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Consulting Engineers Serving the Marine Community

Next Generation Research Vessel:
Balancing Performance with Zero Footprint Objectives

Presentation to: UNOLS 2012, Greening the Research Fleet
10 January 2012

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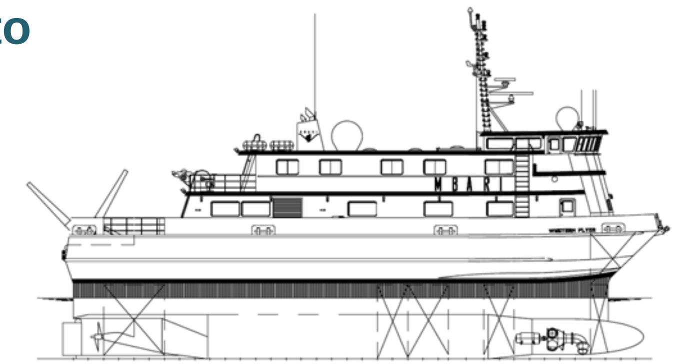
Introduction and Design Requirements

- Develop a highly capable, low environmental impact research vessel to replace the R/V *Western Flyer*
- Design and evaluate 4 concept using 3 hulls
- Specialized for ROV and AUV, while supporting general science missions
- Employ innovative methods and technologies to improve capabilities
- Maximize use of “green” features without compromising performance, reliability, availability, and maintainability
- Select “green” features that lead to operational cost reductions, reduced air emissions, and effluent discharges
- Provide an enjoyable working and living environment

R/V *Western Flyer*: Images courtesy of MBARI



R/V *Western Flyer*: Outboard Profile

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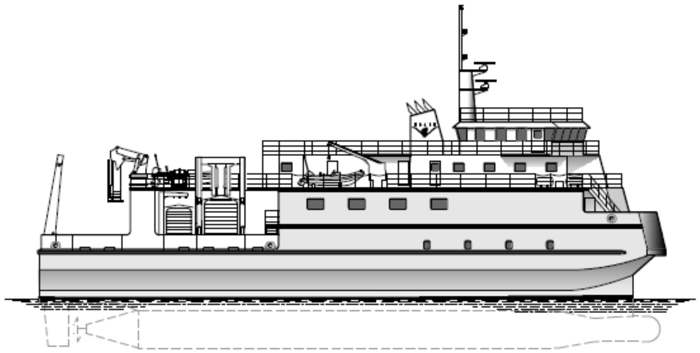
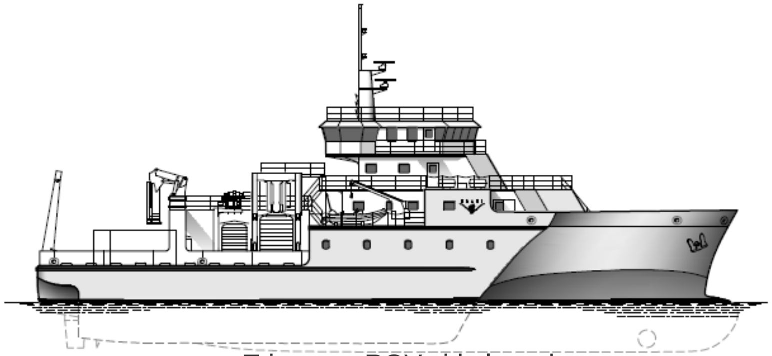
Concept Designs

- **Three hulls and four concept designs: SWATH, trimaran, and monohull**
- **Integrate "green" features to each concept**
- **Evaluate environmental performance**
- **Perform comparative seakeeping analysis**
- **R/V *Western Flyer* used as a baseline for comparison**
- **Review overall performance, cost and risk**

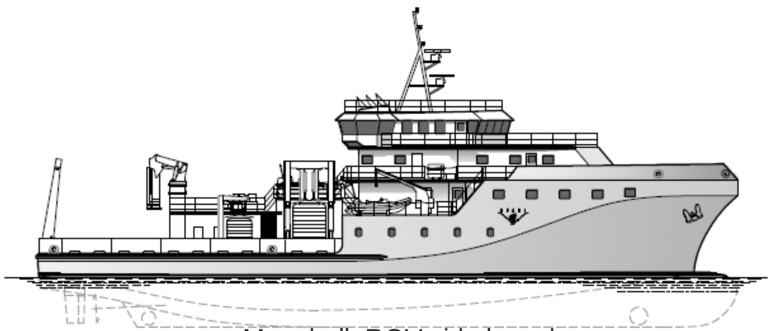
Vessel Designs Requirements	
Length overall max	170 ft
Beam maximum	56 ft
Draft maximum	12 ft
Range	4,000 nm
Endurance	21 days
Calm water speed	12 kts
Crew accommodations	11 total, maximize singles
Science accommodations	18 to 20 total, min 1 single



