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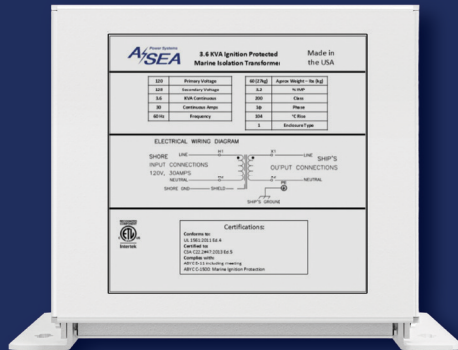
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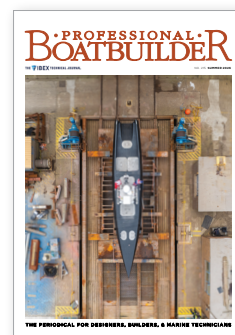
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On the cover: The second Oceanus 12 from ZeroUSV (Plymouth, U.K.) is readied for launch. Named *Viper*, the all-black unmanned vessel, with an advertised range of 2,500 nm at 7 knots or 3,400 nm at 3.5 knots, will be available for commercial charter from Leeway Marine based in Halifax, Nova Scotia. Story on page 40.

Photograph courtesy of ZeroUSV.



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FROM THE EDITOR

Boats Without People

The first boat I saw that remotely fits the category of an unmanned watercraft was a model of a windmill-powered catamaran created by Camden, Maine-based polymath Havilah Hawkins Sr. On a visit to his shop in the mid-1980s he explained to my teenaged self how the simple angled shaft with big fan blades in the air on the upper end and a small propeller in the water at the other would track directly and unerringly to windward, as the wind blades that drove the shaft also caused the boat to weathercock while the propeller simultaneously pulled the boat forward. Although the model's range of unmanned performance was very limited, its simple, mechanically determined program to always track upwind meant it would reliably change course to match the conditions without someone onboard or steering through radio controls directing it. I was fascinated.

That idea of a boat navigating doggedly upwind unencumbered by limitations of human endurance or blessing of human judgment was the impetus behind Amsterdam-based artist Wipke Iwersen's "Expedition to the Origin of the Wind" project that *Professional BoatBuilder's* founding publisher Carl Cramer introduced me to in 2009. Built on the same premise as Hawkins' windmill boat, Iwersen's *Windvinder* was a whimsical-looking skin-on-frame multihull she launched on an unmanned voyage in the open ocean, perpetually powered by a wind-driven propeller. While the relatively delicate fabric-and-wood structure was likely to be destroyed by any impact, I remember thinking that however inspired the artistic conceit, the boat had no navigation lights and failed to meet other international COLREGS requirements to prevent collisions at sea. And although the vessel was unmanned, it was not exactly adrift, as it was perpetually traveling upwind. Any sailor encountering it would be perplexed by the autonomous behavior of the *Windvinder*.

The scale of and potential risk from Iwersen's unmanned vessel seem quaint in comparison to the unmanned surface vehicles (USVs) that proliferate monthly in 2026. For example, on April 20, Saildrone introduced its 170-foot (52m) Spectre model USV. The 277-ton wind-, solar-, and diesel-powered vessel capable of 30 knots is built to ABS standards, complies with High-Speed Naval Craft certification, can carry a payload of as much as 77 tons, and can accommodate twin shipping containers. While the company states that the model "is fully capable of complying with COLREGS in both day and night conditions," it does not specify how and in what configuration. The same uncertainty is true for U.K.-based ZeroUSV profiled by Nic Compton (page 40), and all builders of unmanned boats.

COLREGS require "proper lookouts" on any vessel, which has been interpreted internationally to mean a human watchstander is present onboard, not a remote operator monitoring an unmanned vessel through electronic cameras and sensors. In addition, heeding all standard rules of the road for a powered or sail-driven USV becomes problematic for remote operators as sensors, connectivity, and machine learning are prone to glitches and failure. Compounding that risk is the absence of lighting or day-shape requirements that could alert mariners in the vicinity that a vessel is not manned. Such an indicator would allow them to behave like the prudent pedestrians who sensibly step back from the "self-driving" cabs behaving erratically on San Francisco streets. On the other hand, there's something chilling in the notion that we should feel a need to step back and let the bumbling machines have the right of way precisely because they aren't really very good at reliably navigating the complex realities of conditions outside of the theoretical and ideal.

