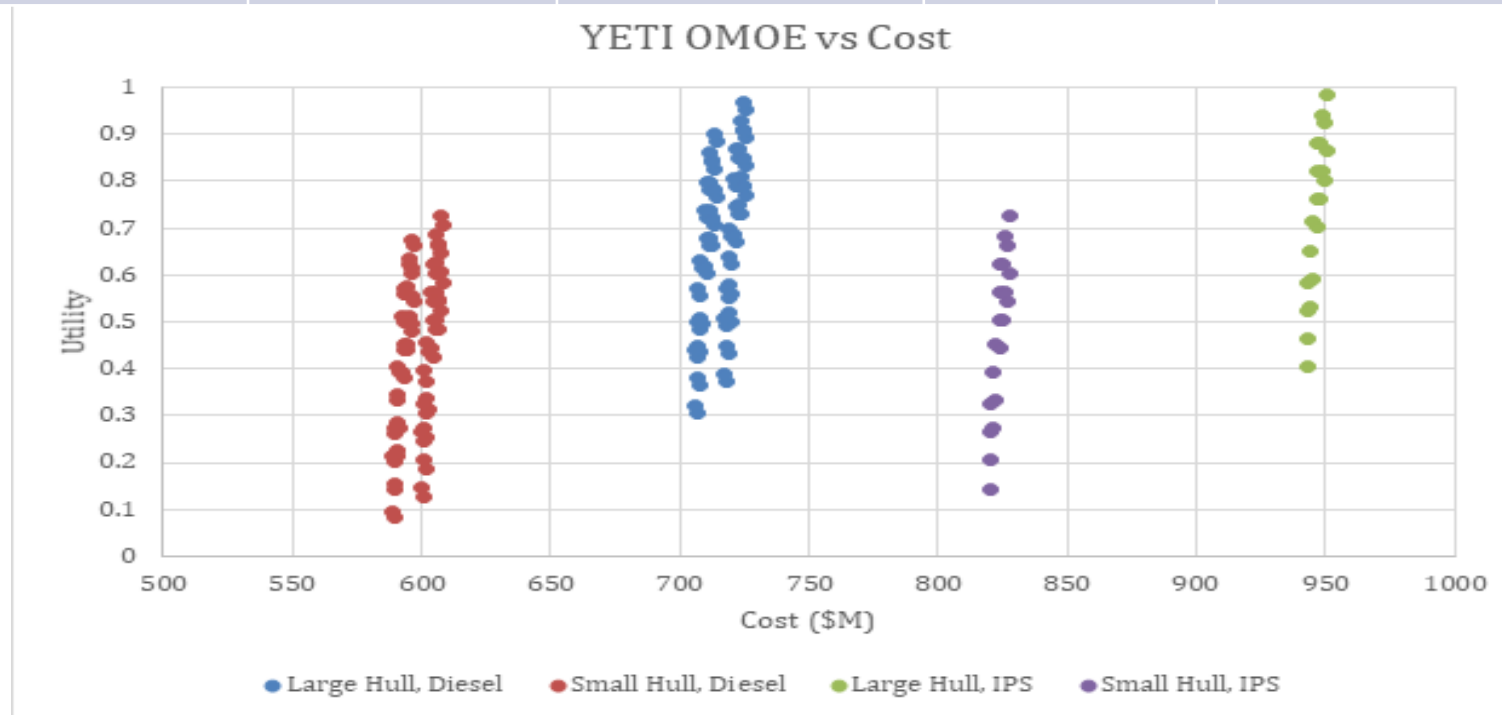




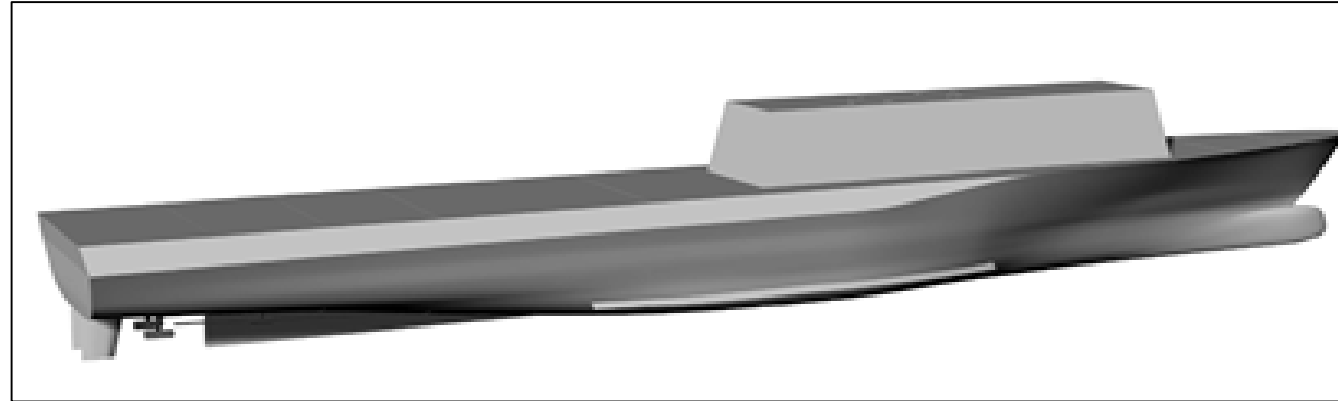
# Variant Description, Evaluation, and Selection



Variant	Hull	Propulsion	UXV Loadout	Ice Rating	Utility	Cost (\$M)
25	Small	Diesel, Small	High	PC6	0.674	596.4
65	Small	Diesel, Large	High	PC6	0.726	607.6
105	Large	Diesel, Small	High	PC6	0.900	712.0
145	Large	Diesel, Large	High	PC6	0.969	723.6
185	Large	IPS	High	PC6	0.983	950.4



