GREEN LANTERN
RACER/CRUISER CATAMARAN
10.5

General Description:

The Green Lantern is intended for those wishing to travel oceans in the ideal cruiser with the ability to race inshore or offshore when looking for the thrill of competition. Her design will allow the voyage to be enjoyed as much as the destination during either event.

Design priorities were to develop a product that included high offshore safety while being easily handled in inclement weather. She must be capable of fast passages in varying conditions without compromising safety or comfort. She must be nautically aesthetic and a head turner while entering port. Her cost to build professionally is moderate and low if home built by her master.

Her accommodations are set up for a couple to cruise comfortably with two occasional guests for longer cruises and possible four guests for shorter legs. Ease of sail handling was always considered imperative for the lone sailor and her displacement has been optimized to acquire such ease. Her bow-berths will provide privacy for owners and guests in separate hulls and additional single settee berths will provide restful sleep for the occasional others.

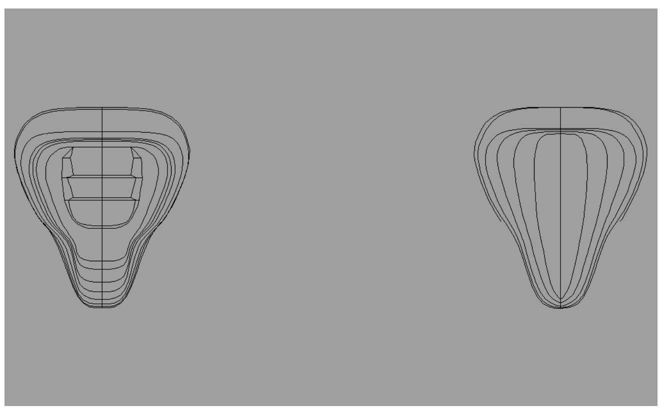
The initial accommodation design was for 30 feet. This was then extended to 34 feet without any increase in accommodations. This provides adequate cruising necessities while increasing safety margins due to greater footprint, easier motion, more easily driven, and greater interior room with little if any increase in weight. This design tactic generates a minimal increase to costs.

Specifications:

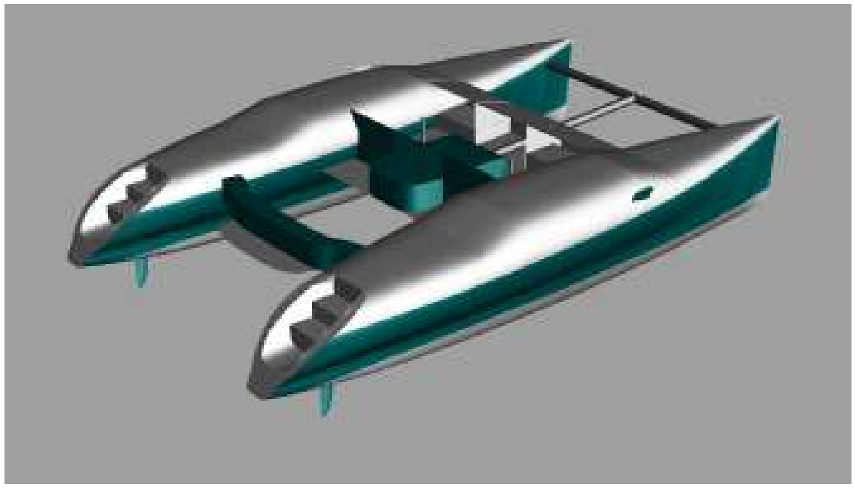
Length Overall	34.253'	Mainsail	388 sq.
Length Waterline	33.163'	Jib Blade	169 sq.
Beam Overall	22.111'	Spinnaker	850 sq.
Beam Hull	6.000'		
Hull Waterline Beam	2.522'	Mast Height	42.5'
Draft (board down)	4.559'	Mast height above WL	45.914'
Draft (board raised)	1.407'	Displacement Race Trim	6,074#
Draft hull	1.407'	Displacement	7,172#
Bridge Deck Clearance	2.567'	Displacement Max	8,794#

Hull Design:

The hulls are designed to be fast and slim below the waterline and comfortably wide and spacious above the waterline. This setup provides optimum cruising accommodations without compromising performance. The bows are designed with a large amount of reserve buoyancy above the waterline to allow the CB to move forward quickly when the hulls are depressed for those moments when a deep bury is experienced. With large radius in the forefoot, the hull will further "resist" burying thereby, adding to safety when the bows attempt to dig. The narrow entry will slice through waves easily. The ride can be expected to be moderately dry.