Thirty years ago, when I first considered the possibility, I'd have told you the notion of a functioning boat operable without people onboard was neat, but a gimmicky impracticality at best and a dangerous absurdity at worst. As today's technically and commercially ambitious builders of drones and "self-driving" vehicles push us to redefine norms of terrestrial, maritime, and aeronautical mobility and navigation to their advantage, I can find little reason to amend that assessment.



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Keeping It Upright

To the Editor:

I really enjoyed Patrick Bray's article, "Keeping It Upright" (*Professional BoatBuilder*, No. 214, page 16). It's a solid, well-timed refresher on the importance of vessel stability. The reminder that these calculations are best handled by an experienced naval architect and their computer rings especially true for me.

One addition that may be helpful for readers is that today's naval architecture software allows hydrostatics and intact stability to be part of the design conversation from the very beginning, as soon as an initial geometry concept has been developed. In Orca3D, for example, the same surface model used to represent the hull form is also used to calculate displacement, centers of buoyancy and flotation, static equilibrium, and righting arms. Because those calculations are tied directly to vessel geometry, hydrostatics can be updated in real time as the hull shape changes, making it easy to see the stability implications of design decisions as they're being made. It's an easy and effective way to explore stability early, when changes are still relatively easy to make.

In 2024, Orca3D expanded on this foundation with the Advanced Stability module, which supports modeling of internal compartments and damaged stability analysis. Designers can define tanks, watertight and nonwatertight compartments, fixed and fluid loads, and then evaluate intact and damaged stability against specific criteria from regulatory bodies. Since the calculations are based on first-principles volume integration of the surface model, the approach works especially well for complex or nontraditional hull forms including multihull vessels.

In addition to Orca3D, there are other software tools available to naval architects with similar capabilities, including Maxsurf, GHS, and several others. These modern tools reflect how closely linked hull design and stability analysis have become in contemporary practice, and how much insight designers can gain well before a design is finalized.

Mr. Bray also touches on dynamic stability, which can have profound effects on the safety and performance of a vessel and yet can be difficult for naval architects to assess for a particular design. Modern capabilities for numerical performance prediction, including the application of computational fluid dynamics (CFD), have improved significantly over the last decades such that it is now possible for naval architects to analyze dynamic instability behaviors such as porpoising, heeling to one side, and chine walking for planing hulls. CFD tools are available from numerous providers, and Orca3D provides a marine CFD solution focused on making computational fluid dynamics practical for the naval architect and marine engineer.

I offer these comments simply as a supplement to an otherwise excellent article.

Larry Leibman
Co-Founder and Naval Architect
Orca3D LLC

To the Editor:

I appreciated the articles on stability and electric propulsion and have a couple of small comments ("Keeping It Upright" and "Start With the Propeller," *Professional BoatBuilder*, No. 214, pages 16 and 34).

First, graduates of the University of California, Berkeley naval architecture program are required, as part of their oath to the late J.R. Pauling, to remind people that stability derives from conservation of energy—specifically, the potential energy stored in lifting the weight of the vessel with respect to the center of buoyancy. As a vessel heels, the center of buoyancy not only moves to one side but moves down compared to the center of gravity. The change in vertical distance multiplied by the weight results in foot-pounds or newton-meters (depending on the vessel's nation of registry)—in other words, energy.

If the energy the vessel can store exceeds the input energy of the overturning event, such as a wave or a gust of wind, the vessel will recover and return upright, just as a bowling ball thrown up a hill will roll back down if it is not thrown hard enough to get over the crest.

