Designing and Building Center Console Boats – A Case Study

CORY WOOD, VICE PRESIDENT GREG BEERS, P.E., PRESIDENT

BRISTOL HARBOR GROUP, INC. THE SHEARER GROUP, INC.

SNAME NEW ENGLAND SECTION 29 JANUARY 2020

Bristol Harbor Group, Inc.

- Started by four friends in 1993 while still in college.
- Became self sufficient (read self employed) in 1997.







Bristol Harbor Group, Inc. cont.

- Design everything from 18' fiberglass power boats to 400' long oil tankers.
- Currently employ twelve naval architects and support staff.
- In 2005, partners looked into all manner of business opportunities for diversification from naval architectural services...Bristol Harbor Boats was born.



First Decisions

- What type of boats to build?
- What style to build?
- What size to build?
- How much money are we going to need?

designed Soult in Bristol Fashion

The classic shear of the Bristol Harbor 21 will stir your soul. Below the waterline, the deep forefoot develops into a 17-degree deadrise at the transom, providing a smooth, dry ride. The efficient hull design of the Bristol Harbor 21 will easily achieve 40 mph with a 150 hp engine, minimizing fuel consumption and maximizing time on the water.





DEALERSHIPS: B.L.M. Yacht Sales Enos Marine Pine Island Marina Scandia Yacht Sales All Seasons Marine Works POWERED BY



Always wear a personal floatation device while boating and read your owner's manual.

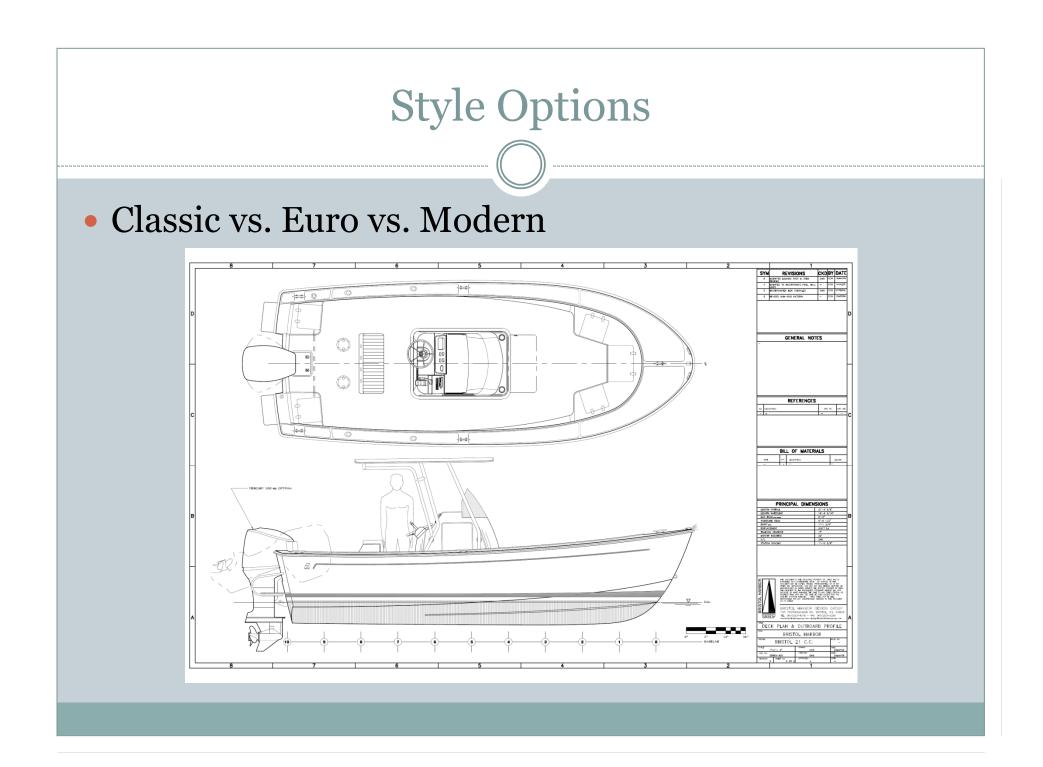
Market Analysis

- Determine total number of boats built in the U.S.
- Determine breakdown of the above.
- Determine what size we wanted to start with.

1980	UTBOARD	INBOARD	STERNDRIVE	JET	PERSONAL				INFLATABLE		ALL	BOAT	OUTBOARD	STERNOR & INBOA
	BOATS	BOATS	BOATS	BOATS	WATERCRAFT	SAILBOATS'	CANOES	KAYAKS"	BOATS-	SALBOARDS	BOATS'	TRAILERS	ENGINES	ENGINE
1901	290,000	8,200	56,000	_	_	73,100	105,000		16,400	21,000	569,700	176,000	315,000	87,75
1982 3	281,000 236.000	8,400 8,325	51,000	_	_	77,100 53,400	126,000	_	20,000 18,800	31,000 27.000	594,500 499.525	190,000 160,000	318,000 293,000	81,50
	236,000	8,325	79,000	_	_	43,740	107,000		23,600	33.000	499,525	184,000	293,000	104,12
	317,000	15,280	108,000	_		40,750	103,000		30,700	43,000	657,730	200,000	411,000	148.00
	305,000	16,700	115,000		_	37,800	78,800	_	33,500	50,000	636,800	192,000	392,000	155.00
	314,000	18,000	120,000			37,200	80,200		30,600	60.000	660.000	194,000	410.000	161,90
	342,000	19,700	144,000	_		33,500	85,300		30,000	70,000	724,700	216,000	444,000	210,80
	355.000	20,900	148.000	_	_	14,500	89,800	_	32,200	65.000	725,400	223,000	460.000	211,90
	291.000	21,400	133.000	_	_	11,400	80,100		29,800	55.000	621,700	209.000	430.000	190.70
	227,000	15.000	97,000	_	_	11,800	75.300	_	26.600	42.000	494,700	165.000	352,000	134,10
	195.000	9.800	73.000	_	68.000	8,700	72,300	_	21,200	41,000	448.000	133,000	289.000	92,40
	192,000	9.950	75,000	_	79.000	10,600	78.000	_	22,200	_	466.750	147,000	272.000	94.60
	205.000	10,175	75,000	_	107,000	11,900	89,700	_		_	498,775	163,000	283.000	94,70
	220.000	11,400	90.000	_	142,000	13.000	99.800	_	_	_	576.200	176.000	308.000	114.00
	231,000	12,360	93,600	14,700	200,000	14,300	97,800	_	_	_	663,760	207.000	317,000	120.00
	215,000	11,350	94,500	14,100	191,000	15,900	92,900	_		_	634,750	194,000	308.000	120.00
	200.000	12,400	78.800	11,700	176,000	10,500	103.600	_	_	_	593.000	181,000	302.000	116.10
	213,700	17.600	77,700	10,100	130,000	14.500	107,800			_	571,400	174,000	314,000	104.50
	230,200	19,100	79,600	7,800	106,000	18,850	121,000				582,550	168,000	331,900	108.50
	241,200	23,900	78.400	7.000	92.000	22.500	111,800				576.800	158.500	348,700	110.40
	217,800	21,900	72.000	6,200	80,900	18.600	105,800	357,100			880.300	135,900	299.000	103.70
	212,000	22,300	69,300	5,100	79,300	15,800	100,000	340,300			844,100	141,200	302,100	105,00
	207,100	19,200	69.200	5.600	80,600	15,000	86,700	324,000	30,500		837,900	130.600	305,400	99.00
	216,600	20,200	71,100	5.600	79.500	14,300	93,900	337,300	31,600		870,100	133.400	315.300	103.80
2005	213,300	20.400	72,300	6.700	80,200	14,400	77,200	349,400	30,100	_	864,000	134,100	312,000	104.40
2006 3	204,200	20,000	67,700	6,200	82,200	12,900	99,900	393,400	25,100	_	911,600	130,900	301,700	97.90
2007	188,700	18,200	60,400	6.800	79,900	11,800	99,600	346,600	29,400		841,400	126,200	275,500	90.40
2008	151,400	13,100	38,500	4,900	62,600	9,300	73,700	322,700	28,300		704,500	92,400	227,000	57,70
2009	117,500	9.500	26.550	3.550	44,500	5.400	89.600	254,000	21,700	_	572,300	56,900	180,700	40.60
"Saiboats "Kayak ca "Tinfutabi	category adds	ed in 2001. added back	Company's Annu to the category in		ines Review									

3.2 Annual retail unit sales estimates

572 300 new boats were sold in 2009; kavaks led unit sales followed by outboard boats



It's the Supply Chain Stupid

- The concept for Bristol Harbor Boats was developed around an innovative supply chain.
- Rhode Island company, but only do in the State that which makes SENSE to do in Little Rhody:
 - o Design
 - Market
 - Assemble
 - o Rig
- FRP (fiberglass) work done by a third party.
- Innovative supply chain, boat parts fit INSIDE standard 53' trailers (one of which is the hull itself).
- Parts are offloaded and assembled in our final assembly facility in Bristol, Rhode Island.

