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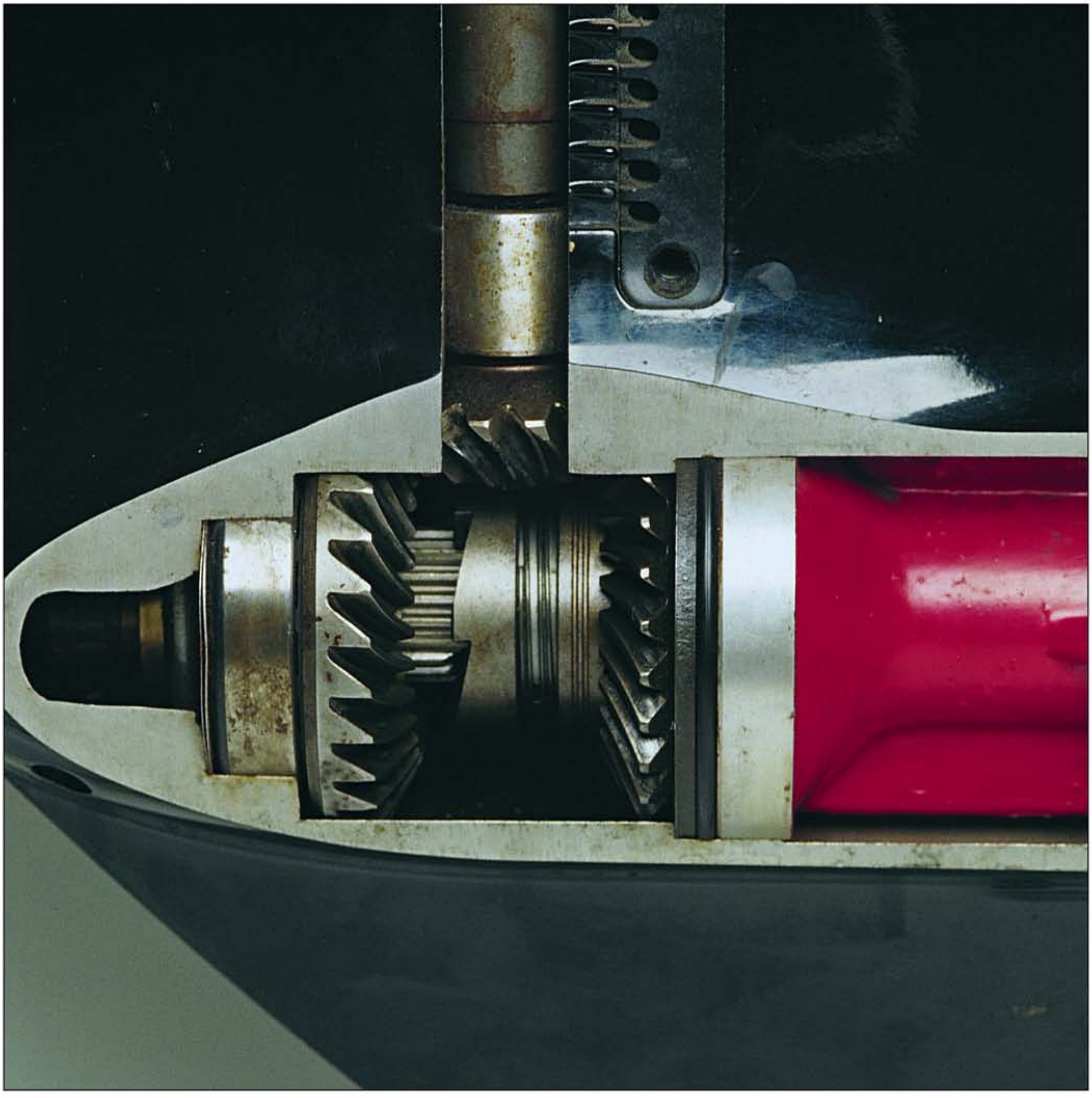

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ANALYZING STERNDRIVE FAILURES
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THE EDUCATION OF A NAVAL ARCHITECT

Keeping It All Interesting

LEAD PHOTO, ULTIMATE SAILBOATS; INSET, STEVE CALLAHAN

Naval architect Jim Antrim has pursued two passions in the course of his professional career: disciplined engineering, and a diversified design portfolio.

by Steven Callahan

Critics of the recreational sector of the marine industry say it produces expensive and purposeless toys. But Jim Antrim makes no apologies for designing them. After all, play serves as a powerful instructional and creative tool, even for adults. Whether he's belting out blues on his guitar, showing his kids a Mozart riff on the piano, or sculpting a trimaran capable of reaching 30 knots, Antrim says, "I take the concept of fun quite seriously. I make every professional effort to make sure you'll have a great deal of fun with any toy I've created." Fun to Antrim hinges on performance. "Speed is an eye-opening experience for most sailors," he says. "Doing 14 knots with two fingers on the helm…That's the fountain of youth."

His acceptance of unusual design directives, his preference for avant-garde construction and surfboard-like hulls, not to mention his casual, tanned demeanor at sunny weekend regattas, all might lead you to mistake Antrim for a natural-born Californian. In fact, he grew up on the opposite side of the continent. After moving as a young child from New Jersey to Nahant, Massachusetts, in the 1950s, Antrim was soon racing a 9′ (2.7m) Turnabout dinghy with his brother; he then moved up to a 15′ (4.6m) keelboat, the Cape Cod Mercury-class, in which he won the nationals in 1969 and 1970. By age 16, he'd already drawn a number of boats, but in those days, a residential education in naval architecture was pretty much limited to MIT, Webb Institute, the University of Michigan, and Stevens Institute. Jim applied to all four, and in 1968 found himself at Webb, well known for training ship designers. "I really liked the feeling of Webb," recalls Antrim. "It was small, very focused, and practical. What I learned at Webb about fluid dynamics, structural engineering, and computers was easily transferable to sailing." *[For a closer look at Webb and its curriculum, see "The Education of a Naval Architect" on page 36—Ed.]*

"When I was in college," continues Antrim, "the big sailboat design firms were Sparkman & Stephens, Dick Carter, Britton Chance, and Gary Mull.

I remember the first time I saw Mull's 42′ [12.8m] sloop *Improbable* in a magazine. I was awed." Carter, though, not only provided similarly innovative potential but also a work-study opportunity for Antrim while he was still at Webb. At the time, Carter was transforming composite construction by employing hat-section stringers to reinforce and significantly lighten fiberglass skins. And, he was beginning work on *Vendredi Trieze*, a 128′ (39m) three-masted schooner—the world's then-largest fiberglass structure—for the 1972 Singlehanded Transatlantic Race. In addition, Carter had created numerous progressive IOR (International Offshore Rule) winners, and his office served as a breeding ground for talent that would eventually include designers Doug Peterson, Yves Marie Tanton, Bob Perry, and Chuck Paine. Here, Antrim got his first look at a working design office (as well as the occasional whale spouting off of Boston Harbor), but he wanted more than to take offsets and run prints. Fortunately, a more promising opportunity fell into place.