Most stability standards for boats and ships include criteria for coastal or ocean passages, including ISO 12217-1 Category A or B exposures. The energy criteria requirements for righting energy in the rules actually confirm the weight-rise explanation in that the requirement is for a certain amount of "righting area." This is the area under the righting arm curve, in either foot-degrees or meter-radians. Radians (about 57 degrees) have units of 1, so area in meter-radians is precisely the rise of the CG above the CB in meters; when multiplied by weight, it equals energy. This explanation seems a bit convoluted, but if considered, it gives a "deep" understanding of stability. (Of course, Noether proved that conservation of energy derives from symmetry of time—the final "but why?" of ship stability for readers planning to appear on *Jeopardy!*)

Regarding electric propulsion, I am pleased to see manufacturers of electric propulsion systems optimize propeller design to the characteristics of electric motors. One note on that is that ducts or nozzles, particularly more advanced designs such as the Nautican nozzles designed by the late Josip Gruzling, may play an important role in some applications, particularly sailboat outboards or other relatively low-speed uses. I am working a project now that will need about a 3-kW outboard with a nozzle, so I hope RAD Propulsion can offer one in the next couple of years. (By an odd coincidence, the author of the stability article is also known for using nozzles in his designs when appropriate.)

Chris Barry
Edgewater Beach, Maryland

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Boat Evolution co-founder Matt Foley illustrates the stability of the 3D-printed tender.

Machine-Printed Tenders

Additive manufacturing, more commonly known as 3D printing, first appeared in the boatbuilding industry more than 15 years ago, primarily as a tool for prototyping. Especially when building components or hardware remotely, it was expedient to confirm the designed dimensions were compatible before producing the actual parts. We also saw a spate of fragile plastic model hulls and accommodations details used as sales and design refinement tools.

Next, the robotic printers were applied to printing small, specialized component parts that would be difficult for boat manufacturers to build with molded composites. Marine subcontractors **Superfici** (La Spezia, Italy) were early adopters who now deliver custom and production parts to many boatbuilders, having become part of their supply chains.

The technology's next leap was into mold building for production builders, including full hull molds. When we reported on a **2018 project** led by former tech executive Stephen

Wu to build infusion-capable hull molds, the limiting factor was a maximum print envelope of 8' wide, 20' long, and 6' tall (2.44m x 6.10m x 1.83m). Only a year later the University of Maine's Advanced Structure & Composites Center printed a 25' (7.6m), 5,000-lb **patrol boat**, not intended for on-water service, on their Ingersoll printer with a 70' x 22' x 10' (21.3m x 6.7m x 3m) envelope and integrated 5-axis CNC router.

While a few companies have been printing actual ocean-worthy vessels and drone hulls in limited volume since then, now Maine-based startup Boat Evolution is aiming to build 3D printed tenders for volume production by the third quarter of 2026.

Co-founders Doug Donaldson and Matt Foley were fans of the New Zealand-built OC Tenders and Australian OneTenders and realized there would be a market for a boat with comparable performance that was 3D printed from recyclable materials and powered by an electric outboard. Donaldson said their early exploration of the possibility led them to collaborator James Anderson, an experienced composites engineer and boatbuilder with extensive expertise in 3D printing (he oversaw the printing of that boat at the University of Maine in 2019).

"We were the first ones to come to him with a small ocean-worthy tender," Donaldson said.

With Anderson's help, they have refined the structure of their original basic 9'6" (2.9m) tender design and have printed multiple prototypes, starting with a 1/6 scale model, to test production timing and dynamics as well as on-water performance. When we spoke in March, the latest boat—a 30-hour print on a Dutch-built CEAD printer from the University of Maine's Brunswick facility—had been a crowd pleaser at the February New Jersey boat show.

"That print is gorgeous," Donaldson said. "We came away with three pages of names of people who want one."