Initial Dealer Network

• Sales are the most important task.

start.

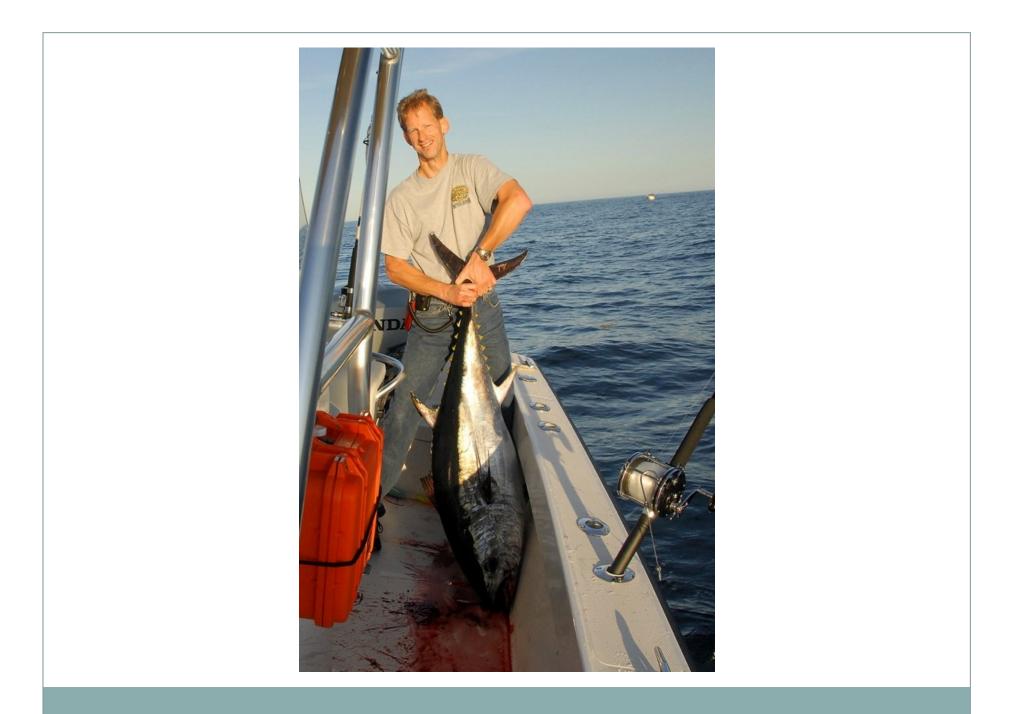
• Maximize regional coverage to provide a running

 Image: Sector of the sector

Design Elements

- K.I.S.S.
- Family Fun
- Minimal Maintenance





Hull

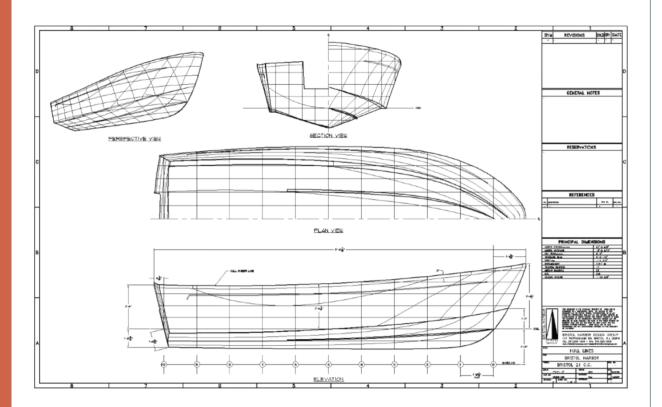
Bristol Harbor Group, Inc. employed its years of experience to design the modified deep-vee hull.

Modified deep-vee hull, 17° dead rise at transom, 21° amidship.

Hard chine

Deep forefoot

High gunnels



Laminate Schedule

Hull: solid E glass

Transom: 2" high density foam core

Deck / Sole: E glass with Spherecore

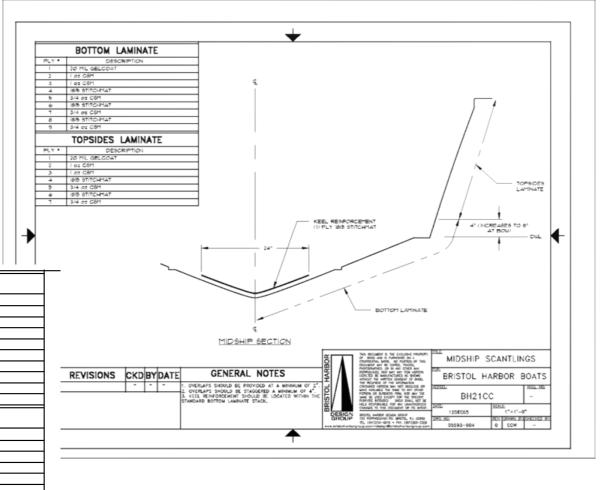
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	BOTTOM LAMINATE
PLY *	DESCRIPTION
1	20 MIL GELCOAT
2	I oz CSM
3	I oz CSM
4	IBI5 STITCHMAT
ъ	3/4 oz C6M
6	IBI5 STITCHMAT
7	3/4 oz CSM
8	IBI5 STITCHMAT
9	3/4 oz CSM
	TOPSIDES LAMINATE
PLY *	DESCRIPTION
1	20 MIL GELCOAT
2	l oz CSM
3	I oz CSM
4	IBIB STITCHMAT
5	3/4 oz CSM

1815 STITCHMAT

3/4 oz CSM



Weight Estimate

Tedious

Brute force effort

Often most junior task

However, it has to float!

Very important for EVERY design

Margin, margin, margin

This one came out within several pounds, which was luck (best +/-2%), nonetheless, we took this as a good omen.