Mid-ships, the hull begins to become semicircular and has a flat run fully aft with the sides almost vertical. The semi-circular shape has the least wetted area for the geometry and the vertical rise aft allows the CB to remain well forward when the aft sections of the hull are depressed. The flat run aft reduces hobby horsing and other negative performance or comfort attributes. A narrow stern is chosen for the design because with reduced pitching from a flat run aft, all that remains is reducing drag from pitching which is easily accomplished with a narrow stern. Her aft engine room layout makes her a bit more sensitive to weight due to her narrow stern but having had this weight incorporated into the design and keeping all other weights well forward, she will easily float on her lines.



Above the waterline she has low windage and her light bulb section is conducive to further reducing drag by promoting undisturbed flow around the structure. By keeping the hull wide, the interior accommodations are made to feel less restrictive and less confined with no increase in windage whatsoever. Generous radiuses further promote flow while increasing safety for crew. Combined, the hull produces excellent aerodynamic and hydrodynamic results which translate into an optimized hull for the purpose intended.

Inboard rudders are optimized NACA 0020 series with high aspect ratio of specialized design to kick back and swing into the hull in case the vessel happens to ground or encounter flotsam below the keel line. This design also allows easy beaching for drying out or having her on the hard for maintenance.

The symmetrical dagger boards are optimized NACA 0012 series with high aspect ratio of specialized design to sheer off at the keel line. They are designed to be raised and lowered by low voltage, medium torque motors from the helm for ease of tack. The boards do not protrude beyond the windage of the hull when raised for performance, safety and aesthetic reasons and they can be easily removed for repair or maintenance. Canted inboard for extra lift and with 2 degrees toe in, they are designed to produce high lift to drag ratios.

Hydrostatics:

Block coefficient	0.1295	Prismatic coefficient	0.6398
Vertical prismatic coefficient	0.6278	Wetted surface area	217.46
Longitudinal center of buoyancy	16.9	Vertical center of buoyancy	0.872
Mid-ship section area	5.307	Mid-ship coefficient	0.2036
Water plane area	126.65	Water plane coefficient	0.2062
Transverse moment of inertia	4,076.7	Longitudinal moment of inertia	11,974
Transverse meta-centric height	37.301	Longitudinal meta-centric height	106.13
B/T Ratio	1.792	Wind-age	16.33%
LWL/BWL Ratio	13.149	D/LWL Ratio	87.80

Rig Design:

For affordability reasons, wing masts have been excluded from the design as they can easily double the cost of the rig. Having that said, wing masts' are reliably formidable and unsurpassed for performance and weight. The mast section chosen is elliptical and generally efficient with single spreaders swept back to low angles. The mast chosen for the design is the Z501 7/8 Elliptical Series 1 section from US Spars as is the Z360 Boom.

A 7/8 rig with jib blade for the fore-triangle is an efficient combination for almost all circumstances. The blade with the moderate ratio main will provide lively performance while also allowing the blade to be self tacking while cruising. The blade has an area that is a good compromise for making way during storm conditions and roller furled to further reduce sail without going forward will make inclement conditions much tolerable. The spinnaker will be the down wind sail which will keep her making way instead of corking around on the water. A large Genoa could be included which could provide efficient upwind sailing in light winds, but not necessary. All lines and controls at the helms reach makes for comfortable and safe cruising or racing under all conditions.

Accommodation Layout:

The layout is symmetrical. Aft are the outboard 9.8 HP engines on vertical tracks in self sealing wells for drag reduction below the waterline with twelve gallons of gas and one starter battery for each. Totally enclosed and vented, they are accessible from outside in order to eliminate the possibility of fumes in the hull.