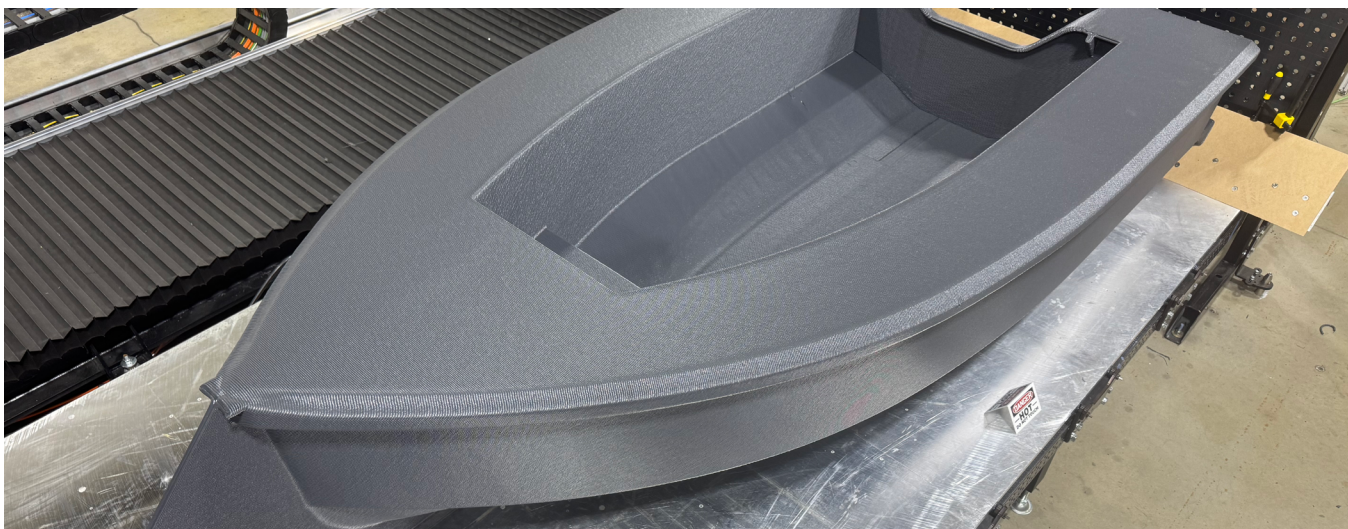
Video of the boat under way confirms that powered by a 10-kW Momentum electric outboard, it can get on plane quickly with two people onboard. (Conventional gasoline outboards can be used as well.) Donaldson said the ambition is to reduce weight to about 200 lbs for the finished tender as the



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Boat Evolution's 3D-printed tender is made from recyclable plastic feedstocks, so it's fully recyclable at end of life. They plan to be in production this fall.

final material selection and the printing protocols are refined.

Anderson explained that while test panels confirm attainable structural properties from printed material, when printing a boat there can be a lot of variation based on changes in print process parameters.

"We need to ensure we understand how the 3D printing process impacts the final strength of the material in the part. You can't just rely on the data sheet," he said.

In the final phase of development before starting production at their facility in Downeast Maine this summer, the team plans to print multiple full-size hulls from a range of composite materials using plastic feedstocks. They'll also be refining hull structure for durability, weight reduction and distribution, performance, and manufacturability. Printing the next prototypes will reveal how tolerant each material formulation is of changes to processing like print bead width and print speed. Those are important parameters in determining whether they can print the boats cost effectively. To go into production, they need to select the right material to optimize production efficiency as well as vessel structure.

Anderson explained that short print times become critical when demand requires high output. At that point you need to know "how wide a window you have to keep the strengths you expect." In practical terms,

can you effectively cut the print time from 30 hours to 12 and deliver the same quality boat?

They're also looking to eliminate as much processing after printing as possible. "We'd love to be 90% ready to be sold post print," Donaldson said. That means including as many details such as storage spaces and engine mounting pads as possible in the printed hull.

"Post processing is going to be as little as possible because that's just cost," Anderson said. Which points to the underlying calculation that makes 3D printed boats attractive to start with.

"It's labor savings," Anderson said. "Boat-builders are all screaming for labor, and the labor they do have they'd rather have them doing the fine woodworking and added value."

The Boat Evolution shop will be very clean, and staffing will likely start with a single technician running the printer, its associated software, and feedstock of pelletized plastic. It sounds modest, but even at one boat per day, they would be able to print about 300 boats per year. To print more, they'd need to increase the print speed or add another expensive printer.

The other factor they're counting on in marketing the boats is the environmental appeal of plastics that can be fully recycled at end of life, and for which there's good-quality recycled material to be used in building the boats initially.

"We don't want to paint them. We don't want to add adhesives unnecessarily, or anything that could get in and hinder recycling," Anderson said. "We're trying to keep it as pure as we can so you could literally grind it up and print another boat."

Because this is a mold-less process, changes can be made to the boats between prints, and new models can be prototyped and refined with minimal fuss and expense. Once the initial tender has been perfected, Donaldson said, they intend to develop a workboat model with lower freeboard for tending aquaculture operations like oyster and kelp farms.

"The public curiosity and excitement are there for sure," Anderson said as we discussed the market for the printed tender. Ideally, it's a boat owner who wants a durable, stable tender and is attracted to the recyclability of the material and the unique utilitarian aesthetic of the printed hull. But the initial interest from boaters seems broader than that.