Ounct Brutol Harbor Boats Vessal Bruto 21 by COW Phinopair Characteristics	Revision	ght Analysis		Date		17-Mar-1	1					
Versal By COW Bustol 21 COW Principal Characteristics Displacement (at DWL) LWL 3,816 fbs 1687 ft 860 ft WP Avas 643 ag tt 1687 ft 1068	 New Property 	В										
Versal By COW Bustol 21 COW Principal Characteristics Displacement (at DWL) LWL 3,816 fbs 1687 ft 860 ft WP Avas 643 ag tt 1687 ft 1068	Project Number	05593										
By COW Performant (stDWL) 2.45 mm mm (stDWL) 4.60 mm	Client	Bristol Harbor Boats										
Victorial Characteristics Displacement (stDWL) 3,816 fbs LWL 186 7 ft DWL 600 ft WV Avas 643 s g1 ft LOB 111 38 ft 60 0 %L LOF 110 8 ft 59 3%L TransRMDag 201 ft bs 59 3%L PPI 506 Ibulin Floateston Calculations with Half Tankage Poil -0.63 in (+ = up) Trans (LCE) LCO) x 0 top Long/MOleg -0.69 deg (+ - box down) - (LWL x 12) x sin/tim/deg/57 298()) -2.71 in (+ - box down) - (LWL x 12) x sin/tim/deg/57 298() -2.71 in (+ - box down) - (LWL x 12) x sin/tim/deg/57 298() -2.71 in (+ - box down) - (LWL x 12) x sin/tim/deg/57 298() -2.71 in (+ - box down) - 2.00 ft down Stop down -2.80 ft down 0.80 ft down 2.01 ft down Stop down -2.71 in (+ - box down)	Vessel	Bristol 21										
Displacement (st DWL) 3,816 lbs LWL 18.67 ft BWL 600 ft WP Area 6403 sq ft LOB 11.38 ft 60.0% LOB 11.38 ft 60.0% LOB 11.38 ft 60.0% LOF 11.08 ft 59.3% TransRADeg 2.173 ft lbs 59.7% LongRMDeg 2.173 ft lbs 59.6 bb./n PPI 506 bb./n (* - up) Trans (LCE - LCO) > 0.10p LongRMDeg -0.69 an (* - up) Trans (LCE - LCO) > 0.10p LongRMDeg -0.69 deg (* - box down) • (LWL s 12) a sur(thm(deg/57 208)) -2.71 in (* - box down) • (LCG measured as positive alt the origin. -2.001 10.600 0.83 1.046 0.00 0 2.020 ft destable 551 19.17 1.63.17 1.44 1.754 0.00 0 2.021 exatured as positive ab the origin. -2.001 9.00 1.64 -72 5.13 3.0 Mechanical 651 19.17 16.317 1.44 1.754 0.00 0 3.0 Mechanical 651 19.17 1.63.17 1.44 59 0.00 0 3.0 Mechanical 508 61 <t< th=""><th>By</th><th>CCW</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></t<>	By	CCW										
LVL 18.47 ft BVL 660 ft WP Aea 64.03 s.q.ft LCB 11.38 ft 60.01% LCF 11.08 ft 50.9% TransPM/Deg 301 ft bis 50.9% LOF 11.08 ft 50.9% TransPM/Deg 2.173 ft bis 90.0000 PPI 506 bbs/m 50.0000 Floatation Calculations with Haif Tankage PRs = (Displacement - Wanghg / PPI -0.60 in (+ = up) Trans - (LCGL - LCG) × Displ Long/M/Deg -0.60 doarnj - - (LWL x 12) x sin/thm/deg/57 208() -271 in (+ = box doarnj * UCG measured as positive sibne DWL - - * UCG measured as positive sibne DWL - - * UCG measured as positive sibne DWL - - * UCG measured as positive sibne DWL - - * UCG measured as positive sibne DWL - - * Distinctial - 651 16.17 16.317 1.48 1.960 0.00 0 * 20	Principal Charac	teristics										
BVL W2 Area 64 05 k ct 44 03 k ct 11 08 t 64 05 k ct 40 0 %. LCB 11 38 t 60 0%. LCB 11 08 t 50 2%. TransPMDeg 301 t bs. LongPMDDeg 2.173 t bs. PPI 506 tbulin Focasion Calculations with Half Tankage Rel = (Displacement - Weighd / PPI - 0.63 in (+ = op) Trans (LCG) - LCO) x Displ LongPMDeg -0.69 deg - 0.02 i. LCO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. CO) x Displ LongPMDeg -0.69 deg - 0.02 i. C	Displaceme	erit (at DWL)			3,616	lbs.						
WP Area 04 63 sq.ft LOB 1138 ft 60 9% LOF 1138 ft 60 9% LOF 1108 ft 59 3% TransPMDbeg 201 ft fts 506 ibs/n PPI 506 ibs/n 506 ibs/n Foctation Calculations with Half Tankage Page - (Daplacement - Weeght / PPI -0.63 in (+ - upi) Timm - (LCB - LCG) x Disp/ LongRMDeg -0.69 deg (+ - bow down) - (LWL x 12) x ant/tim/(deg57 200) -271 in (+ - bow down) * UCG measured as positive above DWL -271 in (+ - bow down) * UCG measured as positive above DWL -200 fte-down) -0.63 in 1, 4, 4, 200 in * UCG measured as positive above DWL -200 fte-down) -200 fte-down) -200 in * UCG measured as positive above DWL -50 it 10.17 it 16,317 it 48 it 1,264 0.07 it 63 -0.00 it 1,200 it	LWL				18.67	ft.						
LCB 11.38 ft 60.9%. LCP 11.08 ft 59.3%. TrininRADeg 30.11 fbs. 59.3%. LongPMDDeg 2,173 ftbs. PPI Fostation Calculations with Half Tankage -0.63 in (+ - up) Frontation Calculations with Half Tankage -0.63 in (+ - up) Prime -0.69 in (+ - box down) - (LWL x 12) x sin(thm(dep57 208)) -2.71 in (+ - box down) - (LCG measured as positive aft the origin. -0.69 in (+ - box down) - UCG measured as positive aft the origin. -0.00 is 10.00 is 10.00 is 10.00 is 0.00 is 0.0					6.80	ft.						
LOF 11 08 h 59 3% TransRMDag 301 h bs Lorg/MMDag 22,173 h bs PPI 506 ibulin Floatation Calculations with Hall Tankage Res = (Displacement - Weight / PPI -0.63 in (+ = up) Trom = (LCE - LCG) is 0 top: Long/MMDag -0.64 dag (+ = box down) - (LWL x 12) x sin/tim/dag/57 298()) -2.71 in (+ = box down) * UCG measured as positive alt the origin -2.01 is 0.00 is 0.												
TransPMU0ag Long/MU0ag 2011 t bis 2.173 n bis 900 PPI 500 bbs/in Floatation Calculations with Hait Tankage Rise = (Displacement - Waighg / PPI Trm = (LGG - LGG) x Disp Long/MUDag = (LWL x 12) x sin(tim(deg57 208)) -0.93 in 2.09 disp disp 2.11 in (+ = box down) (+ - up) • LGG measured as positive alt the origin • (LWL x 12) x sin(tim(deg57 208)) -2.71 in 2.01 in (+ = box down) + - box down) • LGG measured as positive alt the origin • (LWL x 12) x sin(tim(deg57 208)) -2.71 in 2.01 in (+ = box down) +												
Long/RMDeg pPi 2:173 ft lbs 506 lbs/n Trm - (LCB - LCG) + Disp Long/RMDeg - 0.49 deg (+ - box down) - (LWL + 12) + sin(thm(deg/57 298)) -0.93 in (+ - up) - 0.49 deg (+ - box down) - 0.49 deg (+ - box down) • (LCG measured as positive alt the origin. -0.93 in (+ - up) - 0.49 deg (+ - box down) -0.93 in (+ - up) - 0.49 deg (+ - box down) • (LCG measured as positive alt the origin. -0.93 in (+ - up) - 0.49 deg (+ - box down) -0.93 in (+ - up) - 0.49 deg (+ - box down) • UCG measured as positive alt the origin. -0.93 in (+ - up) - 0.93 in (+ - box down) -0.93 in (+ - up) - 0.93 in (+ - box down) • UCG measured as positive alt the origin. - 0.93 in (+ - up) - 0.93 in (+ - box down) - 0.93 in (+ - up) - 0.93 in (+ - box down) • UCG measured as positive to STBO - 0.93 in (+ - up) - 0.93 in							59.31	6				
PPi 506 ibuin Focatation Calculations with Half Tankage Price = (Displacement - Weight / PPi Trm = (LCB - LCB) x Disp/LangPMDag = (LWL x12; x anrthem(dagS7 298i)) -0.93 in -0.69 dag -0.69 dag (+ - box doarrij -2.71 in (+ - box doarrij -2.72 in (+ - box doarrij -2.75												
Prostation Calculations with Half Tankage Pipe = (Displacement: Weight / PPI Trm = (LCB : LCG) x Displ LongRMDeg = (LWL x 12) x ar(thm(dig/5/2 200)) -0.93 in (x = up) -0.69 deg (x = bow down) * LCG measured as positive aft the origin. -0.67 deg (x = bow down) * UCG measured as positive aft the origin. * VCG measured as positive aft the origin. * UCG measured as positive aft the origin. * UCG measured as positive to STBO 20 Structural 2.001 9.30 16,600 0.63 1,665 0.00 0 3.0 Mechanical 651 1917 16,317 1.48 1,264 0.07 63 4.0 Electrical 651 1917 12 866 0.014 -7 2.25 113 5.0 Electronics 6 111.04 66 3.10 19 0.00 0 6.0 Auxiliary Systems 30 0.44 263 1.645 0.00 0 7.0 Deck Outriting 508 8.01 4.522 1.387 7,239 -0.21 -110 0.00 0 6.0 Finishes 29 9.55 272 1.47 42 0.00 0 Cappain 1 ex 175 175 6.07 5.100 2.275 4.00 700 0.00 0 Cappain 1 ex 175 175 6.07 5.101 2.43 5.427 0.04 175 Hait Load Condition 4.347 11.87 5.1016 1.24 5.322 0.04 175		ng										
Rise - (Displacement - Waight / PPi Trm - (LCB - LC0) a Disp Lang/MDeg - (LWL x 12) x sur(trm(dep5/2 208)) -0.69 in (+ - up) -0.69 deg (+ - box down) * LCG measured as positive aft the origin. * VCG measured as positive at the origin. * VCG measured as positive above DWL. * TG measured as positive above DWL. * CG measured as positive above DWL. * OB Exercised 20 Structures 20 Structures 20 Structures 20 Structures 20 Bectificat 50 Exercised 50 E	PPI				506	lbs/in						
Trm = (LCB. LCG) x 0xp/LangPM/Deg = (LWL x12) x sin/tem(dap57 298)) -0.69 deg -2.71 in (+ - bow down) • LCG measured as positive aft the origin. • UCG measured as positive above DWL • TCG measured as positive above DWL • TCG measured as positive above DWL • 20 Structured • 20 Structured • 20 Structured • 20 Structured • 50 Electronicits • 60 Auxillary Systems • 20 9 0, 55 272 • 72 0 eck Ourthing • 60 auxillary Systems • 60 auxillary Systems • 1 ea 175 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 • 1 1 87 •	Floatation Calcu	dations with Half Tankage										
- (LWL ± 12) ± sur(trim(deg/57 296)) -271 in (+ - box down) • (LCG measured as positive aft the origin. • UCG measured as positive above DWL • TCG measured as positive above DWL • TCG measured as positive above DWL • TCG measured as positive to STBO • UPC - 100 -												
LCG massured as positive aft the origin VCG measured as positive aft the origin VCG measured as positive to STBO <u>Weight Breakdown 2,001 0,30 16,000 0,30 16,00 0,0 0 0 0 0 0,0 </u>												
* VCG messured as positive above DWL * TCG messured as positive above DWL * TCG messured as positive above DWL * VCG messured as positive above above DWL * VCG messured as positive above DWL * VCG messared as positiv	= (LW	L x 12) x sin(trim(deg/57.296))			-2.71	in	(+ = bo	w down)				
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6.0. Auxilliary Systems 30 9.44 263 1.94 58 0.00 0 7.0. Deck Ourtitring 508 8.91 4.532 2.62 1.334 0.00 0 8.0 Finishes 29 9.55 272 1.47 42 0.00 0 Gasotine 85 gil 6.14 522 13.87 7.209 -0.21 1.10 0.00 0 Captain 1 ea 175 175 13.00 2.275 4.00 70.00 0.0 0 Cerev 1 ea 175 175 15.016 1.24 5.372 0.04 175 Hull Load Condition 4.347 11.87 51.916 1.24 5.322 0.04 175	4.0 Electrical					50	17.12	856	-0.14	-7	2.25	113
7.0 Deck Outfitting 508 8.0 ft 4.532 2.62 1.334 0.00 0 8.0 Flishings 29 9.55 272 1.47 42 0.00 0 Tankage Gasoline 65 91 6.14 522 13.87 7.298 -0.21 -110 0.00 0 Captain 1 en 175 175 13.00 2.275 4.00 0.00 0 Captain 1 en 175 175 6.67 1.167 2.33 409 0.00 0 Pull Load Condition 4.347 11.87 51.616 1.24 5.372 0.04 175 Hait Load Condition 4.066 1175 47.307 1.33 5.427 0.04 175	5.0 Electronic:	3					11.04	66		19	0.00	0
B.0 Finishes 29 9.55 272 1.47 42 0.00 0 Tankage Gasotine 05 9.16 1.45 522 1.3.87 7.2.99 -0.21 -110 0.00 0 Captain 1 ea 175 175 13.00 2.275 4.00 700 0.00 0 Crew 1 ea 175 175 6.67 1.167 2.33 6.00 0.00 0 Full Load Condition 4.347 11.87 51.616 1.24 5.322 0.04 175 Halt Load Condition 4.066 11.157 47.09 1.33 5.427 0.04 175	6.0 Auxillary 3	System s				30	9.44	263	1.94	58	0.00	0
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Captain 1 es 175 175 13.00 2.275 4.00 700 0.00 0 Crew 1 es 175 175 6.67 1,167 2.33 408 0.00 0 Full Load Condition 4.347 11.87 51.616 1.24 5.372 0.04 175 Half Load Condition 4.096 11.75 47.097 1.33 5.427 0.04 175	Tankage											
Crew 1 es 175 175 6.67 1,167 2.33 408 0.00 0 Full Load Condition 4,347 11.87 51,616 1.24 5,372 0.04 175 Halt Load Condition 4,066 11.15 47,997 1.33 5,427 0.04 175		Gasoline										
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Half Load Condition 4,086 11.75 47,997 1.33 5,427 0.04 175	Captain		1									175
	Captain	Full Load Condition	1	 		4.347	11.87	51.616	1.24	5.372	0.04	
	Captain		1	 								
	Captain	Half Load Condition	1	 		4,086	11.75	47,997	1.33	5,427	0.04	175
	Captain	Half Load Condition	1	 		4,086	11.75	47,997	1.33	5,427	0.04	175
	Captain	Half Load Condition	1	 		4,086	11.75	47,997	1.33	5,427	0.04	175
	Captain	Half Load Condition	1	 		4,086	11.75	47,997	1.33	5,427	0.04	175
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Page 1