SWATH: ROV side launch shown, moon pool not shown

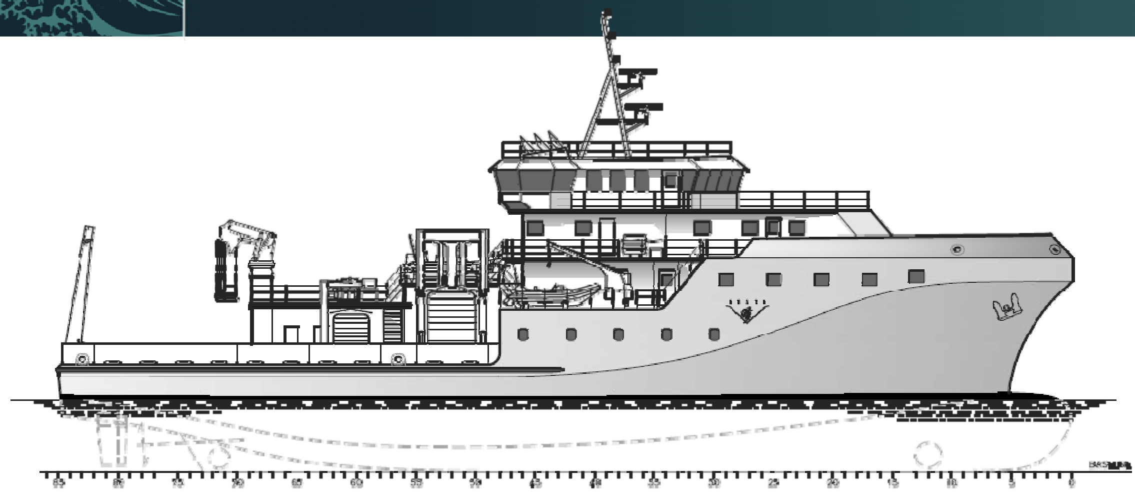


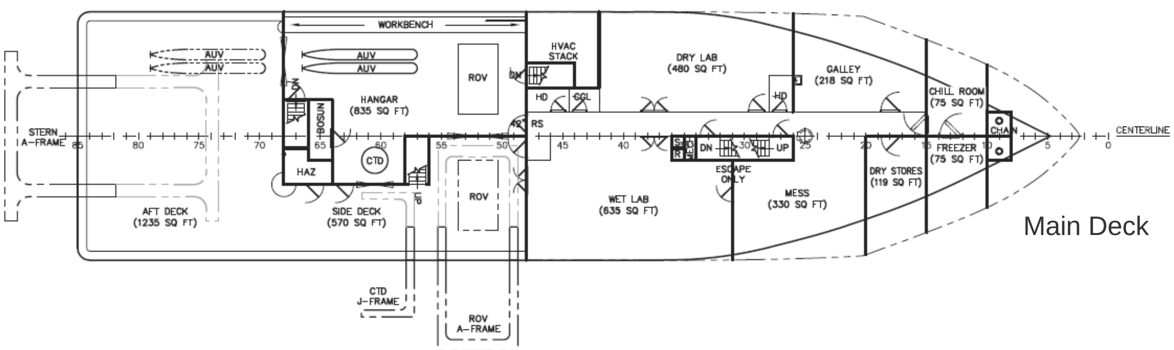
Trimaran: ROV side launch



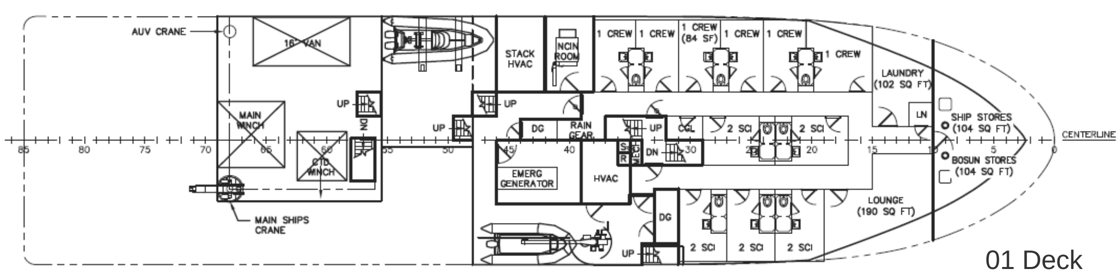
Monohull: ROV side launch

Selected Design Overview





Main Deck



01 Deck

Monohull:

- Highest deadweight capacity = greatest flexibility
- Lowest installed power
- Lowest environmental footprint
- Best seakeeping
- Lowest capital and lifecycle cost
- Lowest overall risk

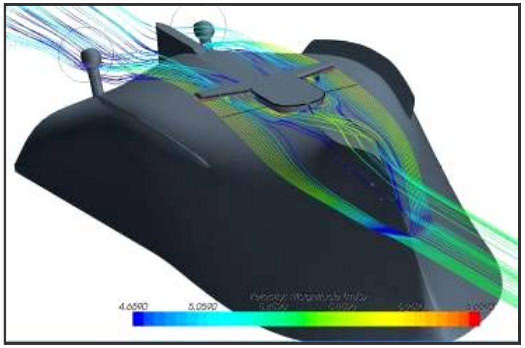
Environmental Footprint

Green Options

- Kite propulsion: reduce fuel on windy transits
- Emissions after-treatment: reduce NOx, HC, and PM
- Photovoltaic array: electricity generation to save fuel
- Battery hybrid: reduce installed power and air pollution, permit emissions after-treatment, and "plug-in" capability
- Water management: eliminate invasive species, fresh water recycling
- Waste heat recovery: produce potable water and generate electricity
- Hull optimization: reduce resistance and save fuel

Images courtesy of SkySails GmbH

- Other green options could be included but analysis focused on differentials between concepts
- LNG not found to be a viable option for research vessels at this time