Antrim was Webb's sailing team captain when he crossed tacks with Britton Chance, who was campaigning his own racer. Chance asked him, "You know how to do the foredeck?" To which Antrim replied, "'Oh sure,' though I'd never done foredeck in my life." But he proved his mettle with Chance, so after Antrim graduated in 1972, Chance enlisted him for four years. "Chance was real interesting to work for; he stressed the science and engineering of design," says Antrim. "As soon as I walked in the door, Britt wanted me to create a mathematical way to fair lines, which is now common but was not in practice at the time. Our first big projects were the maxi-boat *Ondine* for Huey Long and the 12-Meter *Mariner* for Ted Turner's *America*'s Cup campaign. I learned a lot from *Mariner*, especially about tank testing, which for sailing yachts was still unusual in those days." *[For a discussion of Olin Stephens' landmark development of model testing in the design of sailing yachts, see "Applying Science to Sail," PBB No. 60, page 66—Ed.]*

The ill-fated *Mariner* underscored the embryonic stage of strictly technological design; the boat featured a chopped-off bustle. "Twelve-Meter yachts were getting bigger and heavier," recalls Antrim, "which helped their high-wind performance a lot. And *Mariner* was a big, heavy boat." Surprisingly, tank tests showed no ill effects from the model's severe stern, but because the model was relatively small, its size effectively hid problems only evident at larger scale. Also, says Antrim, "the towing tank locked the boat into a constant speed, so the water flow stabilized around the stern. With no acceleration and deceleration, it looked better than it did in real life. When the actual boat tried to accelerate out of a tack, big heavy vortexes rolled off the stern. It was awful." The tank didn't introduce waves, either. "Any sailboat constantly accelerates and decelerates in response to every puff and wave, especially upwind," adds Antrim. "*Mariner* just never stabilized." The *Mariner* lesson did not weaken Antrim's enthusiasm for enlightened engineering and other modern design tools; but it did highlight the need to meld the theoretical with the empirical.

Nevertheless, the gap between theory and practice offered ways to beat the rules. The early IOR credited centerboards. Why? Because it was assumed they had less stability than deep-keel boats. So Carter created novel boats (like *Red Rooster*) with swinging ballasted keels to capture the rating advantage without any effective penalty. The IOR tried to close the loophole, but Chance—and others—produced boats like his one-ton world champ *Resolute Salmon*, which matched heavier displacement with unballasted boards, delivering equal stability but deeper draft and better upwind performance.

Gary Mull, Antrim's third mentor, was attracted to Antrim's board experience, and Antrim wanted to move to the West Coast anyway. "What was great about Mull's office was that his personality was the polar opposite of Chance's," Antrim remembers. "Mull was intent on generating drawings and getting them out the door. 'This is how we make our money,' was Gary's mantra, whereas Britt was more of a perfectionist. In the long run, I'm a lot more like Chance, but the neat thing about Mull's office was that everybody did everything. Because I'd done a lot of rating-analysis and performance-prediction work, that's what I concentrated on, but I also engineered structures and drew lines, decks, and interiors. In three years I worked on about 30 boats, mostly IOR racers like *Hot Flash*, a one-ton champion, plus a few Six-Meters and several production boats. It gave me a broad exposure to all aspects of the design process."

Antrim would never be fulfilled

ULTIMATE SAILBOATS

***Left and facing page**—When it comes to sailing craft, Jim Antrim **(inset)** prefers performance, and the higher the better. His Ultimate 20 one-design, a* Sailing World *magazine Boat of the Year when introduced in '94, reveals Antrim's straightforward approach to speed and simple good looks. He also engineers for other designers (structures, rig components, appendages, drivetrains, etc.).*

working under others, though. "I'd set a life goal to be on my own by the age of 28," he says, "and I was turning 29 in December of 1979, so I left Mull that November." Since then, Antrim has produced everything from a record-shattering electric boat and racing trimaran, to an Open 50 skimming dish, tunnel-hulled RIB, and sampan-like electric barge. "I love variety," he says. "It's not very profitable because you have to keep learning new things all the time; you can never charge enough for the time you spend. But, it certainly keeps it all interesting, and there's a great deal of cross fertilization."

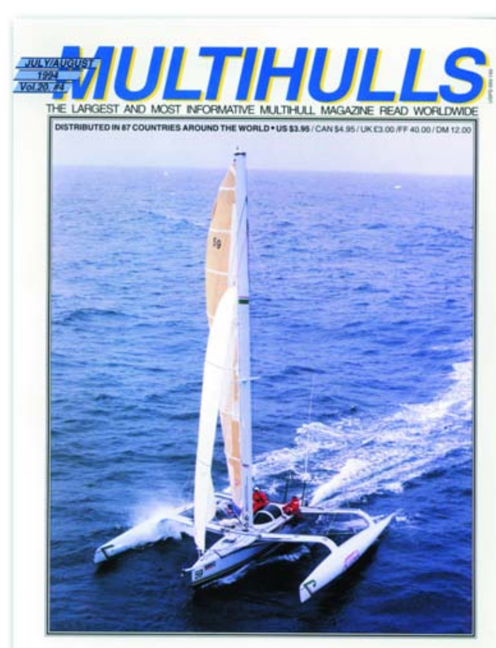
Often, designers who've succeeded have built careers on an early breakthrough boat that they then refine for decades. While Antrim awaited his breakthrough commission he engineered composite structures for others. But that didn't diminish his appreciation for honing the fun factor of any recreational boat design, by making it lighter, stronger, and stiffer. "Something I learned from Mull was that you not only have to design something strong enough; it also has to be stiff enough. That seems obvious now, but it was a revelation then."

Antrim, like many of his contemporaries, says that, basically, "I use ABS [American Bureau of Shipping] scantling rules—along with my own fudge factors. We all still use static analysis. Things like Herreshoff's and Nevin's Rules are based on so much background that it would be stupid to ignore them as historical benchmarks. Still, loads ultimately depend on dynamics. What's the boat's life span, its potential speed, and the worst wave it will encounter? Okay, so it has to be going a certain speed to launch up a wave of a given height, and that wave has to be a specific length to be X high, so what's the farthest you're going to drop and how fast are you going when you hit the bottom?" This approach, he says, supersedes the old days when designers waited to see what broke and made it just a little stronger. "Whereas before you couldn't translate empirical evidence from a 30- to a 40-footer [9.1 to 12.2m], and certainly not to a 100-footer [30.5m], *now* you can fit a theory to empirical data points. Consequently, you can engineer different kinds of boats and different sizes with a lot more confidence. You must have some science behind you before you can escape the 'what broke' envelope. That was Chance's approach, and I guess I got a lot of my design philosophy from him."