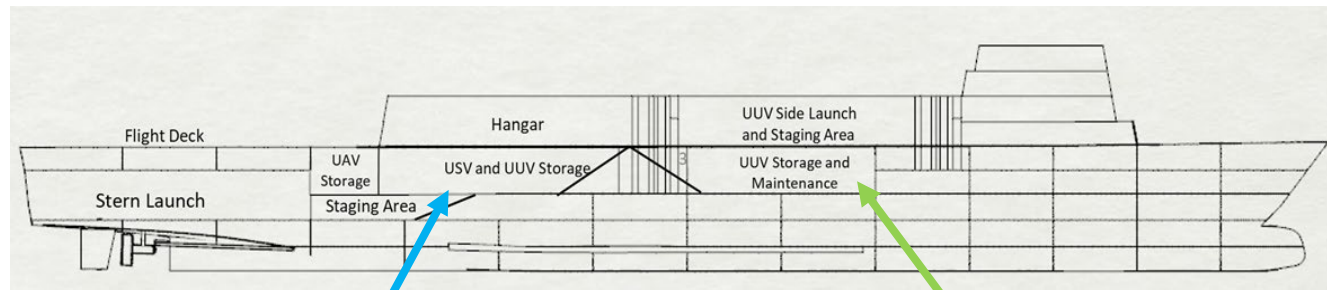
# Preferred Concept/Configuration



	Threshold	Objective	YETI
<b>Range</b>	One refueling required on deployment	No refueling required	No refueling required
<b>Station Time</b>	3 months	6 months	6 months
<b>UXV Loadout</b>	Low	High	High
<b>UXV Onload</b>	In Port	In Port and At Sea	In Port and At Sea
<b>Ice Hardening</b>	PC7	PC6	PC6

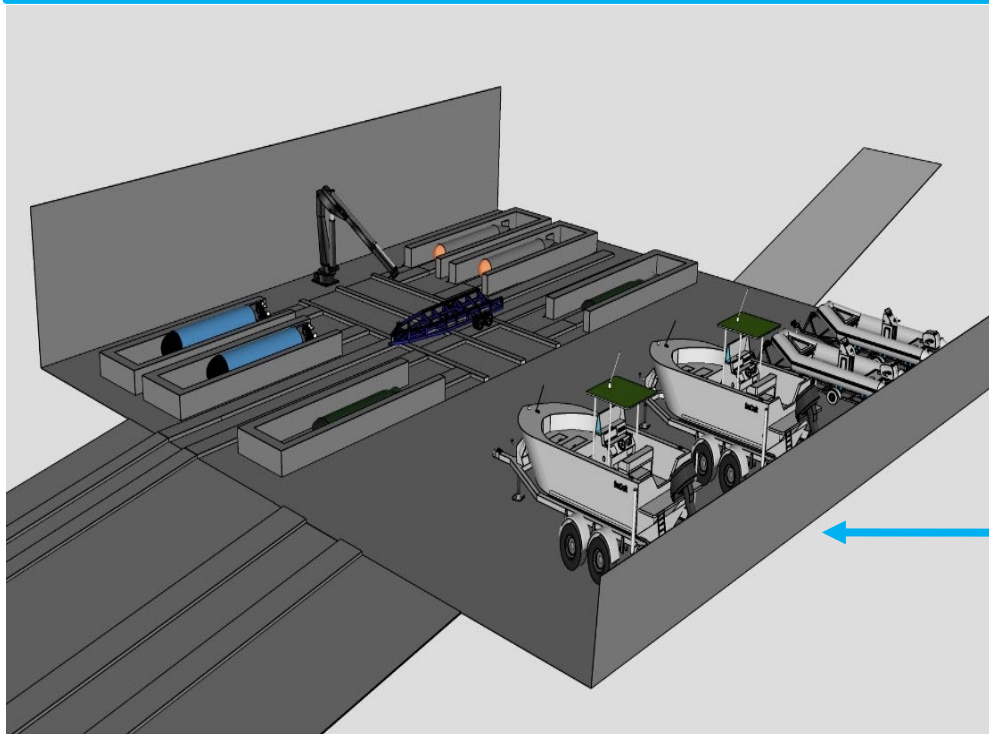
Hull Length Between Perpendiculars	150.84 m	Maximum Speed	16.26 kts
Hull Design Waterline Beam	22.19 m	Sustained Speed	15.00 kts
Hull Depth At Station 10	13.78 m	Design Endurance Range	14,000 NM
Hull Design Waterline Draft	7.62 m	Endurance Ship Speed	14.77 kts
Hull Draft At Full Load	6.38 m	Main Engine Power	2527.92 kW
GMT	2.93 m	Weight At Full Load	10348.7 MT