Any concerns about competition from other builders? "Everybody's standing back and watching at this point," Anderson said. "As soon as they see two or three successes, everybody's going to come piling in." Boat Evolution is counting on being out in front as one of those early successes.

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—Aaron Porter

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Joe Berkman's lovely G20 is now a sought-after collector's boat and a testament to the down-to-earth man who built it.



Joe Berkman: The Man in Tyvek

Boatbuilding lost another fine craftsman when Joe Berkman, 64, of Gloucester, Massachusetts, died on Feb. 5, 2026. While Joe's name will be added to the annals of boat- and shipbuilders in the Boston area stretching back to the 17th century, his life is a story that needs to be recalled by the boatbuilders across this country who make up his second family.

Joe grew up landlocked in Brookline, Massachusetts, in a household with plenty of love but short on cash. His mother raised Joe and his five siblings on her own. Their absent father had left behind an old catamaran he had built in the backyard, and that was a spark for Joe, fueled when the kids spent summers with their grandfather out on Nantasket Beach. There, Joe was consumed with cobbling together makeshift boats and testing them out. They didn't all float.

Back at home, school held little motivation or inspiration for Joe. He left without graduating and faced grim prospects living on his own in the projects. That's when Joe sought out his father, who had moved to Rockport on Cape Ann and ran a bicycle store in Magnolia. Joe relocated and gave school another shot but found it still didn't offer him anything, although there were ample distractions for a young man adrift. Fortunately, Joe heard about a shop up on Blackburn Circle that built high-end race boats, and he became convinced that this was his calling. He told owner Mark Lindsay that he wanted to be a part of the team so much that he would work for free.

That was in 1982. Joe became a key employee of Mark Lindsay Boatbuilders Ltd. in Gloucester for the next 14 years. During this time, he and the crew were tutored and tempered in the

crucible of resin, sandpaper, dust, and deadlines that is the real world of boatbuilding. Lindsay started his business building cold-molded 16' (4.9m) International 505 sailboats. His reputation for light, stiff, race-winning sailboats brought in larger commissions. Lindsay teamed up with yacht designer Jim Taylor to build a dozen race boats in the 40' (12.2m) range.

During those years, Joe was exposed to the full range of the process from lofting to final painting. Lindsay's recipe for fast meant fair hulls and fins. Anyone who has worked in this business will tell you that a good portion of a fair hull ends up on the floor. There were plenty of times when the shop's famous attention to detail meant getting and staying filthy. Teammate and close friend Burn Kenyon recalls how Joe always lifted everyone's spirits when the going got ugly. There's no glory in pushing a longboard, and it's easy for some people to cut corners, but not Joe. One Berkman maxim was, "You just can't teach 'give a shit.'"

Joe's attitude and focus drew the attention of syndicates in grand prix racing. Several *America's Cup* campaigns had Lindsay's shop build rudders and fair keels. These were the days before lasers, CAD/CAM, or 3D printing—it was all "hands and eyes." Joe became a foil perfectionist.

When Lindsay moved his shop to East Boston and teamed with Scott Smith and Geoff Berger to form Boston Boatworks, Joe made the move and helped build the first Taylor-designed boats to leave the new facility. However, after a few years, Joe realized it was time to begin a new chapter in his life. He wanted to start his own company.

In 1998, Joe formed the Gloucester Boatbuilding Co. in East Gloucester. His dream was to build the very best production 20' (6.1m) center-console. Despite the size, this was no prosaic goal. Joe demanded that his G20 was to have yacht-quality finish with commercial boat reliability. He knew he wanted a bold Carolina flair rolling into a deep tumblehome at the transom. Marblehead designer Doug Zurn shared his vision and produced the finished lines. The final product was a jewel of a boat with meticulous detailing, not only in the hardware and systems but also in the hand-laid laminates. With the help of Joe's brother, Eddie, and the brothers Kenyon (Pete and Steve), the first G20 made it down the ways with more following close behind it.