Today, Antrim continues to employ his engineering skills for others as well as for his own work, a good example being design colleague and El Sobrante, California, neighbor Tom Wylie. Antrim has engineered structures such as rudders, keels, bulbs, and wishbone booms on Wylie-designed boats. *[See "Native Son," a profile of Tom Wylie and his work, in PBB No. 75, page 38—Ed.]* For Disneyland, Antrim engineered scantlings for their Splash Mountain log ride. And for composites companies, such as Orcon and Knytex (now owned by Hexcel), he wrote composite-engineering software and with it designed everything from a composite aircraft tail, blimp passenger car, and helicopter rotor blade, to an Olympic bicycle, a skateboard, and advanced auto-bodies. Antrim also wrote the PBJ sandwich-laminate engineering analysis program offered by Sandwich Software. Antrim's diversified engineering practice has done more than just keep bread on the table; in recent years, it has allowed him to design remarkable powerboats and sailboats with both single and multiple hulls. Although his portfolio is not yet broad enough to invite direct comparisons to an acknowledged master such as Nathaniel Herreshoff, the so-called Wizard of Bristol—the rare designer who succeeded in all nautical realms—Antrim has nevertheless earned the nickname, "the Wizard of El Sobrante."

Antrim spun his first bit of magic for offshore multihull racer Peter Hogg with the 40′ (12.2m) trimaran *Aotea*, launched April 1990. Virtually right out of the box, she set a singlehanded record to Hawaii of under nine days. In 1992, while Antrim was engineering *America*^{3} for Bill Koch's *America*'s Cup campaign, Hogg set a 34-day transpacific record from San Francisco to Japan. *Aotea* featured both sophistication and simplicity. At first glance, the tall wing mast, large-roach mainsail, small jib, arched beams, plumbish skinny bows, and round, big-volume 'midship sections all appeared borrowed from winners on the European circuit. But close inspection reveals important divergences.

Although light displacement helps boats exceed the rather slow hull speeds relegated to heavy-displacement craft, most multihull designers also choose thin hull sections that more easily accelerate through bow waves to exceed hull speed. Skinny, deep sections soften the multihull's ride in waves, but the aft sections provide little resistance to pitching, a particular problem in multis. And, the hulls are sensitive to loading. Shallow flat sections, like those found in light-displacement monohulls, bounce more on the water's surface, but they easily surf and plane, and they provide more pounds of load per inch of immersion. Both extremes carry substantial wetted surface area. To attain the best all-around compromise, most multihull designers have gravitated toward roughly semicircular sections. To optimize reaching speeds, many European racing trimarans now feature immense tubular outer hulls with



The 40′ (12.2m) custom trimaran Aotea *made a sensational debut in 1990, setting a singlehanded record from California to Hawaii— right out of the box. Two years later the boat set a transpacific record from San Francisco to Japan.*

TOM MCDERMOTT/MULTIHULLS MAGAZINE

almost no rocker and lots of volume throughout their length. They're very fast reaching in flat waters. Upwind in bigger seas and offshore, however, these boats tend to give a hard ride.

To maximize his amas' performance whether they were being driven deeply into the water in heavy airs or prancing across it in light winds, Antrim carefully considered the bow and stern shapes separately. *Aotea*'s outer hulls exhibit significant rocker aft, so the after sections add no wetted surface in near calms. The increasingly elliptical sections oriented laterally give the floats unusually flat exits and high reserve buoyancy once pressed. Antrim says, "This is a crossover from different kinds of boats. The conventional thinking used to be that a trimaran's amas always should have fine, skinny sterns in order not to generate considerable drag when the boat is pitching. But in a monohull, you would never make a skinny stern because the boat will then pitch a lot. I thought wide sterns would reduce high-speed resistance while also dampening pitching. It worked.

"My studies," continues Antrim, "also taught me that the windage of a multihull is a huge percentage of total drag. You don't think about that in a monohull, but in a multihull it's as big as the wave-making drag. That was part of the logic. If you don't need the volume back there for any hydrodynamic purpose, then why have the weight, cost, and windage?" Finally, with less volume aft but a full 200% of the boat's displacement carried in ama volume, *Aotea*'s amas are fuller toward the center of volume about a third of the way aft of the bow, which shifts slightly forward as the boat heels to keep the rudder in the water and lift the nose a touch. At speed, the big flattish sections forward encourage surfing and planing.

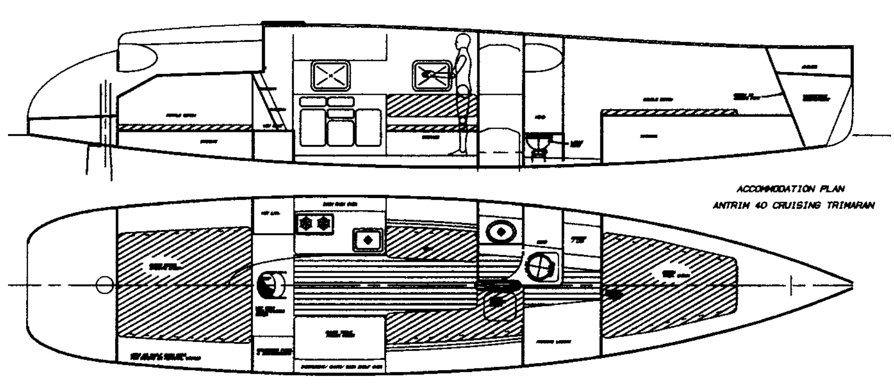
Aotea's overall beam also was more modest than those on European racers. Antrim credits multihull designer Peter Wormwood's wisdom: "When you don't know whether the boat will first capsize, pitchpole, or go over the corner, then you have everything right." To which Antrim adds, "I think it's better to capsize first. Pitchpoling is less easy to control and a little more dramatic." In European round-the-buoys racing, crews usually fly the main hulls of their trimarans as soon as possible. A full crew can trim sails constantly to keep the boat from capsizing or pitchpoling. The result? Boats roughly as wide as they are long. "The beams get frigging gigantic," Antrim notes. "It's amazing how big they are. I can't believe that's right, even though they're very light. For whatever reason, the Europeans figure that light weight is far more important than minimal windage."

Cruising boats and shorthanded racers, especially those like *Aotea* with a single rudder on the main hull, favor keeping the main hull in the water. Also, *Aotea* would use a rig off Hogg's previous boat, and so, says Antrim, "she was undercanvased," allowing narrower width. As Antrim pared her overall beam to 32′ (9.7m), the loads on the structural beams shrank, allowing him to reduce the frontal area and weight of those members, though he was willing to add a bit of weight in order to minimize the beams' frontal profile even more. In the end, Antrim recognizes that he may have gone too far: *Aotea* cracked a beam after falling about 30′ (9.1m) off a wave and landing on one ama bow. Since then, Antrim's designs present somewhat bigger beam sections, but he has retained a similar overall beam-to-length ratio for all his trimarans, which allows him to use structural beams that are lighter and smaller in section than those found on the typical Euroracer.

Antrim humbly points out that *Aotea*'s records required surprisingly moderate speeds, often shy of the teens. *Aotea* never logged more than 26.5 knots "because the speedometer lifted out of the water at that stage," and probably never surpassed 30 except for brief periods. "But," he adds, "she would stay at 20 knots for half an hour at a time. At first, Peter would lie in his bunk until the speed got over 20 knots; then he'd wake up and check things out. After a while, he'd let it go to 22, 23."