# USV and UUV Arrangements

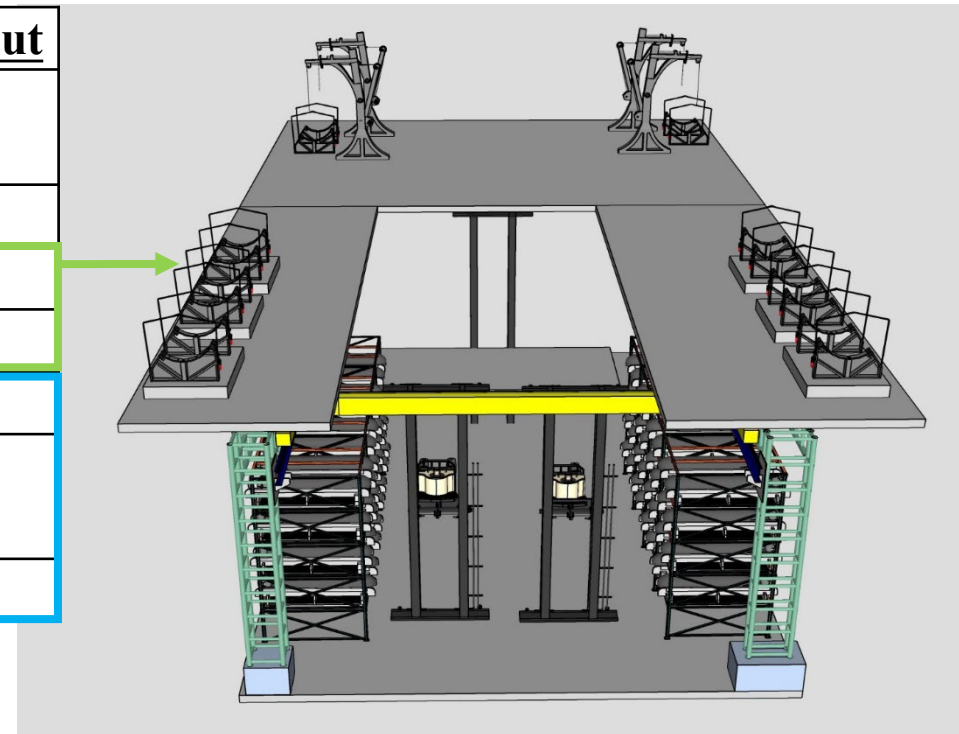


Stern Launch

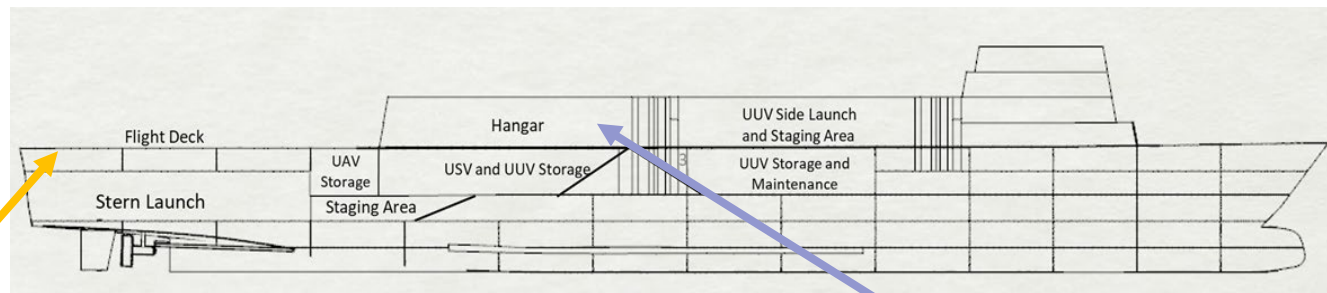
Side Launch



<u>UXV Type</u>	<u>Loadout</u>
Group 1/2 UAV	20
Group 3 UAV	3
Small UUV	40
Medium UUV	40
Large UUV	6
Very Small USV	2
Small USV	2



# Flight Deck and UAV Operations

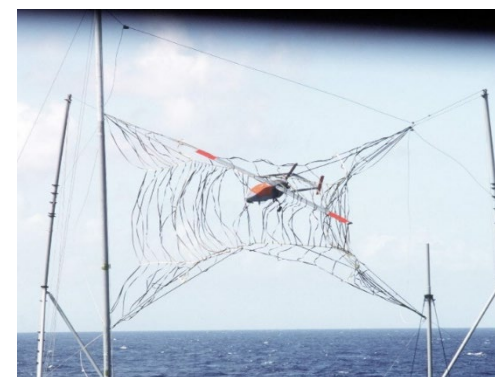
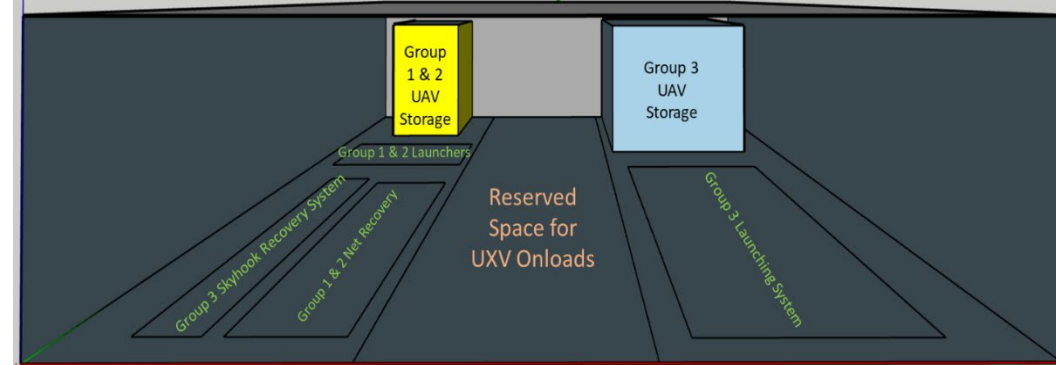