Hull Plug

Computer model sent to Boeing subcontractor and plug for tooling was milled out of 22' block of foam.



Tooling Development

Hull plug sent to laminating subcontractor for finishing.

Laminating subcontractor responsible for building all tooling (ensuring that parts fit together at the end of the project).

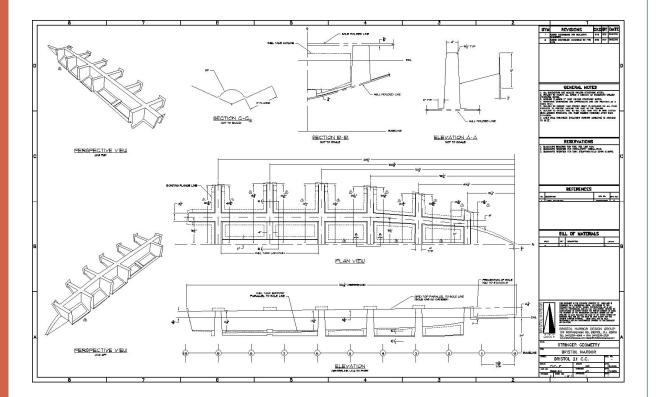


Structural Grid

One piece grid makes up all of the structural components for the boat.

Hollow stringers save weight without losing strength, and hollow longitudinals serve as rigging tubes.

Cavities outboard and forward filled with closed cell floatation foam.