That was more than sufficient for the records Hogg chose to break. Still, the question remains: How would Antrim's design approach measure up in the hotly competitive European circuit? The answer to that is something Antrim would like the opportunity to discover. "It's on the water that you find out whether your performance studies are right," he says. "I'm envious of the whole European multihull scene. It's great to get feedback from racing against comparable boats." With a 28′ (8.5m) trimaran currently under construction in New York, and a 40′ (12.2m) racer-cruiser being built in Quebec, Canada (both due to be launched in 2002), as well as a 40′ cruiser recently begun, Antrim-designed multihulls will soon reach the East Coast to finally begin to provide answers.

Generally speaking, *Aotea*'s primary features appear on all his trimaran designs since, including the Antrim 30, a semi-production racer-cruiser that has finished first in a number of regattas where there have been hundreds of entries. The folding-beam F-series of tris designed by Australian Ian Farrier have dominated the larger trailer-sailer multihull market, but Antrim and Ron Moore (a West Coast designer well known for his innovative Moore 24) believe that Antrim's approach could be faster, drier, and more commodious.



ANTRIM ASSOCIATES

This custom 40′ (12.2m) racer/cruiser trimaran is being built in Quebec. Note the headroom in a hull type considered notorious for its cramped conditions.

*One of the most challenging design problems in multihulls has been figuring out how to fold the boat for storage and/or trailering—without compromising strength and performance under sail. Antrim's elegant solution is a "swing-wing" 30-footer (9.1m). Note the critical hull-connection **(inset, left)**, the track-mounted auxiliary outboard **(inset, right)**, and the space-saving whipstaff tiller **(below, left)**.*

STEVE CALLAHAN

Windage may be bad, but nothing is as slow as dragging through the water deck edges, beam ends, or the connective struts or stays peculiar to most folding multihulls. By choosing a swing-wing design, the Antrim 30's main hull did not have to be hollowed out to accept folded amas, and the amas could be bigger as well. The boat sits higher off the water and provides more power.

Just aft of the forward beam—where heeling forces center and the ama looks inflated to the point of bursting—a canted, asymmetrical daggerboard lends additional lift both horizontally and vertically. "Lift from the board helps keep the ama's nose up," says Antrim, "which gives the board a better positive angle of attack. We can be hard-reaching with the boat totally planing and the leeward ama bow out of the water." Also, this way no centerboard impinges on the main-hull accommodations. Antrim, though, confesses to "some negatives I didn't anticipate. If you leave both boards down, they give so much directional stability that it becomes physically difficult to turn the boat off course. You get stuck in irons when you're tacking. We've learned to pull up the leeward board as we go into the tack and the boat starts to roll, then drop the new one after the boat has settled on course."

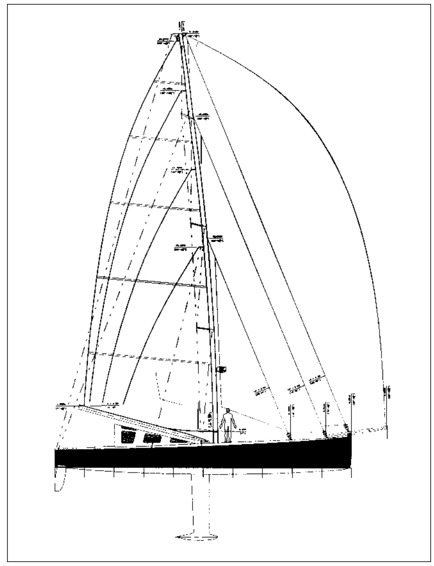
STEVE CALLAHAN

The 30 illustrates several additional Antrim touches, too. The outboard motor bracket runs along dual genoa tracks, like a railway. When not in use, the engine raises and flips forward where it slides across the stern scoop to shelter, thereby taking weight off the transom. Inspired by a 1970 Chance quarter-tonner, Antrim gave the whipstaff a renaissance. The vertical tiller provides the same leverage as a horizontal one, but it does not sweep the cockpit, giving the crew more room to work. The rudder quadrant's cables turn through blocks to a second quadrant, the hub of which is a tube that pierces the bulkhead, sits in a trough, and is welded to the whipstaff. The tube serves as both tiller fulcrum and large cockpit scupper. Antrim believes using rudders on the ama sterns would help make the steering "lighter and more joyful, like on my other boats," and he is employing these in future designs. But, he chose to keep a single rudder on the 30's main hull to reduce production costs and facilitate folding the boat. After releasing a guy wire, the crew can swing the amas—set into matching tapered sockets in the main hull—forward and inboard. "It's a bit clumsy," he admits, "and intended only for occasional trailering. But you can complete the procedure in less than 10 minutes. The boat floats in the water fine with the amas pulled in; you can dock her in a narrow berth."

Antrim also responsibly addressed the practical considerations of grounding, a special problem for deep, vertical foils. To keep hulls from splitting on impact, some designers employ crash boxes behind

COURTESY JIM ANTRIM

An Ultimate 20, like the one in the opening spread, at speed. The success of the 20 and 27 prompted Ultimate Sailboats to commission Jim Antrim to design 24- (7.3m) and 34- (10.4m) footers for its product line.



ANTRIM ASSOCIATES (BOTH)

These side-by-side profile views of an Antrim 27 and an Antrim-designed Open 50 show some of the crossover between a civilian production performance sailboat and a custom ocean racer intended for shorthanded sailing. For Antrim's detailed explanation of the so-called trickledown effect of raceboat technology, see his essay on page 73.

the boards. Antrim prefers Kevlar "grounding straps" looped around the foil's aft edge at the bottom and bonded into the hull forward. "Kevlar," he says, "may not be great for everything, but it's terrific in straight tension and, unlike carbon or glass, its rubbery tenacity is very good at absorbing impact," noting that *Aotea* survived a grounding at 15 knots. Antrim's 30 and even his Open 50 monohull, which we'll look at in a moment, feature similar schemes. On the 30, the rudder too is fitted into a kick-up cassette.

While working on his 30, Antrim caught Jeff Canepa's eye. Canepa, who'd bought molds for the Hotfoot 20, asked Antrim to do a redesign. Except for the hull, the Ultimate 20 turned out to be a whole new boat, and as such was chosen Boat of the Year in 1994 by *Sailing World* magazine, which covers performance sailing exclusively. Ultimate Sailboats (Santa Cruz, California) had good reason, therefore, to hire Antrim again; this time he responded with a wholly original 27-footer (8.2m) whose speed and surefootedness have inspired a loyal and enthusiastic following.