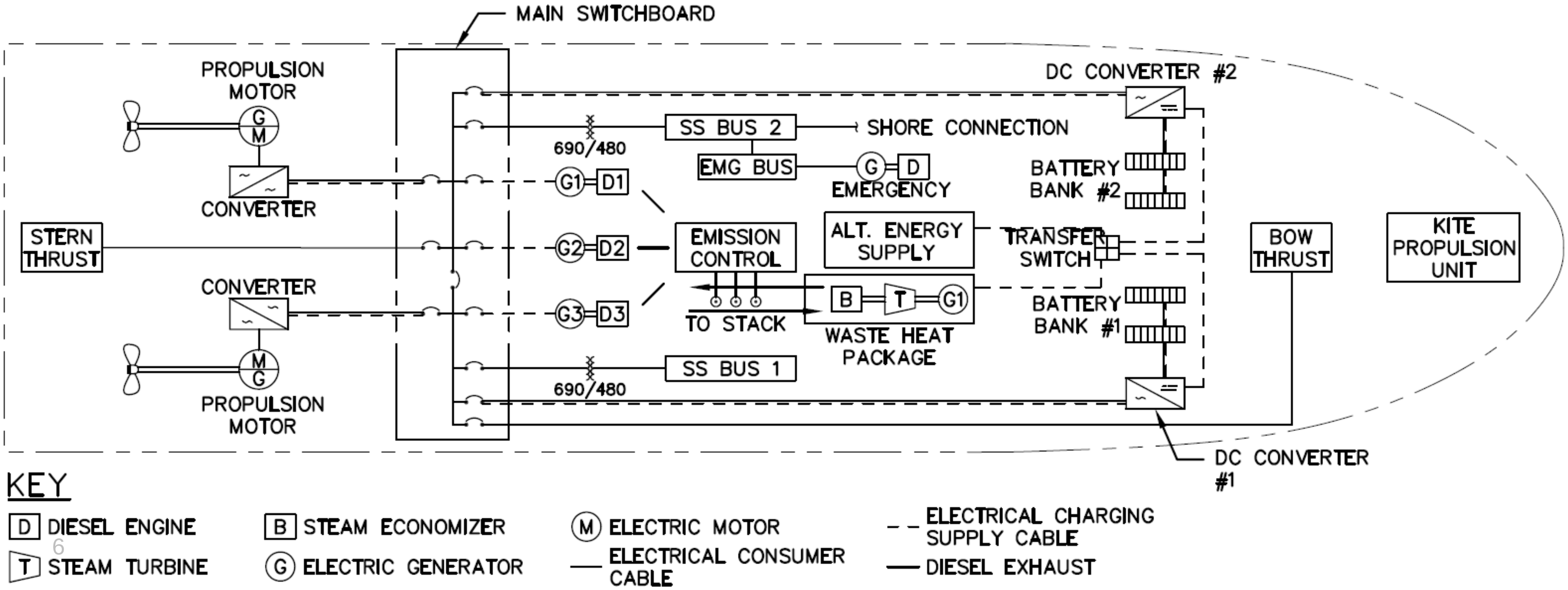


CFD optimization of hull with sonar fairing

Battery Hybrid

Battery hybrid system critical to reducing emissions

- Engines run at optimal load producing constant temperature exhaust and waste heat
- Shore power, PV panels, onboard generators, or alternative power source can charge batteries
- "Quiet" running for up to 8 hours
- Cost-benefit sensitive to operating days per year and fuel cost



Air Emissions

Exceeds EPA Tier 4 emissions standards

CO_2 emissions are largely a function of vessel resistance and chosen transit speed

Monohull has 30 times less air pollution than *Western Flyer**

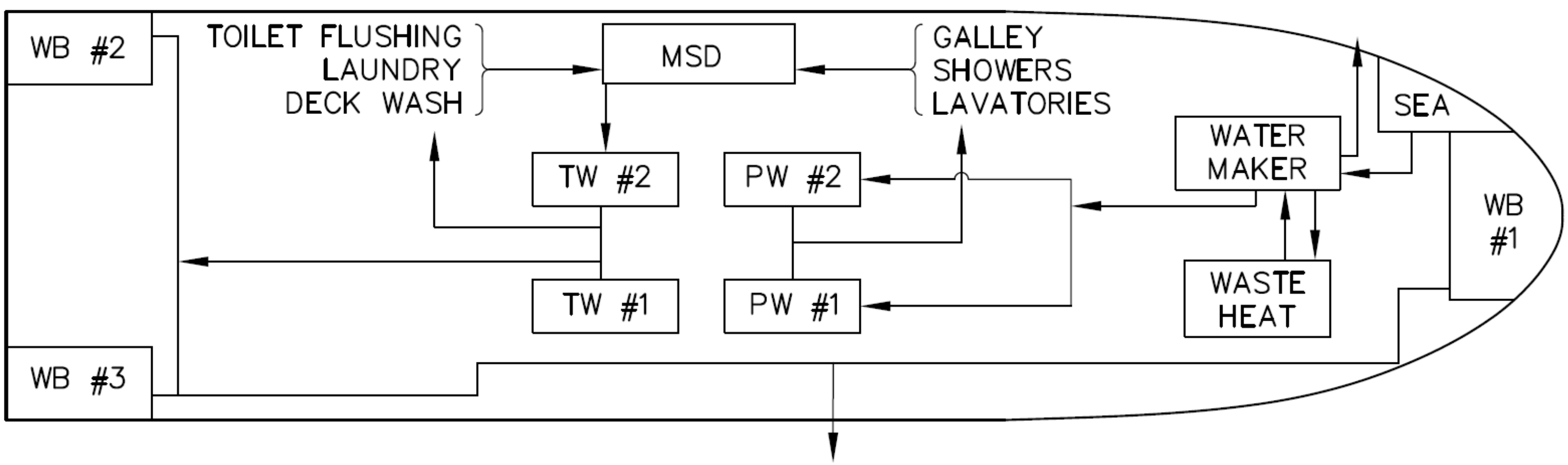
Air Pollution Emissions (Carl Moyer Program) for 15 Year Lifecycle				
	SWATH	Monohull	Trimaran	R/V Western Flyer
Baseline (LT/yr)	16.3	11.2	11.9	42.6
w/ Green Options (LT/yr)	2.4	1.3	1.4	N/A
Green Option Cost ($/lb)	2.5	4.8	4.7	N/A

* R/V Western Flyer is considered a modern research vessel with EPA Tier 1 engines

Water Emissions

Integrated water and effluent management system

- Fresh water generated by engine jacket water waste heat
- Biological MSD as currently being outfitted on R/V *Sikuliaq*
  - Discharge water (*Technical Water*) exceeds standards for reuse
  - Water recycling for toilet flushing, laundry and deck washing
  - Surplus *Technical Water* used as ballast water
- Lower cost compared to convention system
- Eliminates ballast water transfer of aquatic invasive species
- Reduces hull corrosion
- Zero water emissions target met