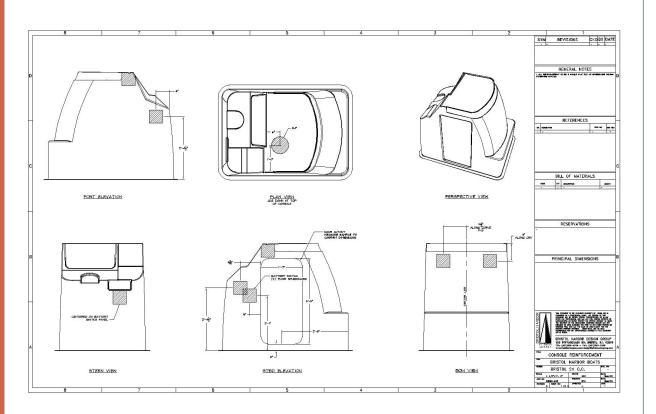
Center Console

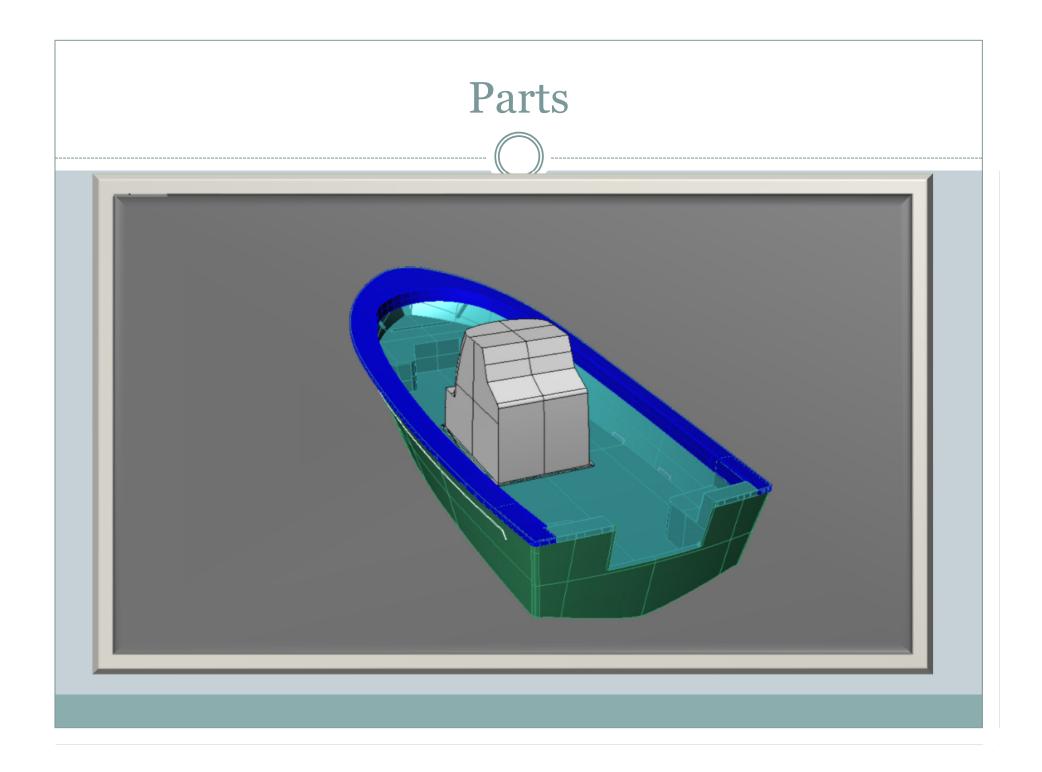
Combining modern curves with a traditional hull sheer line.

Mock up to determine optimum use of space.

Can accept up to a full 10" integrated display.

Head space also provides excellent access to the batteries and electronics.





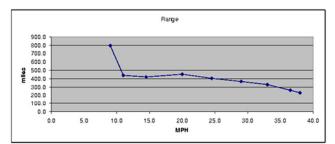
21CC Sea Trial

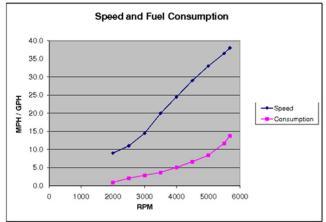
Bristol Habor 21 CC Sea Trial

Date:	August 14, 2007
Time:	1100
Weather:	flat calm, wind from NNE @ 8 knots
Load:	1 POB, 31.875 gal. fuel (85 gal. tank), safety equipment
Propeller:	14 3/4" x 17"

Heading:	3	48°	1	68°	Average			
Revolutions (RPM)	Speed (MPH)	Consumption (GPH)	Speed (MPH)	Consumption (GPH)	Speed (MPH)	Consumption (GPH)	Range (miles) ¹	
2000	9.0	0.6	9.0	1.3	9.0	1.0	795.8	
2500	11.0	2.1	11.0	2.1	11.0	2.1	440.0	
3000	14.0	2.9	15.0	2.9	14.5	2.9	420.0	
3500	20.0	3.7	20.0	3.7	20.0	3.7	454.1	
4000	24.0	5.1	25.0	5.1	24.5	5.1	403.5	
4500	29.0	6.8	29.0	6.5	29.0	6.7	366.3	
5000	33.0	8.5	33.0	8.3	33.0	8.4	330.0	
5500	36.0	11.7	37.0	11.7	36.5	11.7	262.1	
5680	38.0	13.8	38.0	13.8	38.0	13.8	231.3	





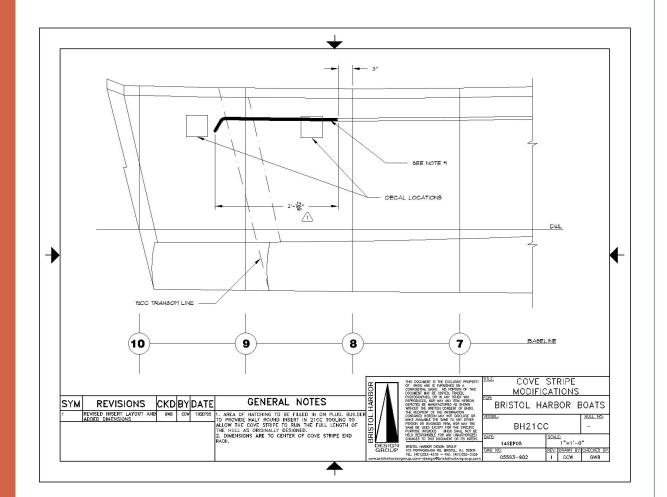


Common Tooling

Hull mold for 21CC is also used for the 19CC

A "block out" is inserted in the mold prior to laying up the 19CC hull part

Liner, deck ring and stringer grid molds are also used for both models









Vanquish Boats

- 23' Bristol Harbor Series Center Console
- 23' Bristol Harbor Series Cuddy Cabin



Bristol Harbor 23' Cuddy Cabin

• Began new model development in 2011.



23' Cuddy Cabin

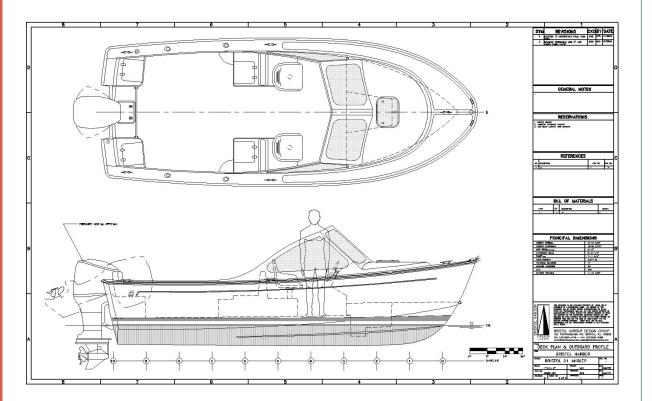
Bass boat style

21CC hull

New liner

New deck ring and foredeck

Addition of an engine well or transom bracket





Advanced Technologies in Commercial Naval Architecture and Marine Engineering

> GREG BEERS, P.E., PRESIDENT CORY WOOD, VICE PRESIDENT

> BRISTOL HARBOR GROUP, INC. THE SHEARER GROUP, INC.

SNAME NEW ENGLAND SECTION 29 JANUARY 2020

Also Commercial Naval Architects

- Full service naval architecture, marine engineering and marine surveying companies; Bristol Harbor Group, Inc. in Rhode Island; and The Shearer Group, Inc. in Texas.
- Technical team includes naval architects, designers and marine surveyors who have graduated from some of the top engineering schools in the country:
 - U.S. Coast Guard Academy
 - University of Michigan
 - Webb Institute
 - Texas A&M University
 - Virginia Polytechnic Institute and State University
 - University of New Orleans
- The Core Purpose of our companies is: **To Create**. This purpose, combined with a passion for boats, serves as a motivation for our talented staff.

Advanced Technologies

Techniques

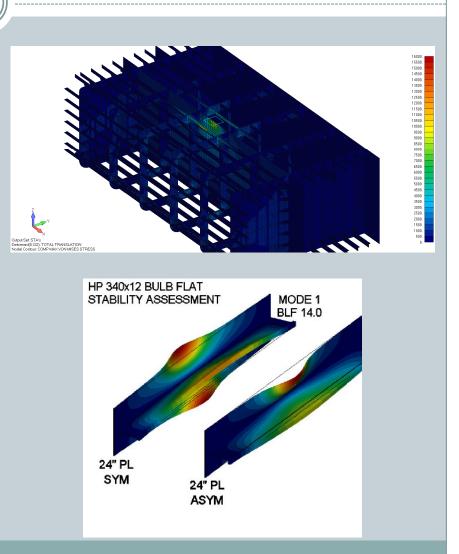
- Finite Element Analysis (FEA)
- Computational Fluid Dynamics (CFD) Analysis
- Operational Modelling (hybrid or energy storage)