Flight Deck

Hangar

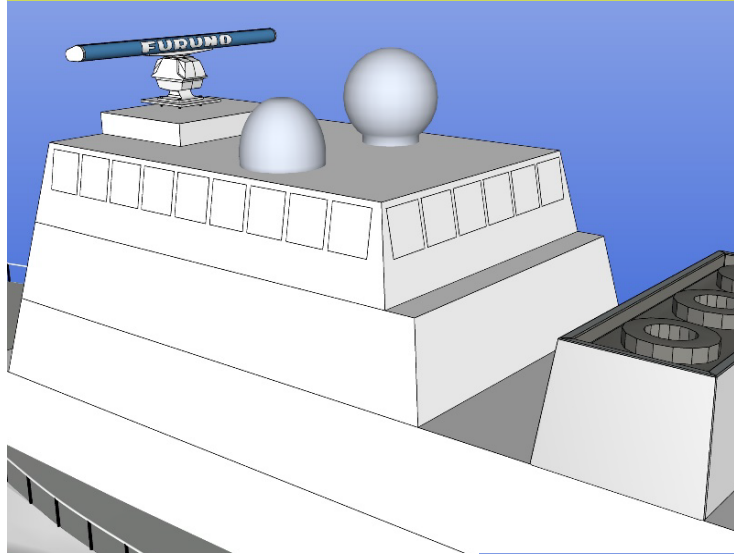


<u>UXV Type</u>	<u>Loadout</u>
Group 1/2 UAV	20
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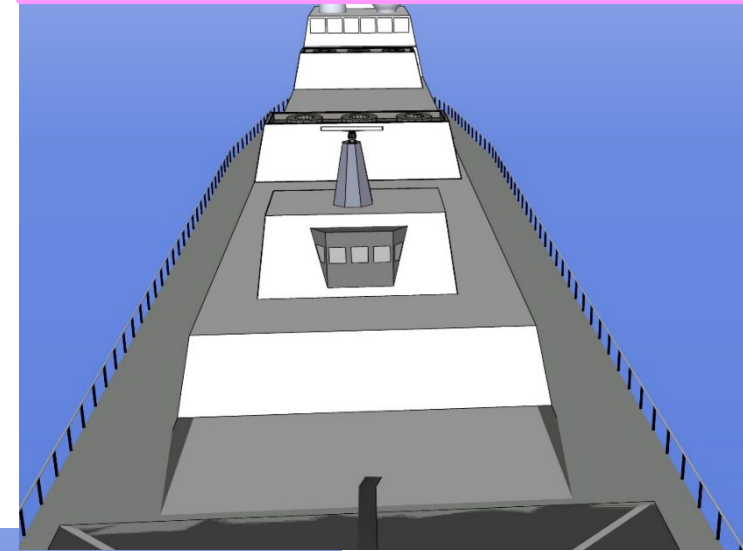