Moving forward, the head contains a five gallon porta potti plumbed for outboard discharge or, walk-off removal with generous shower space and a sink area. Ahead of the shower to outboard, are the navigation station and the companionway to starboard. Forward is a five foot settee to outboard and galley to starboard with swing table for the settee, three burner stove, double sink and deep refrigerated ice box. The bow berth is enormous at over ten feet long with sitting space at the head. Beyond that is the crash bulkhead below and anchor locker above. Storage is moderate and kept centralized with cabinetry kept to minimum.

Her capacities include seventy gallons of water, two house batteries, two starter batteries, twenty-four gallons of fuel and eighty pounds of propane on deck for safety and long term cruising comfort or as reserve during becalmed periods of time. These weights are part of the design and not part of the payload. At 250#'s, there is enough ground tackle for all possible situations and this also is part of the designed displacement. Many designs claim lightship displacements unknowingly without including "essential" weights and regrettably denote deceptive payloads.

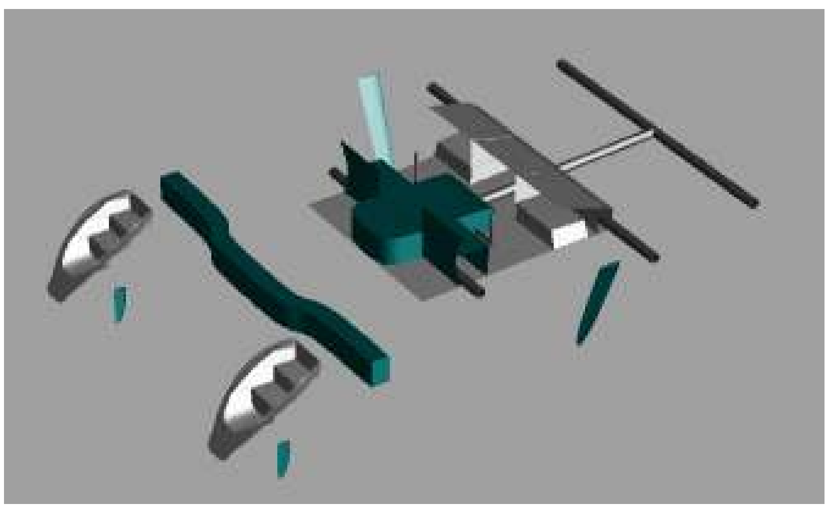
Deck Layout:

An aft cockpit was ruled out from the onset. Weight has a funny way of huddling its way at the ends of the deck and this is especially true when a nice solid sole exists. The deck accommodations are centralized and huge clearances exist between the ends of the hulls and the weights. This centralization of weights and not just the cockpit, promotes comfort and good performance while reducing hobby horsing. Safety is proportionately increased by both.

Forward of the aft beam is a webbed netting area of more than sixty square feet structurally attached at its perimeter. That is it. No heavy sole and no extra weight. Forward of the netting is the cockpit with dual helm stations outboard and a settee measuring four feet by six and a half feet for excellent seating. The same will serve as an enormous watchman's bunk or a cozy double for two to stargaze during fair weather. That is it. The seating arrangements must be proportional to sleeping and it is folly to have ten bunks when the cockpit can only sit five sailors or vice-versa.

The dual "Fighter Stick" steering gives the helmsman good feel for the rudder and minimizes use of space in the cockpit with all electrical controls for motors, pumps, radar, navigation, lights, etc, routed to toggle switches in the grip for easy use. With in line auto-pilot and simple cable system, the steering system is a cruising sailors dream come true for comfort and ease of maintenance or repair. Forward and aft of the center cross beam, within the cockpit are the lockers for the house batteries and propane tanks. A storm rated collapsible dodger fully encloses the cockpit for inclement weather and a small heater is more than sufficient to keep the area toasty during cooler periods.

Forward is the webbed bow netting with an area of more than seventy-five square feet. That is it. No need to ever have to worry about having a wave crash on the fore decks because they just don't exist.