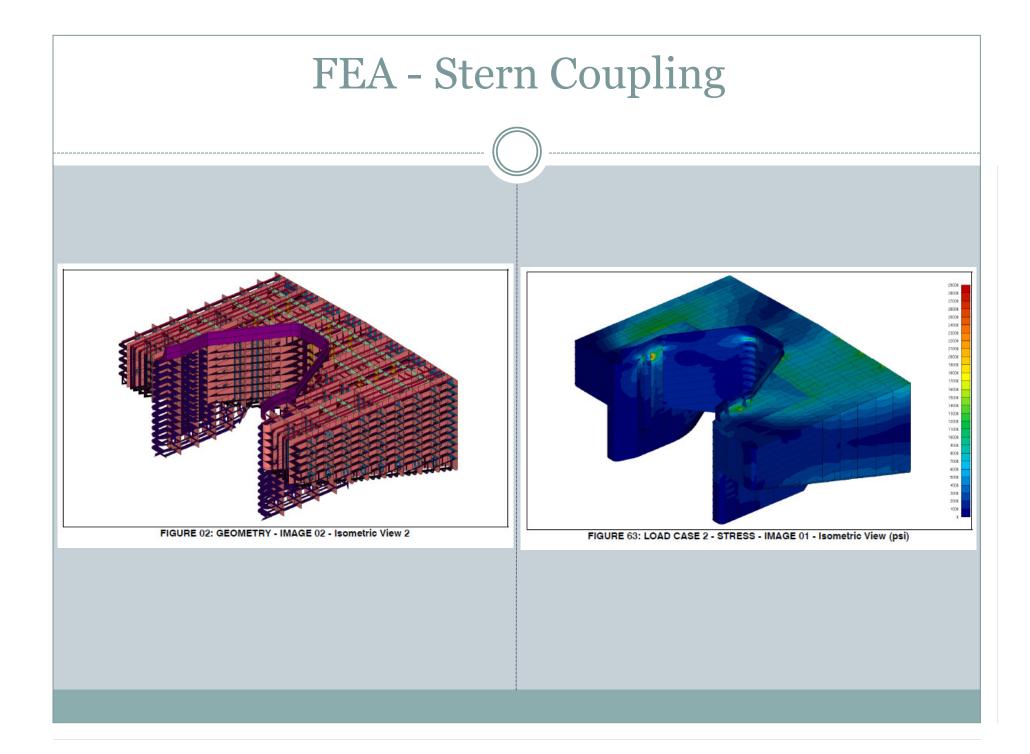
• Examples

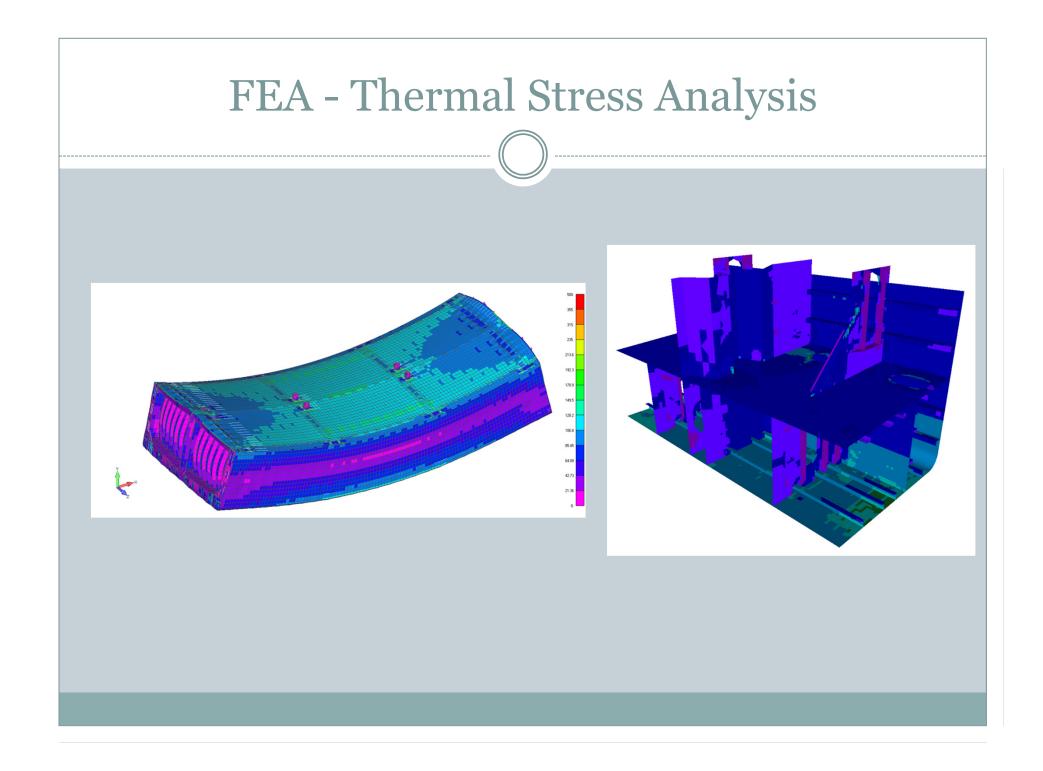
- Alternative Fuels
 - × LNG
 - × Biodiesel
- Electrical Propulsion
- Robotics and Automation
- Unique Cargo (NASA, etc.)
- Future

Techniques - FEA

- Finite Element Analysis
 - Models range from global to detailed submodels
 - Analysis also spans a large range, from crude beam element models for load determinations to detailed solid models with nonlinear gap elements for thorough understanding of contact between structures
- FEMAP and Nastran