# Topside Arrangements

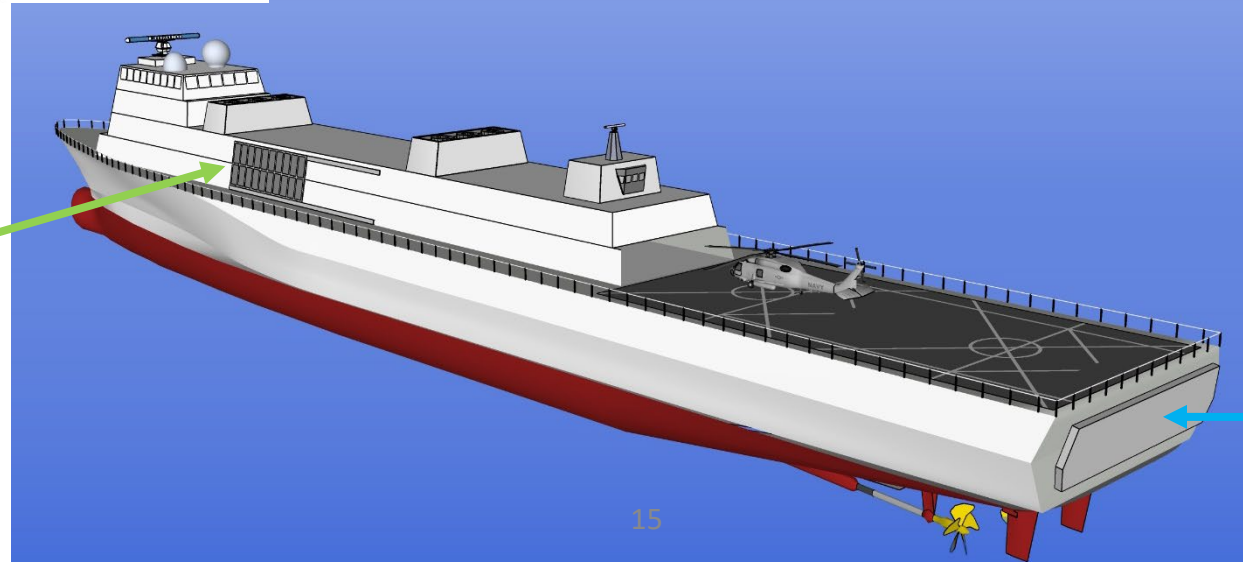
Bridge



Deckhouse



Side Launch

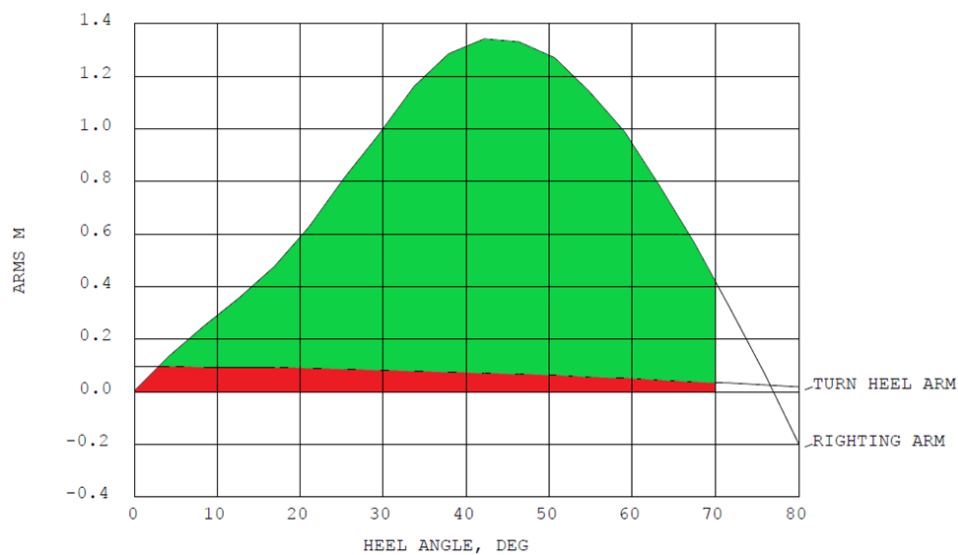
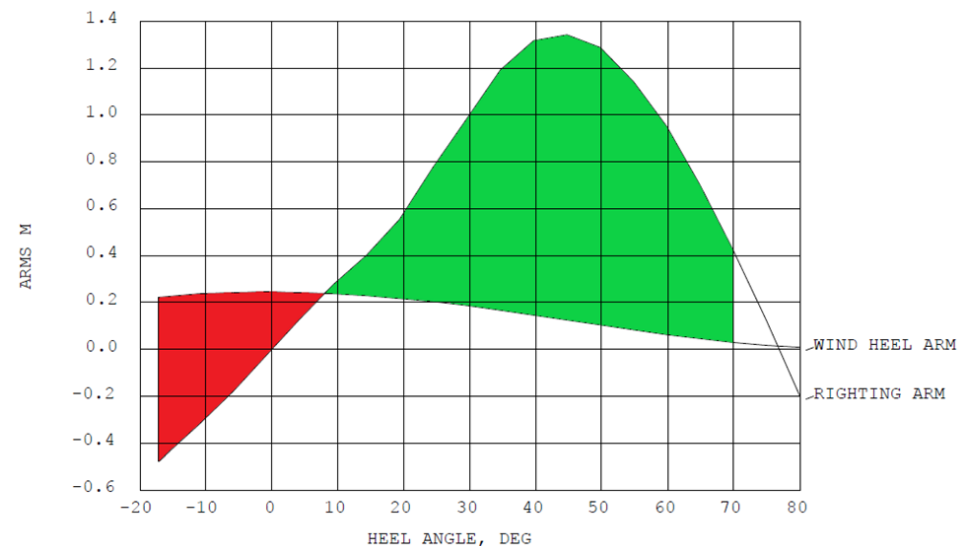
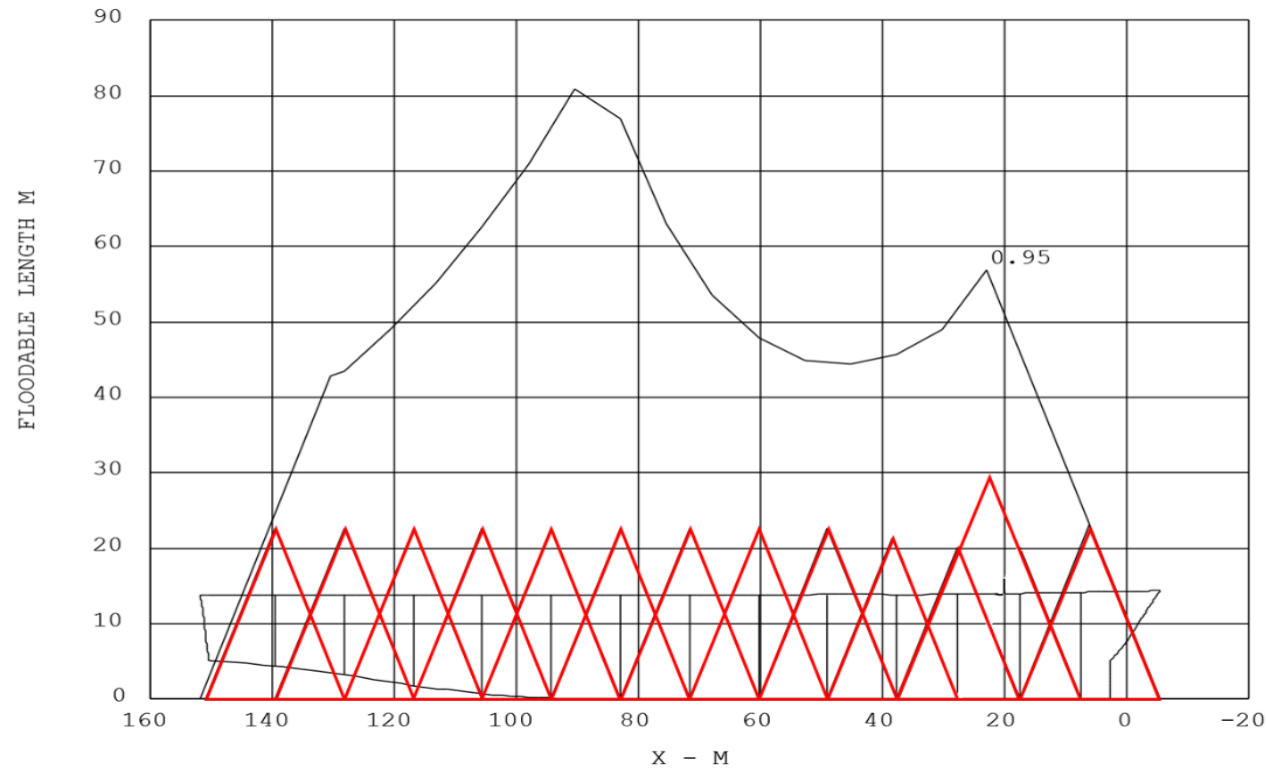
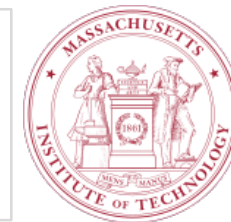