There's nothing drastic about the 27's hull shape. Antrim continues to

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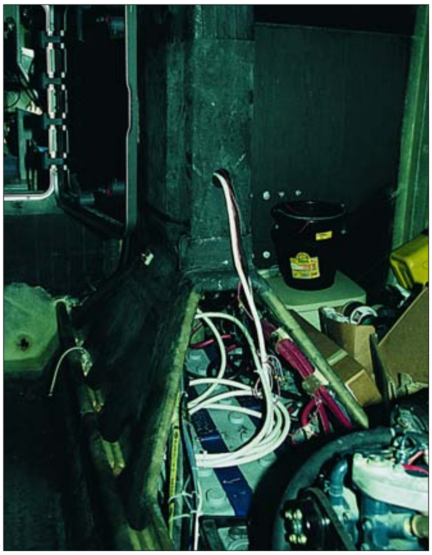
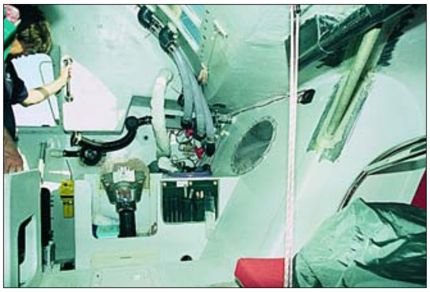
Antrim's long-legged Open 50 design, Everest Horizontal *(ex-*Convergence*), reveals why some observers have characterized her as "a surfboard with a sail." The boat, built of pre-preg carbon and balsa core by Jim Betts Enterprises, will soon be tested on the rigorous round-the-world singlehanded race circuit.*

stress the importance of balance and of keeping the nose up. The boat is beamy with a flattish bottom, especially aft, a wide transom, and slight flare and overhang at the bow. Deck edges are well rounded, making hiking out more comfortable. The boat possesses great stability thanks to a deep keel with bulb, but the crew can raise this unit (by means of a removable crane) for easy trailering.

Jim Antrim prefers rigs that employ only big mainsails; single-blade, self-tacking jibs; and asymmetrical spinnakers flown from an articulating bowsprit. His 27 conforms in all respects but one: the tiny jib is not self-tacking. With no rule-encouraged overlapping genoas, the double spreaders are long, reducing mast compression loads and mast section size, and they're swept back to triangulate the loads without the need for a backstay. Even so, the boat has proven so powerful that crews have pushed the rig past its design parameters, and carbon masts are replacing aluminum. Tacked to the centerline, asymmetrical chutes are highly efficient reaching, but they become blanketed by the mainsail as the boat heads more downwind. A 27's crew can winch the butt of the bowsprit to port or starboard 25° to either side, which swings the spinnaker tack out



STEVE CALLAHAN



STEVE CALLAHAN

*Interior views of the Open 50. **Top—**The centerline beam and pyramid pod tie together keel, deck, and mast. **Bottom—**A cleverly conceived water-ballast system will reright the capsized boat, even if the lead ballast and mast have been lost.*

to weather about 15° from the mast, allowing the boat to sail faster farther off the wind. Safety, too, is enhanced by keeping the sprit on deck. "With the 27," Antrim says, "if you break your pole out in the ocean, you don't have to worry about a huge hole in the hull."

Few would consider the 27 an offshore boat, but Antrim and two friends entered one in the 2000 Pacific Cup race. "It was the most fun race of my life," he says. "Like sailing a dinghy to Hawaii." Despite being the smallest boat in the PHRF class, which otherwise included boats between 38′ and 53′ (11.6m and 16.1m) in length, the 27 finished first boat for boat, and seventh in the entire fleet (81 in all). "Second place in our class was a Farr one-tonner that finished 22 hours behind us," Antrim remembers. No wonder that Ultimate Sailboats is launching a 24′ (7.3m) sister and has begun plans for a 34 (10.4m) as well, or that Antrim is planning another 27 Pacific campaign this year.

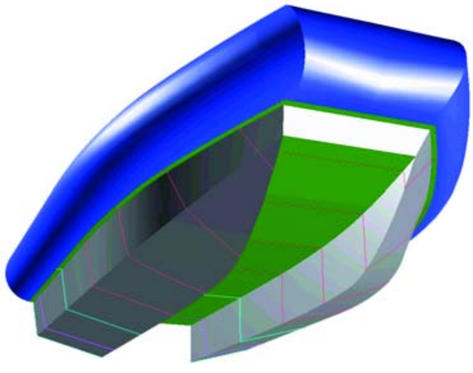
Jim Antrim is also anxious to find out if his 50′ (15.2m) surfboard-with-a-sail will prove the ultimate offshore toy. Antrim's Open-class 50, built of pre-preg carbon and balsa core by Jim Betts Enterprises (Truckee, California), has plumb ends, a deep keel with bulb, water ballast, and extreme beam, but her bottom makes the dominant Groupe Finot standard look positively rotund. Antrim pulled in the stern some, to balance a bow that is sharp close to the water before flaring toward the deck, "like a chipmunk with nuts in its mouth," he says. She employs an articulating sprit not unlike the 27's. Antrim has positioned the water ballast tanks well aft, the intention being to keep the nose up. With this system, he hopes the boat's crew will be able to push harder downwind, and that the somewhat more balanced lines combined with rudders canted 15° will make the boat more forgiving upwind and when reaching.

The 50's rig is non-rotating and rather conventional. She has no swinging keel. "Anything that is apt to break is suspect," he says, "especially in the Vendée Globe [round-the-world singlehanded race], which is such a war of attrition. A swinging keel is potentially faster, but it's certainly a lot more prone to breakdowns." Indeed, safety is Antrim's utmost concern. With mast intact and water ballast in one tank, the boat will automatically re-right from a complete roll. Her high deckhouse, sealed mast, and buoyant bow lend re-righting forces, while the carved-out cockpit that lets the volume free-flood, and the highly rounded deck edge, reduce resistance to re-righting. Even with no water ballast and the mast ripped off, the range of stability upside down is quite narrow; but if ever the crew is trapped in an overturned hull, they can re-plumb the ballast tanks, fill one, and then re-right the boat. To handle structural loads, the boat contains an immense centerline carbon keelson beam and a big A-frame that ties mast and deck to keel, around which Antrim specified laminated grounding straps. "We haven't pushed this boat very hard yet," Antrim says, noting it has sailed only to the 20-knot range, and it missed the last Vendee Globe. But a new owner is now tuning her up for this year's Around Alone race, a nonstop single-handed circumnavigation. *[For a discussion of this particular Open 50 design, and photos of her under construction, see PBB No. 65, page 24—Ed.]*

Antrim's primary love for sail hasn't kept him from powerboats, whose hullforms he increasingly sees as being applicable to high-speed sail. He's designed, or re-designed, rather conventional power craft, including a houseboat the nose of which he replaced with a shapely, longer bow. When the Monterey Bay (California) Aquarium Research Institute needed a rigid inflatable boat (RIB) to collect samples and store aboard its SWATH (single waterplane area twin hull) research vessel, the institute turned to Antrim to maximize the potential of the 14′ x 8.5′ (4.3m x 2.6m) storage space. "I started drawing a conventional V-bottomed RIB," Jim says, "but it got so wide and flat that I knew it would be terrible, so I ended up doing a tunnel-hulled RIB catamaran," a design he subsequently expanded to 22′ (6.7m) for Rutherford's Boat Works (Richmond, California).

Antrim's arguably most interesting powerboat projects center on electric power, including a recent sampan-like barge for Oracle software founder Larry Ellison. The boat serves Ellison's home, set between twin man-made lakes linked by a waterfall and connective canal system.