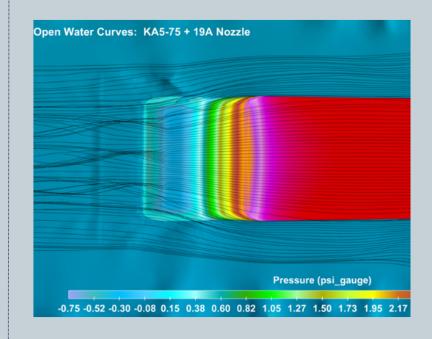


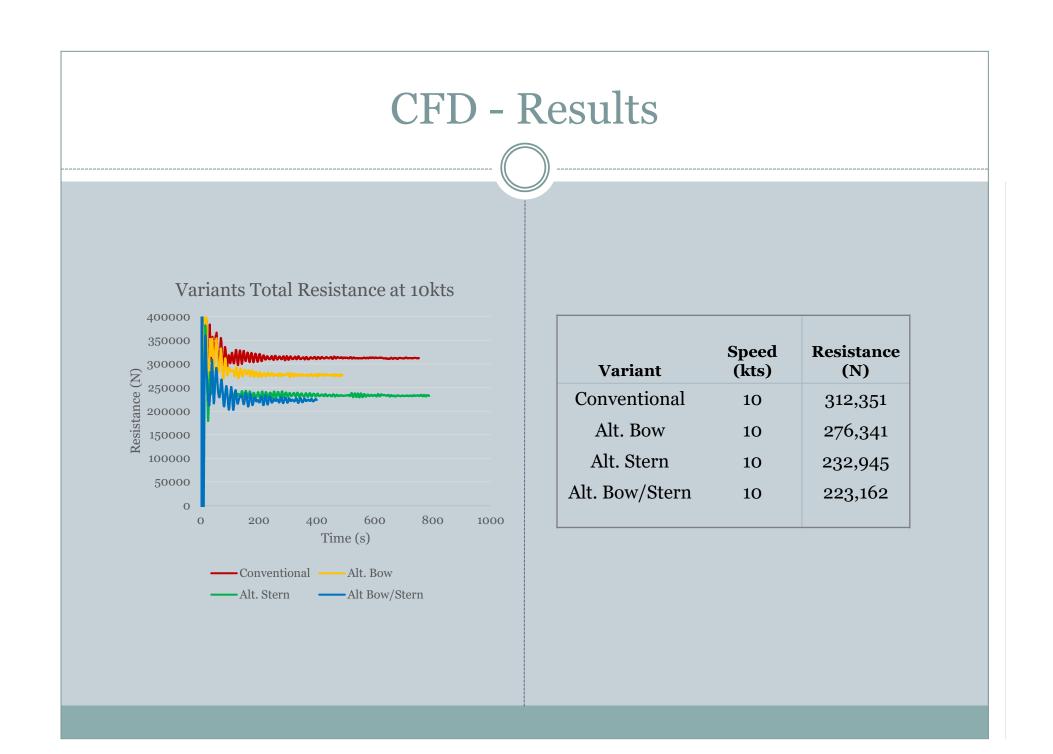


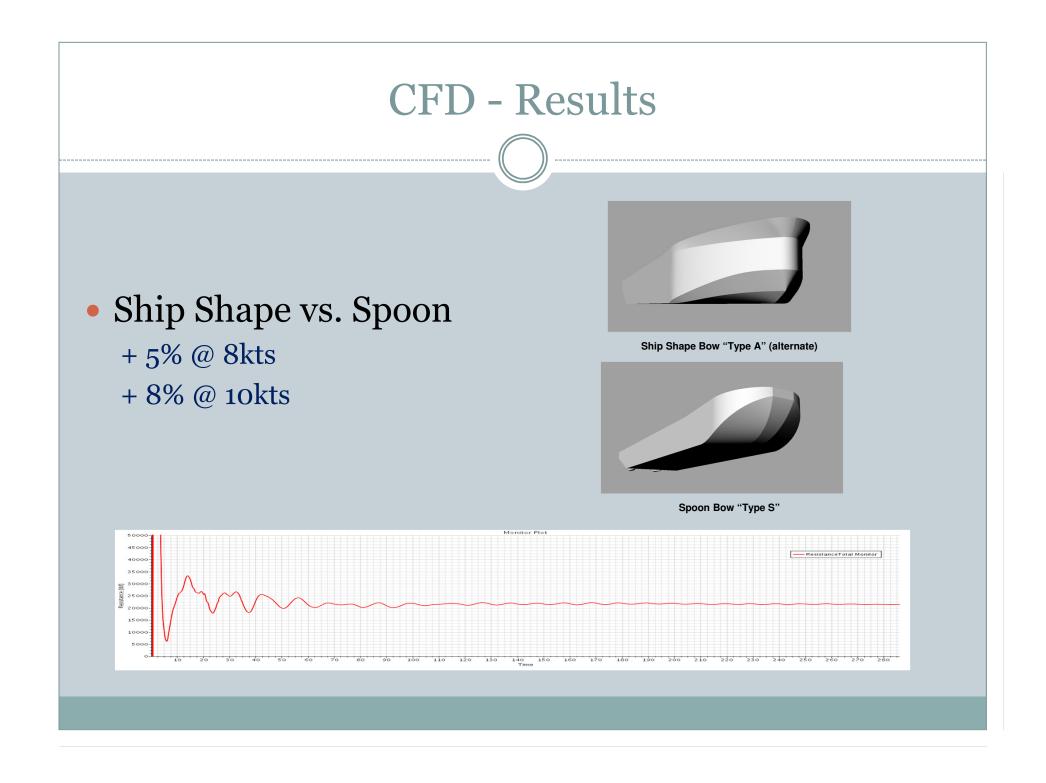


Techniques - CFD

- Computational Fluid Dynamics
- Reynolds -averaged Navier-Stoke (RANS) based code
 - Simerics
 - Star-CCM+
- Resistance and flow optimization as well as detailed seakeeping analyses







CFD - Validation

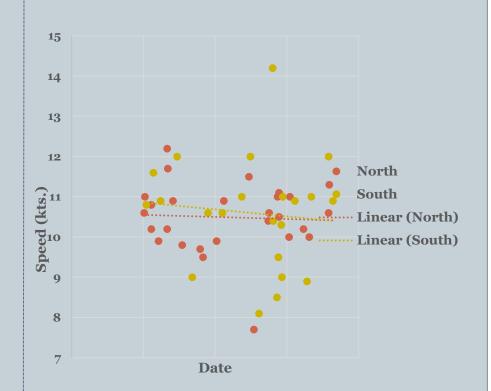
- BHGI understands the need to ground-truth CFD results
- Therefore, tank test with alternate bows
- One model with two bows, one ship shape and the other a spoon bow
- Tested at University of Michigan Marine Hydrodynamics Laboratory
- Data matches CFD delta approximation +/-1 %





CFD - Validation

- Track actual units on Marine Traffic to understand full scale (real life) transit speeds versus calculated
- This example shows that over 10 months, loaded transit speed on average matches our calculated speed for 80% MCR
- Interestingly, when light, this vessel only picks up about ¹/₂ knot at less than 80% MCR
- Point being we "trust but verify" our computational results



Operational Modeling

• Marine Electrical Propulsion Simulation Lab (MEPS)

- Vision Excerpt
 - × MEPS provides a high-impact research capability for hybrid and all-electric marine vessels through collaboration with naval and commercial industries along with other universities





Examples - Alternative Fuels

• LNG

- o Clean Jacksonville
- First LNG bunker barge built in North America
- Delivered in 2018
- GTT Membrane Technology
- Capacity of 2,200m³



Examples - Alternative Fuels

- LNG
 - Towboats
 - × Retrofits
 - Dual-Fuel via Air Fumigation
 - × Ellen-G
 - AiP from ABS



Examples – Alternative Fuels

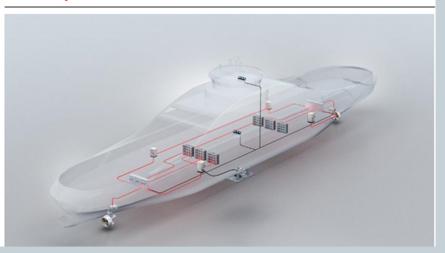
Biodiesel

- In 2013, USACE had BHGI investigate the viability of using various types of biodiesel on a variety of vessels
- Focused on power output and environmental and emissions effects
- Physically inspected and assessed nine candidate vessels including installing monitoring equipment and conducting extended trials
- Culminated in a paper entitled: *Measurement of Criteria Pollutant Emissions from Vessels Operated by the US Army Corps of Engineers and using Advanced Fuels*; Gysel, Miller, Welch &; Cocker; Final Report (Amended), April 2014

Mechanical power train



Electric power train

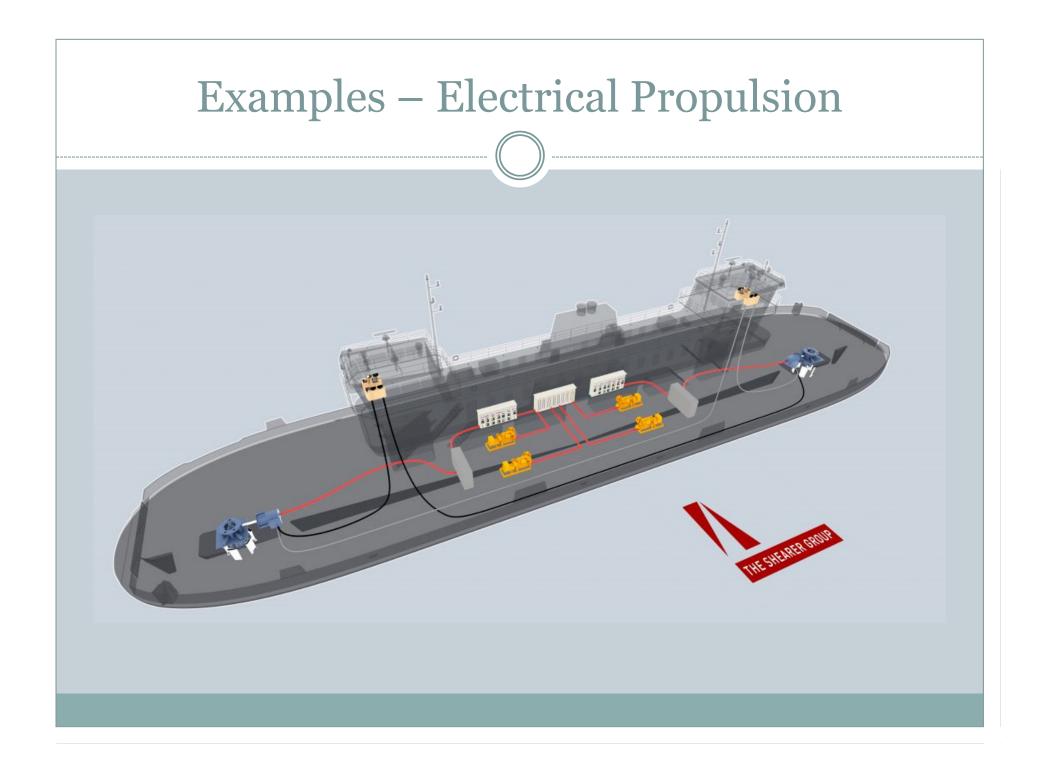


- Electric motor provides shaft power to propeller or thruster
- Several generators instead of main engines + generator
- Generators provide energy for propulsion system as well as house loads – no extra house generator needed
- Ability to shed prime movers when less power is needed
- Redundancy in the event of a prime mover failure, while failure of any part of a direct drive system means loss of propulsion