Structure:

Strength begins in the hulls. The hulls incorporate ring frames making them extremely strong at connective points for the flanges. The flanges are bulkheads and they give the hull rigidity and reduce spans. With safety factors greater than 3, the hull is stiff and strong. With watertight bulkheads fore and aft, safety is increased and dedicated buoyancy is created.

Strength is then extended by connection of the hulls. Scantlings are calculated for beams in cantilever at the greatest possible displacement and safety factors are incorporated which result in a rigid, strong, stiff and capable hull and deck than can fly the windward hull without being concerned that torque, tension or compression will cause failure. The tube beams chosen are the Z701 Series 1 section from US Spars.

Final stiffening is residual but structural. All components that reduce fatigue cycles, stress, span and loads will by their very nature increase stiffness and strength. Once these components are incorporated safety and longevity of design is evident and realized. Many a vessel has lived poor ten year life spans with little or light structure while others have the beef necessary to live healthy thirty year spans. This is obviously radical engineering to keep the hull as light as possible to meet bare minimum structural requirements.

Performance:

Design description thus far has been kept to generalities with some specifics applicable to the cruising sailor. But what does the racer/cruiser really mean in the title of a design and how would it differ from cruiser/racer? Obviously, for the cruiser/racer it will mean that the design must have adequate capacities to make a cruise comfortable and safe while also providing fast passages for every condition that may be encountered while in route, whether inshore or offshore. For the racer/cruiser, the skipper expects that the vessel will perform as a cruiser/racer when required, but wants the design to first perform as a racer with the option to cruise.

How is this measured and what does it mean to the novice sailor? In simplest terms, ratios, non-dimensional figures and generally accepted and proven performance formulas and principles serve to give a good idea of vessel performance specifics whether standing alone or compared to another. Here are the design results that explain the cruiser, the inshore racer (IR) and offshore racer (OR).

Cruiser /3.202 Tons

SA/D	24.06071	LWL/BWL	13.14948
Windage % of LOA	16.33%	Lead % LWL at Combined CE	1.29%
Bruce #	1.227356	RPI1.305091	
Stability #	1.063335	Stability Wind Speed To Lift Hull	19.63603
Reef (Knots)	14.72702	Clearance	45.915
Lowest Deck Clearance	2.5679	D/LWL Ratio	87.80464
Speed Knots	10.54833	Velocity Ratio	1.582357
PIC	0.802398	Base Speed	9.590307
Texel	100.1154	Texel K	0.40367
Stability Capsize	2.942242	B/T Ratio	1.792466
BCL/LWL	0.482465		

The sailor cruising offshore or inshore will find that the ride will be lively and enjoyable. The combination of SA/D, LWL/BWL, windage, bridge-deck clearance, D/LWL and B/T will ensure that the vessel has excellent power to easily drive the hulls to speed even in light airs allowing extremely fast passages in any weather condition other than becalmed.

The high bridge-deck clearance combined with a lead of 1.29% of LWL and a BCL/LWL distance of 48% will ensure stress free cruising and extremely comfortable and restful nights.

Offshore vessels must have high stability for all conditions that will be encountered. A rig that carries a stability # greater than 1 and can handle a stability wind speed of greater than 19 knots before the windward hull is lifted or a need exists to reef is considered offshore capable for prudent skippers. The higher the stability capsize number, the greater the resistance to capsize.

The designed hull speed combined with high velocity ratios and low Texel figures for the hull will result in high speed potential for the design. Hull speed potential increases with high velocity ratios and low Texel figures. The cruiser, sailed at the designed waterline will be an excellent performer offshore easily transiting crew to their destination in superior comfort and safety. With a top payload displacement of 3.926 tons speeds will drop and stability will increase, but the cruiser will still consider her to be an excellent overall performer with a SA/D ratio of 20.98, providing extremely fast passages for her displacement while keeping her transom from dragging her down.