"Right now," says Antrim, "I don't think you can generate enough energy for an offshore boat. Their range is limited. It's going to take a giant breakthrough in batteries or fuel cells, but that's coming. In the mean-



ANTRIM ASSOCIATES

This small but roomy tunnel-hulled RIB stows aboard a marine research vessel that serves as a mother ship. The boat is Antrim's innovative response to a design brief that called for a deployable RIB whose overall dimensions (14' x 8.5' [4.3m x 2.6m]) were dictated by the deck space available to it.

time, electric boats are clean and quiet and are terrific for a lake or harbor." Antrim's involvement in electric boats began when Duffy Electric Boat Company (Newport Beach, California), a pioneer in that realm, asked Antrim to create a vessel to break both the speed and duration records for electric boats. "The design brief," recalls Antrim, "was for a boat capable of going from Newport Beach to Catalina Island and back in five hours at 12 knots. So I went through a bunch of trade-offs between length and displacement, beam-to-length ratios, and battery weight." *Duffy Voyager*, as the finished product was named, ended up a wave-piercing water spider 62′ (18.9m) long and 19′ (5.8m) wide, with tiny stabilizing floats, not unlike the power trimaran *iLAN Voyager*, Nigel Irens' 70′ (21.3m) design that broke the Round Britain powerboat record on her first attempt in 1988. "The *Duffy Voyager*," says Antrim, "is essentially a streamlined battery box. She accelerates like a bat out of hell. It's eerie to watch her silently leap forward in the water."

He believes the boat would have been even more successful had the client employed Antrim's original choice of prop, a large-diameter (21″, or 53.3cm) two-blade with small blade area. Instead, Duffy installed a three-blade, 18″ (45.7cm) bronze wheel. "I was disappointed," says Antrim. "They also installed a Yamaha sail-drive unit instead of the custom belt-operated drive that I had designed, which would have offered lower friction. I'm sure we lost a knot and a half. If you changed the prop and drained the batteries in a half hour, you could do about 20 knots.

"At 12 knots, you could go five to six hours. The record was set at 10-something, utilizing 12-hp, 72 volts, 140 amps." *[For more on the* Duffy Voyager*, see "Rovings", PBB No. 50, page 13;*

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TIM WILKES

Owslarah, *an Antrim 27, screaming along at Key West Race Week.*

The Trickledown Theory

How do boats in the recreational marine market benefit from developments in raceboats?

by Jim Antrim

From a design point of view, four general principles help a raceboat reach the finish line first: light weight, efficiency, ease of handling, and pushing the limits. There's a good deal of crossover among these principles, but let's try to look at each one.

Light weight improves the performance of a boat in many ways. Starting with the obvious, a light boat is easier to propel through the water. In a monohull sailboat, a light structure can carry more ballast; but less ballast is needed because a smaller rig can drive the boat. Powerboats also benefit from light weight—not only in the structure, but in the power plant. An engine with a high power-to-weight ratio reduces vessel weight, which means either that less power is required, or more speed is possible. Light structures can make for more seakindly boats. Light masts, bowsprits, and rudders concentrate the weight toward the pitching center and mitigate hobby-horsing tendencies. Light structures develop lower loads, which is easier on gear, reduces wear on sheets and hardware, and makes the loads more

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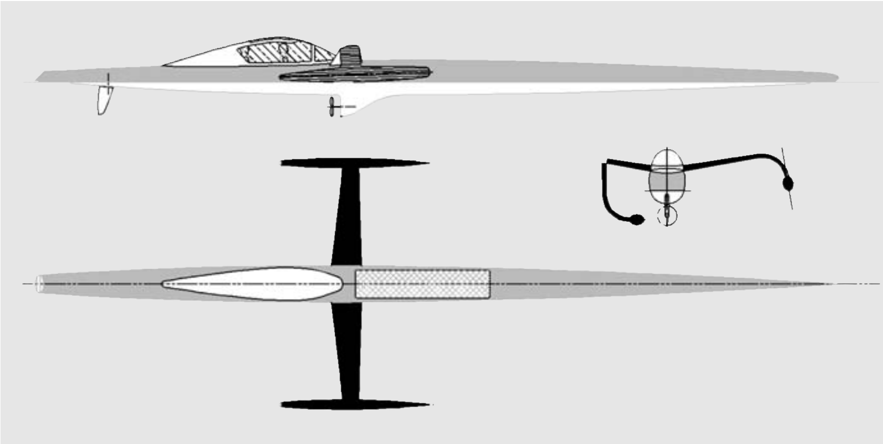


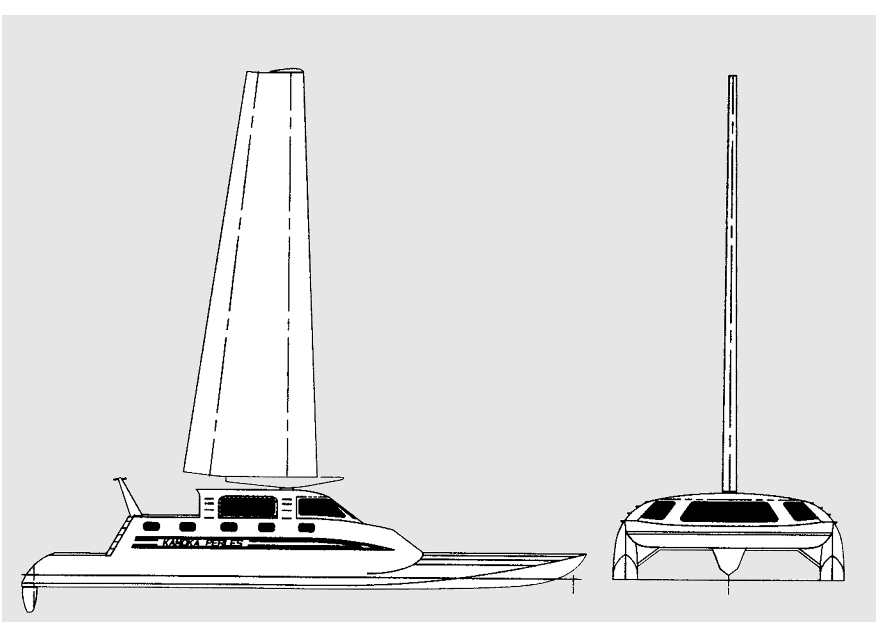
ANTRIM ASSOCIATES

Antrim co-designed (with fellow Californian Alex Kozloff) the water-spider-like Duffy Voyager, a 62' (18.9m) wave-piercer intended to demonstrate the viability of efficient electric propulsion. According to Antrim's original engineering (versus the as-built boat), the craft is capable of 20 knots.

and for more on the Irens-designed iLAN Voyager*, see PBB No. 63, page 86—Ed.]*

Duffy Voyager's wave-piercing hull shapes worked, "but," says Antrim, "their desirability depends a lot on where they're used. When the first 'wave piercer' rode down a wave and drove its bows in, some designers decided to add a powerboat bow hanging between the hulls to add reserve buoyancy. That demi-hull is not great, in my opinion, in big ocean waves, and doesn't make much sense for sailboats under normal circumstances, because a sailboat's center of effort up in the air is always trying to drive the bow under. But, wave piercers are terrific in short waves, like you find in the Caribbean, and for powerboats because the center of thrust is low." Antrim regards his own trimaran bows as "semi-wave piercers" by comparison, because they go through the wave without slowing down much, but retain enough reserve buoyancy to prevent deep diving. He believes the structural complexities of a long skinny nose, the vortices that develop as the bow plunges and rises, and sympathetic resonances may have conspired to cause the notorious catastrophic hull failure experienced by *Team Philips*, a carbon fiber mega-cat wave-piercer abandoned at sea en route to the start of The Race in Barcelona, Spain, in December 2000. "Those problems are all solvable," says Antrim. "But if a guy wants to cross an ocean, I don't think I'd recommend a wave piercer; reserve buoyancy is a good thing to have out there."