Stern Launch

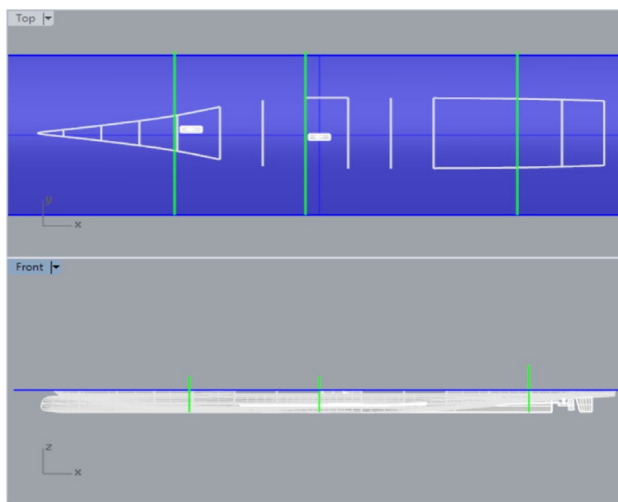
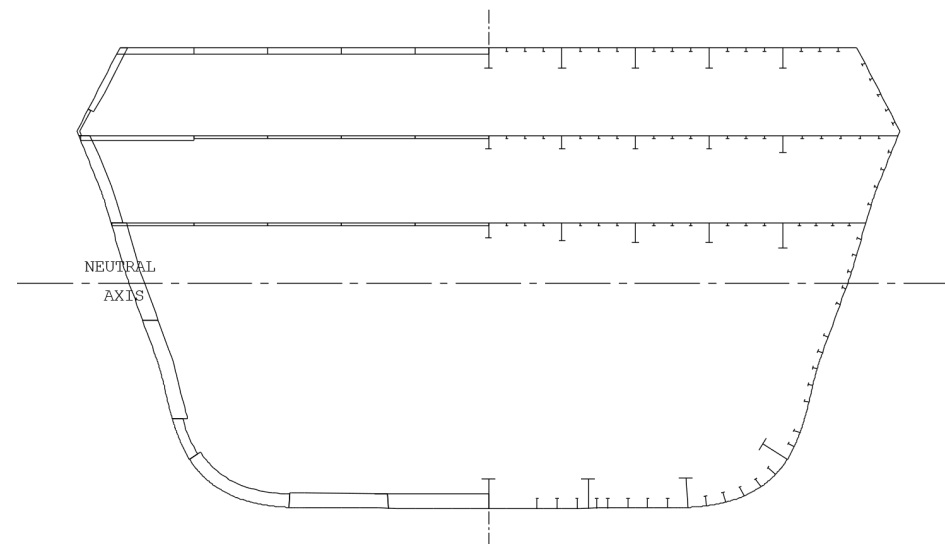
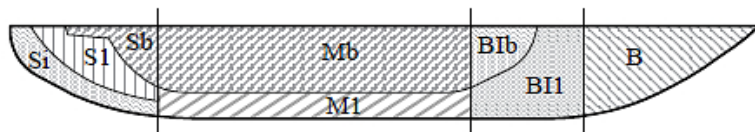
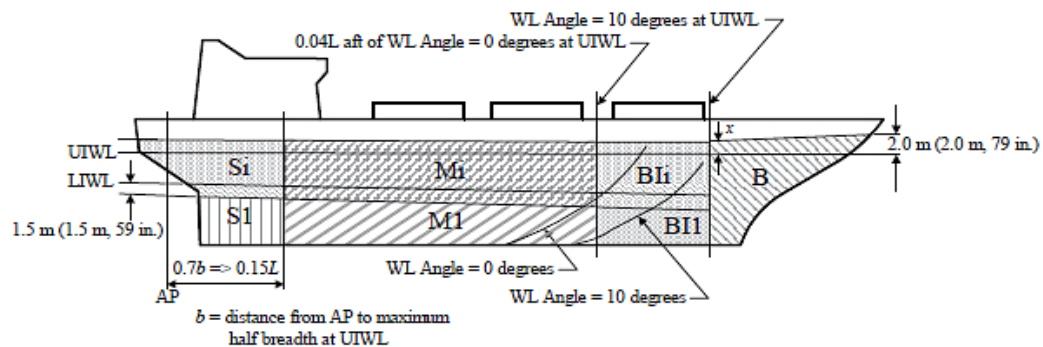




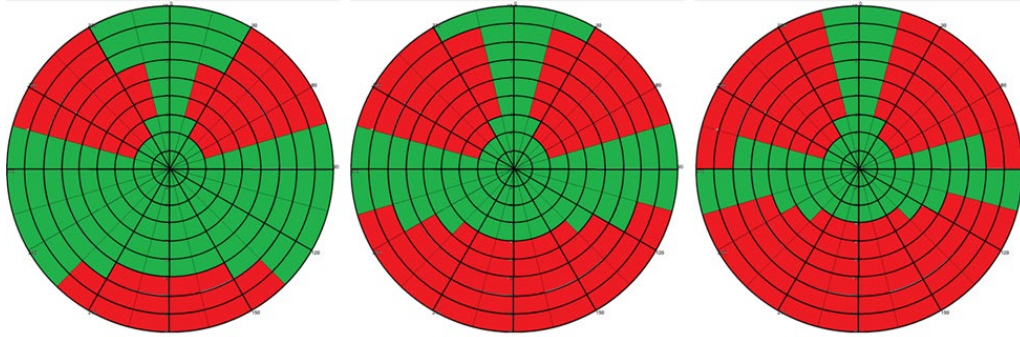
# Floodable Length and Stability







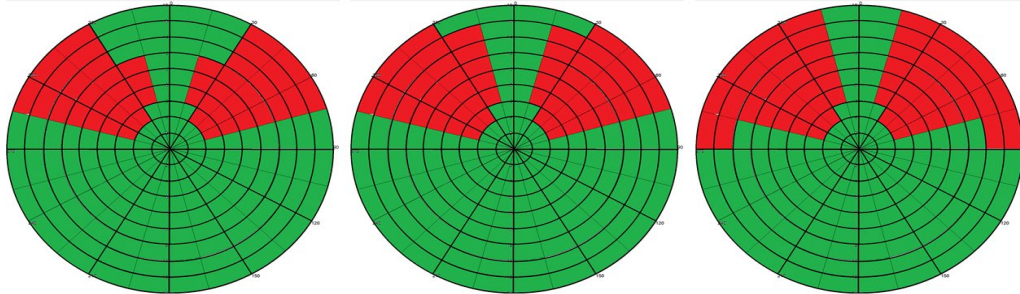
Hull Area	Required Shell Thickness (mm)		
	Mild Steel	HSLA 65	HY 80
Bow	24	19	17
Bow Intermediate - Icebelt	24	19	17
Bow Intermediate - Lower	25	19	17
Bow Intermediate - Bottom	19	15	14
Midbody - Icebelt	23	17	16
Midbody - Lower	17	13	12
Stern - Icebelt	22	16	15
Stern - Lower	17	13	12