Inshore Racer – Single/ 2.822 Tons

SA/D	26.17745	LWL/BWL	13.34967
Bruce #	1.280206	RPI	1.305091
Stability #	0.973212	Stability Wind Speed To Lift Hull	17.97424
Reef (Knots)	17.07552	D/LWL Ratio	80.84433
Velocity Ratio	3.970841	Speed Potential	26.27701
B/T Ratio	1.883077		

Inshore Trim - Single	Current	Weight	Reduction
Ground Tackle	250	0	250
1 Engine Centerline - 9.8HP/ 1 Gal Gas/ 1 Batt	530	168	362
Full Water Tank	560	560	0
Zero House Batt/Propane	240	0	240
Total	1580	728	852

LCB	CG
17.009	16.806

The sailor racing inshore single handed will find that the ride will be spectacular and full of adrenaline. The combination of SA/D, LWL/BWL, windage, bridge-deck clearance, D/LWL and B/T will ensure that the vessel has excellent power to easily drive the hulls to incredible speeds even in light down-wind airs allowing extremely fast races in any weather condition.

For inshore racers under closer supervision with help not far away, those stability ratios can be pushed to a greater limit without sacrificing safety. The design will be found to be fast and on the edge of pure unhindered speed. The designed hull speed combined with high velocity ratios for the hull will result in a speed potential for the design greater than 26.2 knots. The inshore racer will find that the design is close to its maximum potential. The inshore racer, sailed single handed at the designed waterline will be a syringe full of adrenaline and an extreme performer rounding buoys quickly and finding her skipper looking back often at every leg to wave to competitors. No one could have imagined.

Inshore Racer – Team/2.712 Tons

SA/D	26.88036	LWL/BWL	13.40231
Bruce #	1.297280	RPI	1.236923
Stability #	0.953474	Stability Wind Speed To Lift Hull	17.60993
Reef (Knots)	16.72943	D/LWL Ratio	78.88702
Velocity Ratio	4.010507	Speed Potential	26.47201
B/T Ratio	1.913249		

Inshore Trim -Team	Current	Weight	Reduction
Ground Tackle	250	0	250
1 Engine Centerline - 9.8HP/ 1 Gal Gas/ 1 Batt	530	168	362
Zero Water Tank	560	0	560
Zero House Batt/Propane	240	0	240
Live Ballast @ Bows for Sail Handling (2)x160#'s	0	320	-320
Total	1580	488	1092

LCB	CG
17.043	16.985

The sailor racing inshore with a team will find that the ride will be the ultimate chemical imbalance. The combination of SA/D, LWL/BWL, D/LWL and B/T will ensure that the vessel has superior power and least wetted area to easily drive the hulls to remarkable and unbelievable speeds that can only be discounted as a tall tale by GPS confirmation. The race will be over, fast. The design will be found to deliver unprecedented speed on the edge of setting records. The designed hull speed combined with high velocity ratios for the hull will result in a speed potential for the design greater than 26.4 knots. Hull speed potential increases with high velocity ratios, high B/T ratios and large SA/D ratios. The inshore racer team will find that the design is at its maximum performance potential. The inshore racer, sailed with a team of 3 at the designed waterline will become legend leaving one and all in their wake.

Offshore Racer – Single/2.979 Tons

SA/D	24.24835	LWL/BWL	13.27713
Bruce #	1.257282	RPI	1.258309
Stability #	1.000817	Stability Wind Speed To Lift Hull	18.48297
Reef (Knots)	16.63467	D/LWL Ratio	83.54467
Velocity Ratio	3.917456	Speed Potential	26.01638
B/T Ratio	1.843123		

Offshore Trim - Single	Current	Weight	Reduction
Ground Tackle	250	76	174
1 Engine Centerline - 9.8HP/ 4 Gal Gas/ 1 Batt	530	200	330
70 Gallon Water	560	560	0
2 House Batt/2 Propane	240	240	0
Total	1580	1076	504

LCB	CG
16.963	17.085

The weight of the skipper and other items bring the stability wind speed to 19 knots making her completely offshore capable and fully optimized as an offshore racer. Perfect optimization limited only by human endurance. The numbers speak for themselves.