Antrim's most aggressive oceanic design to date was commissioned by, in his words, "an unusual and creative French pearl farmer." The client wishes to commute at 20 knots between Tahiti and the Tuamotos, so Antrim designed a semi-wave-piercing motorsailer with a solid wing-mast. "There is nothing ordinary about this boat," Antrim insists. A single engine drives a surface prop and is positioned amidships to free the hulls for accommodations. In the tradewinds, the wing supplies a nice assist to the engine, saving fuel and adding speed. Three hydraulic controls—trim tab, camber, and tilt fore and aft—keep the wing trimmed without a sheet. Antrim recently returned from a shakedown and swears the wing and boat remain docile and steady even at anchor in light or heavy winds, thanks to the rig's balance, along with custom bearings made of Delrin rollers in carbon races.



ANTRIM ASSOCIATES

Te Marama *is a 72' (22m) custom commuter-cat currently in service in the South Pacific. The boat is a semi-wave-piercing motorsailer, fitted with a solid wing mast, and a single engine amidships that powers a surface prop. Antrim is pleased with her ride, stability, and 20-knot performance.*

Jim Antrim has said he doesn't like the word "can't." That's evident throughout his work. What isn't truly progressive in modern boat design, he calls "goofy," but it's all part of the fun. As Antrim's boats appear on the East Coast (where he originated) and beyond, we'll enjoy the show. PBB

About the Author: *Steve Callahan has designed and built a number of boats, authored several books, and written widely in the nautical press on modern sailing design, designers, and technologies. He also routinely voyages offshore.*

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manageable for the crew.

The benefits of light weight are obvious for a racing boat. But how about for cruising boats? Increased speed, made possible by reduced weight, may allow a cruiser to escape from a bad weather system, or simply to make a passage more quickly and spend more time at its destination. And, for the cruiser, light weight means more payload capacity. Every cruising sailor appreciates the ability to carry more "stuff."

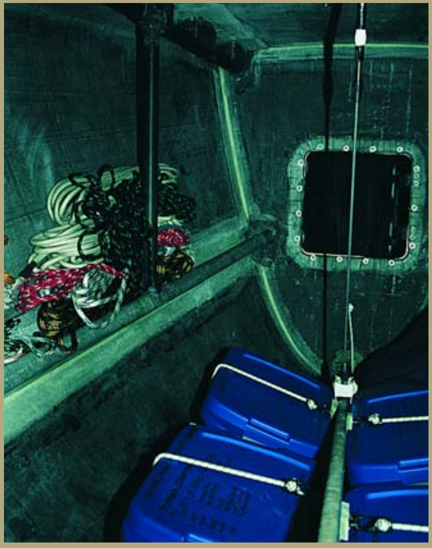
Efficiency can take many forms. Efficient engineering reduces weight by eliminating unnecessary structure. The strength of the hull and deck should be in proportion to the loads applied: more strength near the chainplates, maststep, and engine bed. A finite-element map of the hull shell shows highly stressed areas in red and low-stress areas in blue; but in an efficiently engineered structure, the variations between high-stress and low-stress areas should be small.

Examples of efficient hardware design are low-friction blocks and winches, which reduce the effort required from the crew. Efficiency in deck layout entails well-thought-out gear arrangements that make maneuvering simpler. Faster, easier sail changes get a raceboat to the finish line earlier, and make sailing more enjoyable for the average leisure sailor.

Ease of handing is related to light weight and efficient design. Light boats with efficient gear and layouts will be easy to handle.

Most of the improvements in sailing rigs come from race arenas that have limited crew size. An *America's* Cup boat has a relatively large and certainly well-coordinated and practiced crew. Likewise, rules such as CCA, IOR, and IMS have essentially dictated rigs with overlapping genoas and a wide array of headsails. Consequently, a big crew is needed for sail changes and mark roundings, as well as for righting moment.

Short-handed racers such as boats in the Vendée Globe and Around Alone races, by contrast, have generated a wealth of innovations that have turned up on recreational boats. There is not much similarity in outward appearance between a



STEVE CALLAHAN

The stark interior of the Antrim-designed, Betts-built Everest Horizontal *showcases her carbon construction. Some new performance cruisers now emulate this pure-raceboat "look" down below.*

cruising sailboat and an Open 60, but you'd better believe there is a demand for simplicity, reliability, and ease of handling when one man or woman sails such high-powered racers over long distances through the Southern Ocean. In these boats, evolutionary design has been rewarded, rather than penalized.

Not all innovations, by the way, go from raceboat to cruiser. Sometimes the reverse is true. The asymmetric spinnaker, for example, started as a gennaker for cruisers. Roller furling, now almost universal on shorthanded ocean racers, came originally from the cruising-boat market. In both cases, though, hard service on racing boats has rapidly advanced the design and technology of such features, which in turn has improved the products available to the recreational market.

The spinnaker snuffer is another invention from cruising that is almost essential to the shorthanded racer. Because racers use them in tougher climates and tend to wait longer in building-wind situations to douse the spinnaker, racing has pushed design and technique improvement at a rapid pace. Racers may also be more vocal in their complaints. When cruisers mess up the snuffer douse, they might just figure they did it wrong and stuff the sail back in the forepeak. The same problem on a raceboat might inspire the owner to roll down to his sailmaker and start squeaking for some axle grease.

Because extra weight is detrimental to multihull performance, racing multihulls tend to have much smaller crews than monohulls of similar length; multihull design therefore demands simple, efficient sailing rigs. Many of the features we see in sport boats and other high-performance monohulls today made their first appearance in the multihull fleet. Asymmetric spinnakers are a perfect example. This wonderful invention is still most suitable for light, high-performance boats that generate lots of apparent wind. It is remarkably more efficient than a symmetric spinnaker on a reach. Not many cruisers fit the "light, high-performance" description, but the fact that an asymmetric spinnaker is much easier to jibe than a symmetric spinnaker has definite appeal.