Sea State 3

Sea State 4

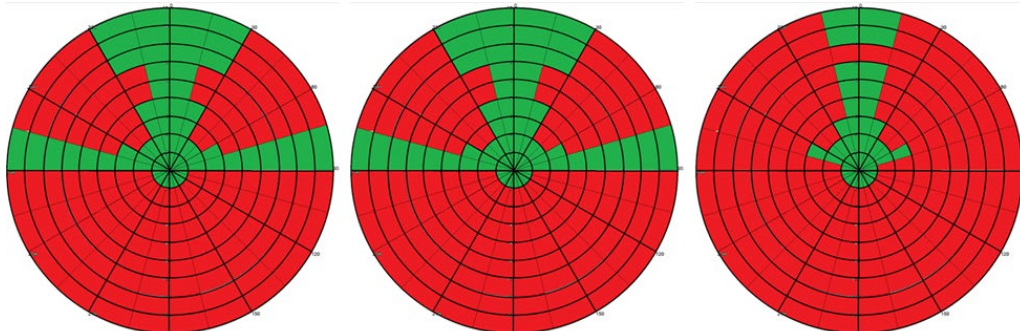
Sea State 5



Sea State 3

Sea State 4

Sea State 5



Sea State 3

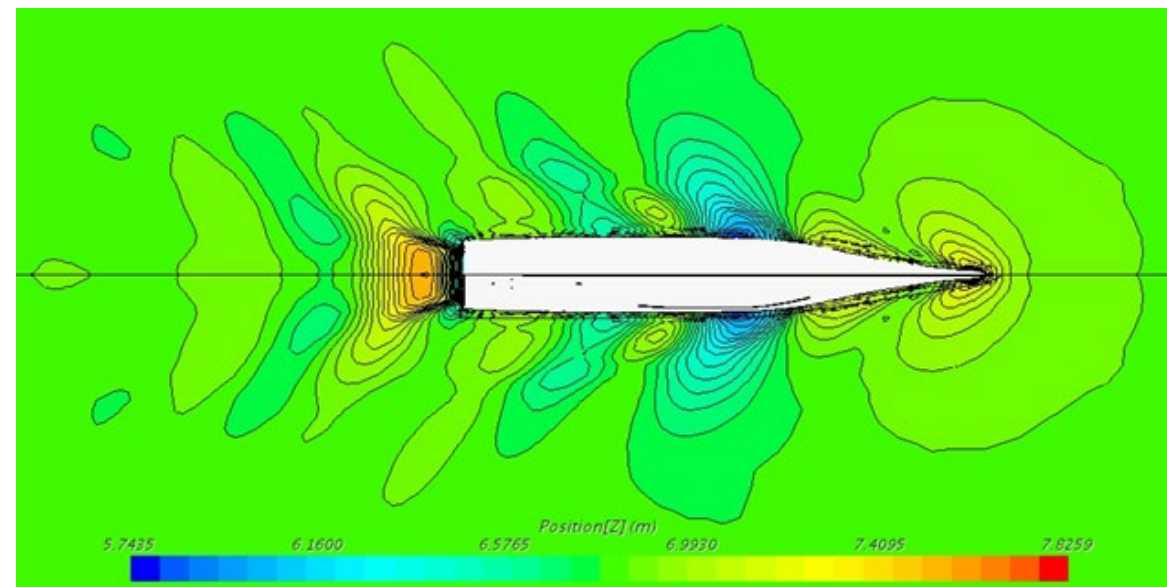
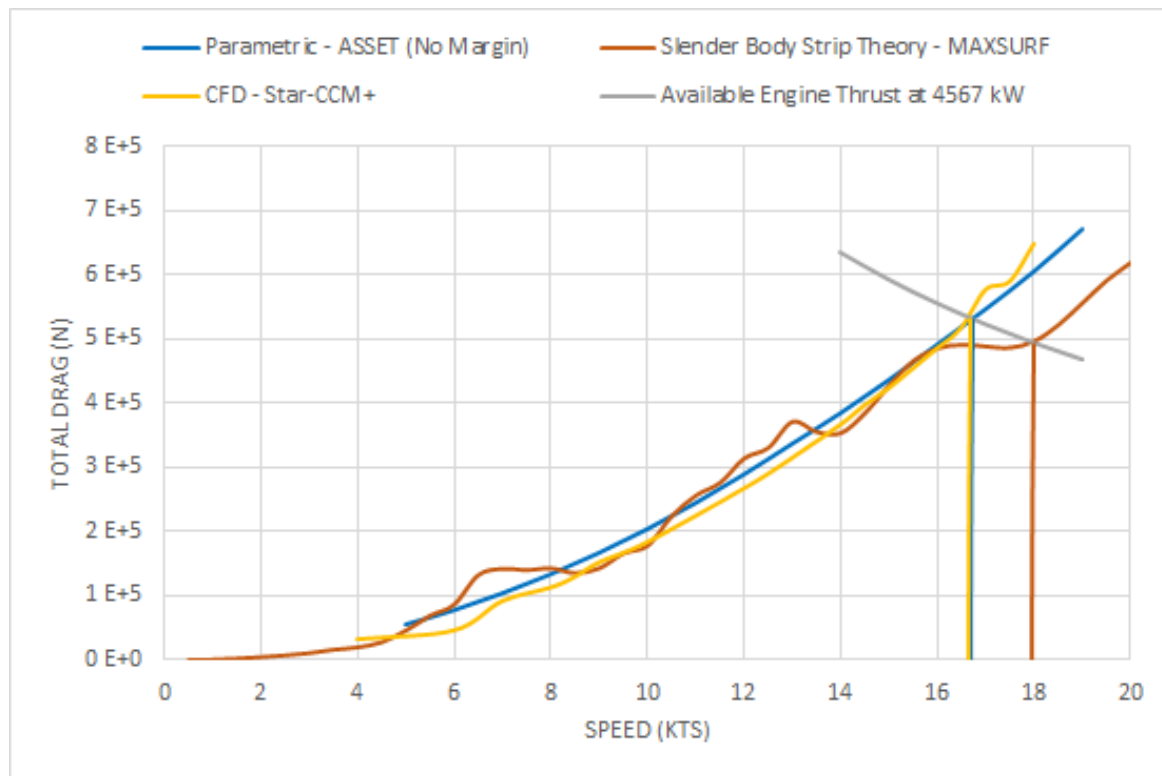
Sea State 4