Construction:

A reasonable balance must be achieved between weight, to attain responsive sailing; costs, to make the build feasible; material, for ease and strength and the ever infamous, performance. The design has been shaved, slimmed and trimmed right from the beginning. The first response to the concept was to keep it light, cost effective and easy to build and performance will be self evident.

A happy medium was reached between high end aeronautical construction methods and low end strip plank woods with skins. The construction method is to be vacuum bagged composite sandwich foam core with glass skins, which is essential to keep down the weight and to maintain good glass to resin ratios without the extreme at either ends of the spectrum. This method is proven and properly implemented produces a structure that is fair and strong. All things equal, end grain balsa is an excellent choice for the core and worked correctly, it will produce a structure unsurpassed for weight and strength with very little worry about water intrusion or dry rot.

DESIGN – 10.5 Cat	PROPERTIES	
Laminating Resin: Epoxy	Total Thickness:	0.655 in
	Outer Skin Thickness:	0.032 in
Core Adhesive: Epoxy	Inner Skin Thickness:	0.032 in
Designation Layer W/T Unit	Total Weight:	1.01 lb/ft^2
	Fiber Weight:	0.31 lb/ft^2
2200 Warp Tri-axial 22.24 oz/yd^2	Resin Weight:	0.46 lb/ft^2
Divinycell H80 Plain 0.59 in	Core Weight:	0.25 lb/ft^2
2200 Warp Tri-axial 22.24 oz/yd^2		
Designation Layer W/T Unit	Total Weight:	1.19 lb/ft^2
	Fiber Weight:	0.31 lb/ft^2
2200 Warp Tri-axial 22.24 oz/yd^2	Resin Weight:	0.46 lb/ft^2
Divinycell H80 Plain 1 in	Core Weight:	0.42 lb/ft^2
2200 Warp Tri-axial 22.24 oz/yd^2		

Neutral axis - from outer layer 0.328 in
Flexural Rigidity: 17,746 lb-in^2/in width
Shear Stiffness: 2,954 lb/in width
Max Moment, Compression: 406 lb-in/in width
Max Moment, Tension: 406 lb-in/in width
Max Shear Force: 90 lb/in width

Material List:

The materials list for any given vessel is never all inclusive and complete and it is my opinion that even after it is built, very few were actually tracked meticulously. Indeed, many times it is found that a build is started long before full plans have been delivered and most times the plans are no more than half complete. Material lists usually follow a “general” but close estimate from experience by designers and builders. There are choices. Let a professional builder guesstimate the cost to build the design and let them build it or get your-self informed and get a general idea of the costs to build plus or minus a small variance. If you really must know the cost of every inch of the design before deciding to proceed then chances are that the design will be out of financial reach.

The purpose of the list is to get a close approximation of required material so that it can be decided if the build is within budget. This can sometimes be illusory and many times eludes reasonable expectations. If within budget, have it built at a “guaranteed contract amount” but, beware of the reduced quality and shortcuts which will be inevitable if not closely supervised.

For the home builder it is much simpler. The approximation can be used to get bulk discounts negotiated for the greater part of the design even if it is stretched out over time as funds become available. Most retailers will extend this courtesy if the builder is viewed seriously about their project and given enough information, most will be helpful and even extend the discounts beyond the initial purchase while the builder is closing up. The material list includes generally accepted waste for the construction method and material for the design.

H80-PVC - 5/8"/15mm	1529	Sq. Ft.
H80-PVC - 1"/25mm	751	Sq. Ft.
2200 Warp - 22.24 oz Tri-axial E-Glass	4561	Sq. Ft.
Glass Mat - .75oz	2090	Sq. Ft.
Dynel – 4oz	367	Sq. Ft.
Epoxy Resin - Raka	1776	#'s
Main Sail	447	Sq. Ft.
Jib Blade	195	Sq. Ft.
Spinnaker	978	Sq. Ft.
Dodger	142	Sq. Ft.
Mast US Spar Z501	43	Ln. Ft
US Spar Z701	77	Ln. Ft
Boom US Spar Z360	15	Ln. Ft
Fighter Stick Tube	11	Ln. Ft
Galley Stove	2	
Galley Sink	2	
Water 35 Gal	2	
Head- Sealand Sanni Pot 5Gal	2	
Engine 9.8HP	2	
12 Gallon Gas Tank	2	
Start Battery 80#	2	
House Battery 80#	2	
Propane 40#	2	
Quarter Ellipse Naca 0020 Rudder	2	
Rudder Shaft 1.5"D	2	
Semi Ellipse Naca 0012 Dagger Board	2	
Forward/Reverse Motors	2	
Incidentals/Contingency @ 3%Total		