Cost / Benefit Analysis of Options

1. Does the initiative pay for itself through fuel or maintenance savings?

2. What is the cost per ton of carbon reduced over a 15 year life-cycle?

3. What is the cost per ton of air pollutants reduced over a 15 year life-cycle?

Cost / Benefit for Monohull

Different Methods to Evaluate Cost / Benefit

Green Options Cost-Benefit (Monohull for 15 Years)						
Green Option[1]	Lifecycle Cost[2]	Breakeven Point	Carbon		Air Quality[3]	
	($k)	(yrs)	LT/yr	$/LT	.T/yr	$/lb
Baseline Vessel (EPA Tier 3)	11,883	N/A	1093	N/A	11.21	N/A
SCR/DPF/DOC	844	No Fuel Savings	Nuetral	N/A	-9.5	2.6
Sail	299	21.6	-85	236	-0.87	10.3
Battery Hybrid	412	18.5	-165	166	-1.69	7.2
Solar (Photovoltaics)	32	34.1	-1.9	1,137	-0.02	49.5

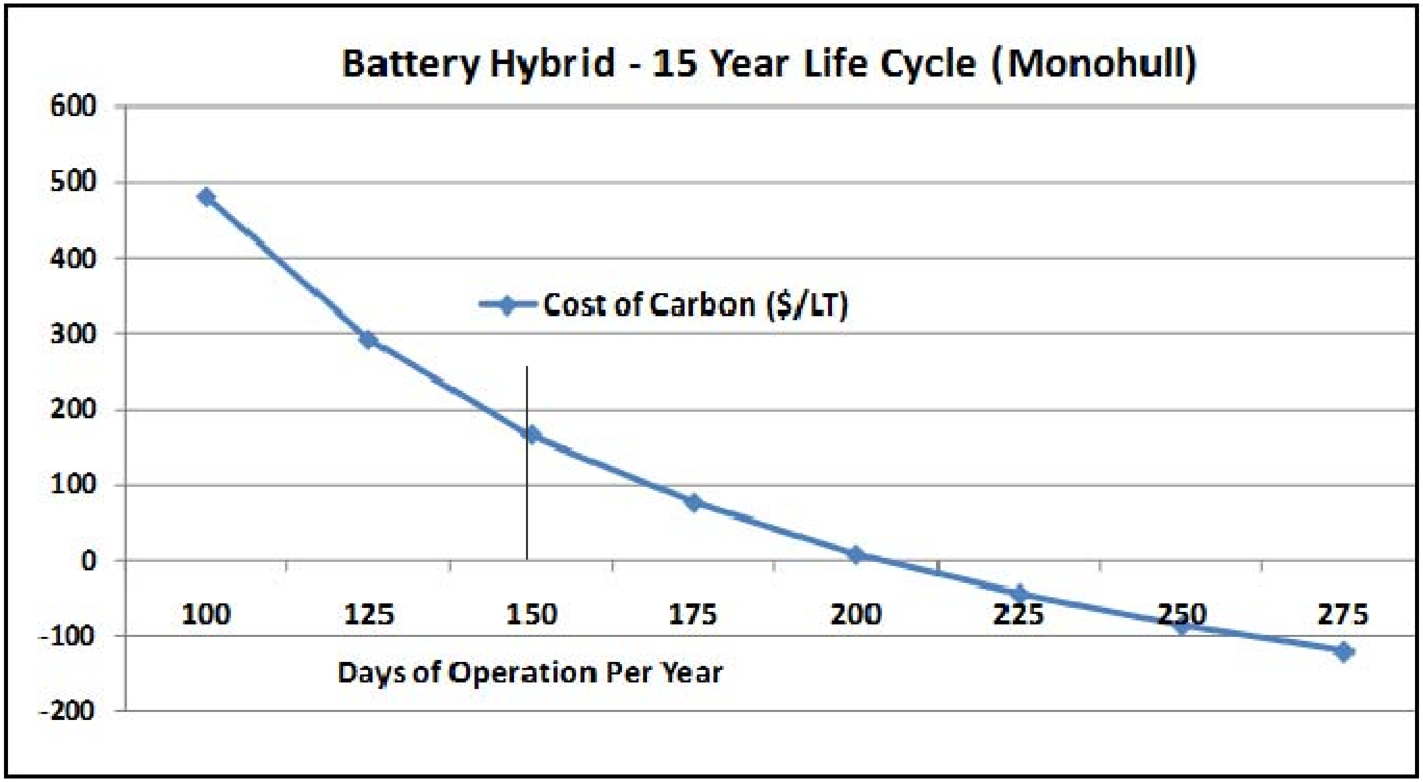
Notes:
1. LT/yr savings computed for single green option applied to baseline vessel
2. Assumes 5% annual fuel cost increases
3. Uses Carl Moyer Formula = 20PM+HC+Nox