Sea State 5

Transit and Patrol

Flight Operations

UUV/USV Operations



Method	Max Speed (kts)	Difference from CFD (%)
CFD	16.64	---
Slender Body Strip Theory	17.94	7.8%
Parametric ASSET Model	16.71	0.4%



# Cost

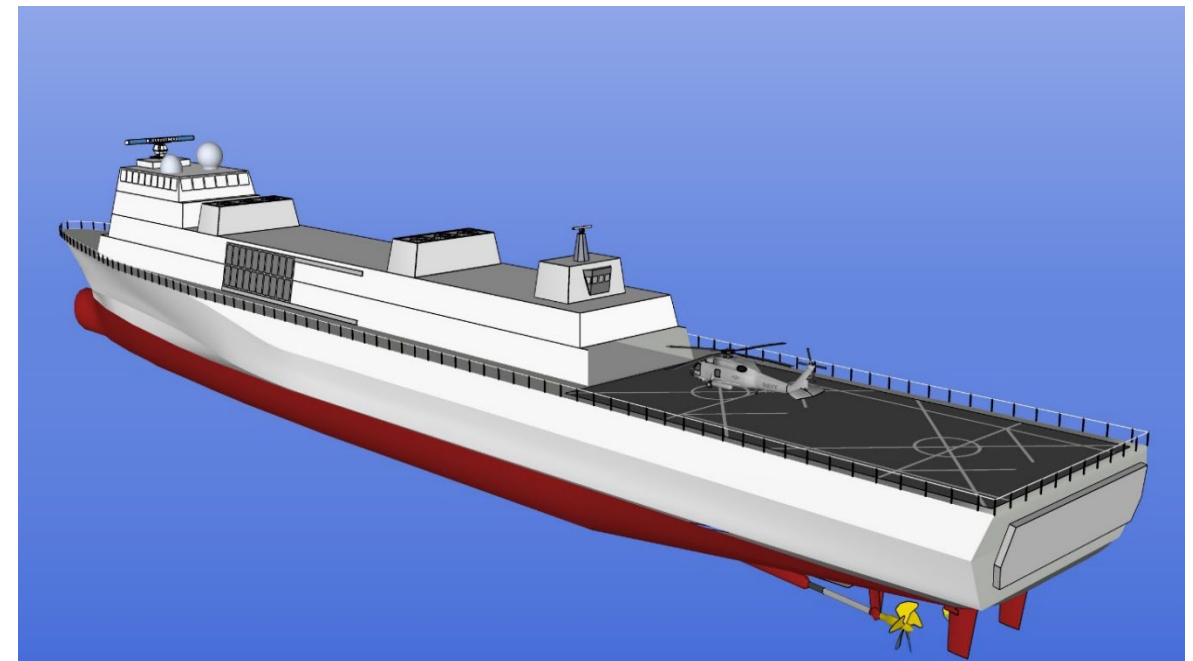


- MIT 2N Cost Model Estimations
- Weight-based model using SWBS group weights
- Class size of 4 ships

	<b>Cost (2020 Dollars)</b>
<b>Lead Ship</b>	\$1.83 Billion
<b>Average Follow-on Ship</b>	\$1.56 Billion
<b>Operating and Support Cost</b>	\$5.40 Billion
<b>Program Life Cycle Cost</b>	\$11.27 Billion

# Conclusions

Parameter	Description
Displacement (Full Load)	11439.9 MT
Length Between Perpendiculars	150.8 m
Beam	22.2 m
Draft (Full Load)	6.82 m
GM	2.12 m
Maximum Speed	16.26 kts
Endurance Speed	14.69 kts
Range	14,000 NM
Endurance	180 days
Propulsion	2 x Caterpillar 3608 IL8 Diesel Engines each producing 3390 bhp (2528 kW); coupled to two shafts, each driving a 3.35 m diameter propeller; Total: 6780 bhp (5056 kW)
Electrical	2 x Caterpillar 3608 IL8 Generators (2660 kW each)
Complement	35 Merchant Mariners including: <ul style="list-style-type: none"> <li>• 14 Officers</li> <li>• 4 CPOs</li> <li>• 17 Enlisted</li> </ul> 20 Navy Sailors including: <ul style="list-style-type: none"> <li>• 2 Officers</li> <li>• 18 Enlisted</li> </ul>
Armament	40 x Small UUV 40 x Medium UUV 6 x Large UUV 2 x Very Small USV 2 x Small USV – 2 20 x Group 1/2 UAV 3 x Group 3 UAV Small Arms for Self Defense
Aviation Facilities	810 m <sup>2</sup> Flight Deck (VERTREP Capable) 425 m <sup>2</sup> Hanger





# Areas for Further Study



- Hullform
- Detailed Arrangements
- Arctic Impact on Equipment and Systems
- Cost

# Questions





# Design Philosophy



*The team aims to deliver a design that is achievable, practical and affordable to the U.S. Navy so that the capability gap in the ever-changing Arctic Region can be addressed by a single platform.*

- The YETI will provide for changes in UXV capabilities by providing ample margin for weight, space, and power to accommodate future vehicles.
- Maintaining flexibility and simplicity in the design process will allow the YETI to adapt to these ever-changing needs while remaining cost efficient in the long run.
- The final variant will prioritize the options that meet the sponsor requirements and provide a solution to the capability gap through the mid 21<sup>st</sup> century.



YETI