Costs:

There are as many ways of estimating costs as there are designs. Some use displacement, others use volume. Some swear by the LOA and others will use square area or a percentage of the cost of the design. It is and always will be a variable that cannot be evaded and requires research and work to really get an honest and accurate estimate. The home builder must strive to complete due diligence research.

A good indicator that the estimate is close is to price out the cost of the hull and deck materials excluding fit-out and finishing, just the bare shell. Those costs will be what they are and are estimated to be 18-20% of a sail away package by most ethical builders. Beware of the builder claiming the shell as 10% of sail away as they are seeking to be overly compensated or have little confidence in their own estimations.

Labor is another variable that swings to both ends of the spectrum. Variable by region, labor can be safely estimated as a percentage of the material since it would take 1 tradesman to handle and work so many square feet with so many pounds per hour and, over a long period of time they become more averaged and steady for all trades. Generally, a low professional rate for a mid size design, neither frugal nor extravagant and of average complexity will be approximately 45% of material costs. A high rate would be approximately 55% for the same with a higher level of quality and finish resulting from more dedicated time to the product. Obviously, the higher rate should be utilized for cost out reasons.

For optional consideration and comparison reasons, it is generally accepted that costs vary by the cube of the design length and it could be said that materials could run 20-30% of the total cost. Based on either calculation the results would be $184,238.00 and $36,847.00 to $55,271.00 as material costs respectively

The rule with multi-hulls is that carbon-fiber is light and expensive and, lead is heavy and cheap. It will cost more on every level to build light than it will to build heavy.

	Material	Labor	Total
Total Hull/Deck	$28,939	$15,917	$44,856

Hull/Deck Costs

	Cost yd	Need #'s	Weight^2'	Need Yd's	Cost per #	Sq.Ft.Cost	Total Cost #'s
H80 5/8"	$50.47	382.22	0.25	169.88	$0.40	$5.61	$8,574
H80 1"	$53.62	315.62	0.42	83.50	$0.63	$5.96	$4,477
2200 Tri	$11.75	710.00	0.31	506.75	$2.14	$1.31	$5,954
Mat	$2.50	22.00	0.01	232.21	$0.36	$0.28	$581
Dynel	$7.75	12.00	0.06	40.80	$0.59	$0.86	$316
Epoxy	NA	1775.50	0.46	NA	$4.62	$0.60	$8,195
Total					$8.73	$14.61	$28,096

Pro comparison	Material	Labor (High)	Total	Sail - Low	Sail High
Cost per^2'	$14.61	$8.04	$22.65	$135.92	$891.02
Cost per ^3'	$76.14	$41.88	$118.02	$708.14	$4,642.24
Cost per #	$8.73	$4.80	$13.53	$81.19	$487.12
Cost per LOA'	$844.87	$464.68	$1,309.55	$6,547.74	$7,275.27
Pro Hr. Cost	$45.94	$39.16	$85.10	$425.48	$472.75

*Discount for bulk purchase not utilized in calculation but waste is included.
*Labor High at 55% of Material and sail away high at (100/18)

*Home Built Hours	4500	*Pro Hours	3500

Material Hull/Deck	$28,939	
Material Sail Away Low	$144,697	Home Built Sail Away Low
Material Sail Away High	$160,774	Home Built Sail Away High
Professional Sail Away Low	$224,280	
Professional Sail Away High	$249,200	
Based on ^3' of LOA	$184,238	