Carbon - $/LT is the cost of carbon required to reach breakeven point in 15 years

Air Quality - $8/lb considered by CARB to be eligible for grant funding

Cost / Benefit

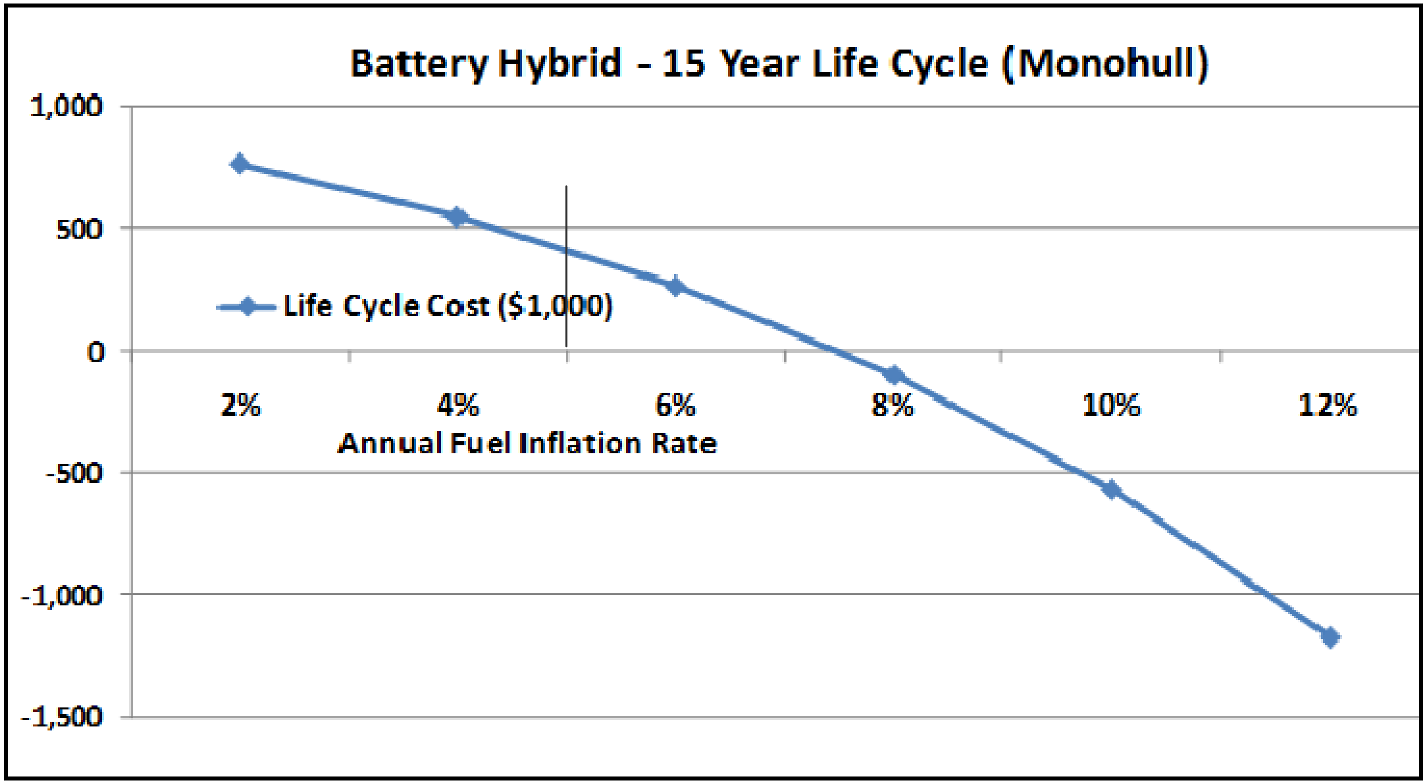
Impact of Number of Operating Days



Analysis for 150 Days per year

Cost / Benefit

Impact of Fuel Inflation Rate



Analysis for 5% inflation per year

Conclusions

- Highly capable vessel with zero water emissions and drastically reduced air emissions is achievable today
- Battery hybrid system can be a cornerstone to emissions reductions
- For items with no direct payback, need to determine a method of valuation in order to effective evaluate options
- Cost/Benefit analysis is highly dependent on days in use and cost of fuel

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Thank You!

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