Fully battened mainsails were first popularized in multihull and high-performance dinghy fleets such as the Australian 18 skiffs. The motivation was efficiency; full-length battens can support a roachy mainsail with a better lift distribution than a triangular profile. Then it soon became clear that a fully battened main could cover a broader wind range before requiring a reef, since the sail flogs less when it is bladed out. A sail that is trailing quietly develops far less drag than a flogging sail. And, a sail that doesn't flog is going to last much longer than one that spends its life simulating a flag. That's something that racing *and* cruising sailors can relate to—how far can my dollar go?

Pushing the limit is part and parcel of successful racing design. There is some truth to the old joke that the ultimate raceboat is the one that sinks right after it gets the finishing gun; it won the race because it was designed right to the limit. Cruising yachtsmen can't afford to push the envelope. They want to be able to go sailing next weekend, too—preferably in the same boat. They are generally risk-averse and slow to adopt new technology. Racers, on the other hand, embrace innovation. At the *America's* Cup level in particular, large design teams and big R&D and design budgets combine to ramp up the rate of advancement. Many brains working on the problem combined with availability of money for testing and evaluation mean rapid progress.

An area of continual development in the racing sailboat realm is in the engineering of new sail fabrics. The majority of this work centers on reducing sail weight and developing sails that hold their shape over a broader wind range. Usually sails made of modern fabrics are more expensive than good old woven Dacron, so where is the benefit to cruisers? Well, lighter sails appeal to everyone. Not long ago, for instance, I remember being unable to move a genoa on a 52' (15.8m) boat by myself. And, if a cruising sailor is also a casual racer, he'll appreciate that sail holding its shape for an extra season. We can also thank long-distance racers for sail durability. Some of those boats now sail around the world non-stop and come back with sails looking as if they were made last week.

Deck hardware is another area where racing has driven huge advancements over the past 20 years. Travelers run more easily, and are more reliable and easier to operate. Winches are lighter, have less friction, and take less work to maintain. Furling gear is tougher and far more dependable. Batten travelers for fully battened mainsails operate more smoothly. Blocks are much lighter and cleaner in design. Snap hooks (usually) open when you want them to and don't when you don't.

Mast-climbing gear has also seen wonderful innovation. If a single-handed ocean racer can make repairs at the top of the mast, so can a weekend sailor. Once again, cruisers usually have crews limited in size and sometimes in experience. It's a relief to the person climbing the mast not to have to rely on someone inex-

COURTESY LATITUDE 38

Antrim's Open 50 is designed to shed water quickly: both the coachroof and radiused deck edge are more pronounced than those found on her European counterparts; a raised pivot ball at the bow, housing the retracting and articulating bowsprit, doubles as a wave break.

perienced on the other end of the line. At a recent boat show, for example, I tried out a mast-climbing system in which you haul a line tight to the top of the mast, then go up the line on a pair of one-way jammers. You sit in the bosun's chair, and your legs do the lifting, working together as they would on a rowing machine.

Sailboats have entered the computer age. The same software that Volvo 60s run in their round-the-world sprint is available to cruisers, too. Onboard computers can receive input from onboard instrumentation and build a performance-prediction profile for the boat. Current weather maps can be downloaded from SSB radio or other sources, and information from these sources can be fed into weather-routing software. Cruisers appreciate avoiding storms and holes as much as the racer does. Last summer I raced an Antrim 27 in the Pacific Cup to Hawaii. On this small, light-displacement yacht, we were receiving weather maps on the laptop and modifying our route plans daily. Some of the less well-informed boats spent a week longer at sea, trapped by a massive hole in the mid-Pacific.

Ocean racing has led the way toward improvement in ship's systems, as well. Watermakers have become an essential piece of equipment for long-distance racing due to the weight savings they make possible. Safety gear, position-location equipment, and advanced communication systems are required under ocean-racing rules, and thus have become more available to the casual sailor. Tragic races such as the 1998 Sydney–Hobart (six boats abandoned, five boats lost) receive a great deal of attention and catalyze the industry to improve safety systems for all sailors.

Again, we can thank Around Alone and Vendée Globe racers for advancements in autopilots. These giant dinghies are very demanding of their primary helmsman—the autopilot. A modern autopilot can sail to a compass course, a constant apparent-wind angle, or an ideal polar performance route, and can make an ocean cruise or weekend sail much easier and more comfortable than was possible only a decade ago.

A now-familiar example of race-boat technology filtering down to the cruising market is the winged keel "invented" for the *America's* Cup by the late Australian racer Ben Lexan. One can still argue its benefits, but this feature is now commonplace in the general marine market. Likewise, the backstayless rig, which goes hand-in-hand with the fully battened mainsail, came from racing dinghies and multihulls. I don't believe there is a single Hunter production boat on the market today that has a backstay. Bulb keels and water ballast, too, are slowly finding limited acceptance in the cruising world.

Probably the most significant transfer of technology from racer to cruiser is in advanced structural materials, and the engineering and construction techniques that go along with them. Here too, the racing client is willing to push the envelope. Once the envelope has been stretched, the designer is more comfortable using the same material or construction technique in his next cruising design.

Carbon fiber masts and booms are an excellent example. Only a few years ago these were exclusively a raceboat feature, but now are increasingly popular among cruisers, particularly large cruisers. Quite possibly, as carbon spars become more common and relative costs decrease, carbon will replace aluminum, as aluminum once replaced wood. The advantages of carbon are significant. Substantial weight savings where it really counts—up high and away from the center of gravity—increases righting moment and gives better weight concentration. Carbon masts are typically about 40% lighter than aluminum. Boats with these spars are faster, safer, and have a better feel. Composite materials are best when the load path is predictable and when parts are weight sensitive. Masts are the most weight-critical part of the boat, and the load direction is obvious—straight down the tube.

Carbon rudders and rudder posts are becoming more popular in the recreational marine market. Aside from saving weight in the ends of the boat, the strength and stiffness of carbon allows the rudder blade to be narrower, which reduces drag and gives the helm, as above, a better feel.

Carbon bowsprits and spinnaker poles meet the criteria of being weight sensitive and having a predictable load path. Anyone who has ever lifted a spinnaker pole on a big boat will be easily convinced of the value of carbon in that function.

Composite chainplates, while not yet appropriate for the general market because of labor expense and builder skill level required, do have one huge advantage—no leaks. That feature, combined with reduced corrosion problems, may help make composite chainplates more attractive to the cruising market.

Cored construction was once viewed as expensive and limited to the raceboat market. Gradually almost everyone saw the benefits of a light, stiff structure, and now sandwich construction is no longer exotic.

Parts that used to be built with wet-laminate carbon—masts and rudderposts, for example—are now often built with pre-pregs. Undoubtedly, as prices converge and building technology spreads, pre-preg hulls and decks, too, will become less exotic. This is a familiar story in the trickle-down of technology. A builder will take on a major raceboat project as its first pre-preg boat. Eventually the shop builds a cruising boat in pre-preg. The bugs get worked out and systems put in place, and pre-preg becomes the builder's standard construction method. PBB

About the Author: *Jim Antrim is the principal of Antrim Associates, a design-and-engineering firm based in El Sobrante, California, and known for its performance multi- and monohulls for sail, and innovative powerboats, including electric-powered ones. A detailed profile of Antrim and his work begins on page 60.*

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