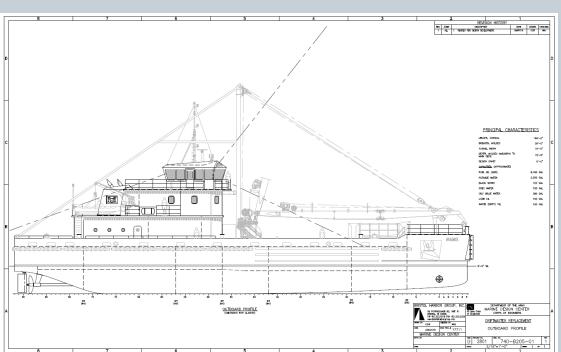
- Diesel electric systems do require additional considerations such as climate controlled area for electronics
- Recent studies indicate that capital expense of diesel electric system very similar to Tier 4 w/ EGR direct drive system
- Diesel electric system generators have shorter maintenance intervals than typical low speed diesels, but ability to make speed with less than the total # of generators available reduces time on each engine and extends maintenance intervals
 - More flexibility for maintenance
 - Out-of-service time minimized

- Texas DOT Galveston to Bolivar Peninsula
- 293' x 66' Car Ferry
- 70 Cars and 495 Passengers
- Voith Schneider Propulsion
- 1.4MWHr Energy Storage



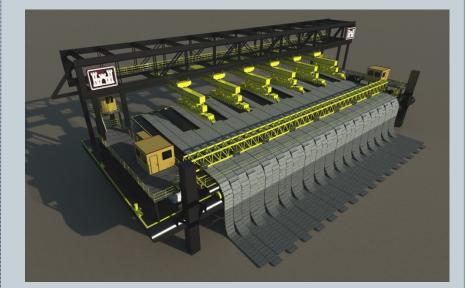


- DRIFTMASTER II
- 148' x 39' Debris Collection Vessel
- Operates in N.Y.C. Harbor
- 3 MWh Energy Storage



Examples – Robotics and Automation

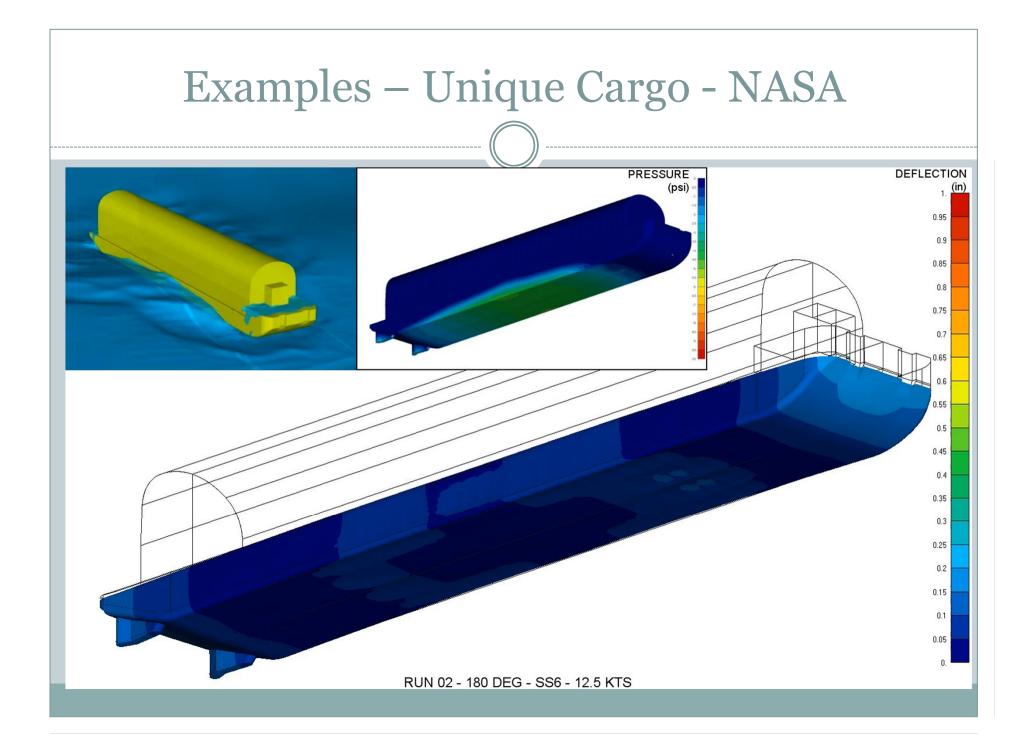
- ARMOR 1
- 188' x 74' Mat Boat
- Floating concrete mat factory for armoring the bends of the Mississippi
- Carnegie Mellon University's National Robotics and Engineering Center

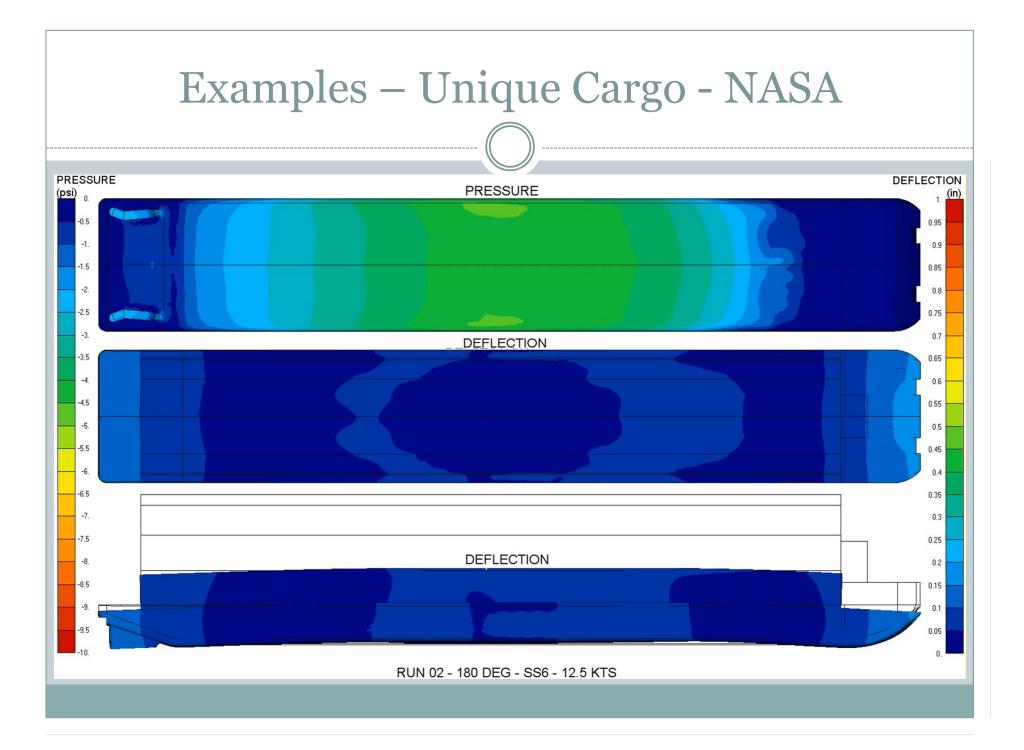


Examples – Unique Cargo - NASA

- NASA RoRo Flight Article (i.e. very light)
- First Space Launch System (SLS) rocket core stage for Artemis program
- En route from Michoud (NOLA) to Stennis (Mississippi)
- Preparation for the Green Run test series, final test campaign
- Larger than Saturn V rocket stages built at Michoud







Examples – Unique Cargo - OTB

- OTB RoRo HEAVY
- 395' x 100' ocean transport barge for General Dynamics Electric Boat
- Under construction at Bollinger Marine Fabrication, Amelia, LA
- Simple answers to complex problems – simple rule for human ops in an emergency



Future

- Committed to the use of advanced techniques and automation for efficiency
- Actively promoting and exploring opportunities for the advancement of alternative fuel AND electric propulsion for tugs and towboats (already doing this for ferries)
- Exploring other opportunities from LNG Dredges to all electric barges
- Exciting time to be a naval architect!