The project lacked no attention to detail, quality, or heart, but after building somewhere around 30 boats, and with no sugar daddy backing it, finances ran out. Consulting accountants would likely have advised that the vision of the Gloucester Boatbuilding Co. was not economically viable, but the fact remains that Joe had realized his dream. Anyone who knew Joe agrees that the man didn't give a damn about money. His guiding principles were integrity, dedication, and hard work. The G20s he built are collectors' items now and a testament to the man in Tyvek who brought them to life.

Joe Berkman grew up with little or no advantages in life, yet devoted himself to the demanding single-minded pursuit of creating floating objects of great beauty and integrity. In doing so, he epitomized what it is to be a professional boatbuilder. Everyone he touched along the way remembers his kindness, humor, and infectious enthusiasm. He leaves behind not only a large and loving family, but also a cadre of fellow boatyard misfits and lifers who were lucky enough to work alongside him.

—Jonathan Klopman



Joe was known for his humor and perfectionist work ethic.



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Flax Fiber for North American Builders

S ometime around 2010, German boatbuilder Friedrich Deimann built his first flax fiber composite boat, a two-person kayak, as a project to qualify as a master boatbuilder. In the ensuing 16 years, the art of building boats with natural-fiber composites has come a long way. That's largely thanks to Deimann's company, Greenboats, refining techniques and materials as they built multiple flax fiber boats and then spinning off expedition vehicle builders Greenlander and the composites supply company Circular Structures.

When we reported on **Greenboats in 2022**, the company was having its own proprietary flax fiber laminates woven at a textile facility in Germany and selling them to a few adventurous boatbuilders interested in reducing their environmental impact. The stuff was still expensive then, and Deimann's crew was learning a lot about manufacturing processes with flax fiber, which is not a simple drop-in replacement for production fiberglass or carbon fiber construction. It was on them to consult extensively with clients and train them in the particulars of infusing flax with epoxy resin. But for our North American readers, it was all academic because the material wasn't readily available on this side of the Atlantic.

That changed in January 2026, as Circular Structures USA Inc. opened a warehouse, showroom, and shop space in Roanoke, Virginia. This new subsidiary of Circular Structures GmbH (Bremen, Germany) will be

Right—Circular Structures USA is distributing this flax biaxial cloth in North America.

Below—RUDI is an outboard skiff designed by Greenboats and built of flat, flax-skinned, foam-core panels.



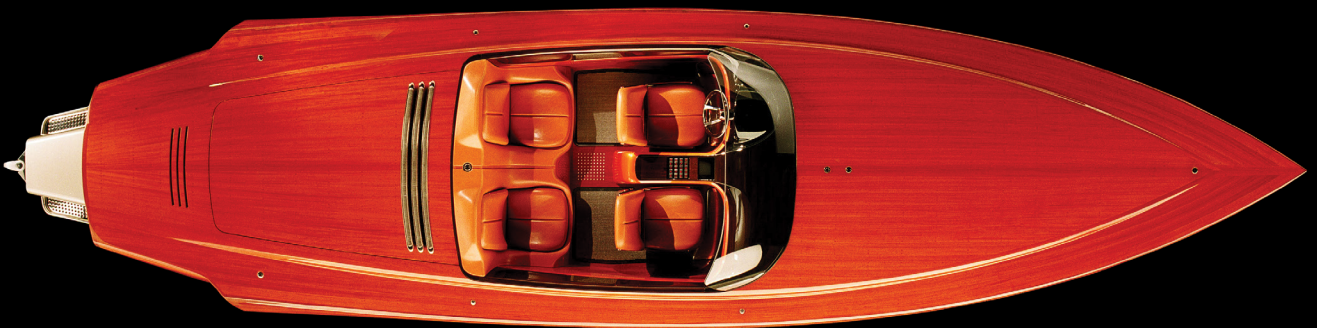
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Gresh Chapman of Circular Structures USA speaks at a Professional BoatBuilder-led panel discussion on sustainability-driven composites at the JEC World Composites Conference this spring.

more than a sales office for the company's flax composite. Gresh Chapman, CEO of the new U.S. company, said he is already scheduling training visits to intrigued builders, as well as composites schools interested in having their students understand how these materials work. He is also planning to produce training videos in the new shop that can introduce even experienced composites technicians across manufacturing sectors to flax. Because the material hasn't been available in North America, "a lot of them still have no idea what it is, yet they're experts in carbon or experts in making skis or campers," Chapman said.

That's exactly where he was four years ago as an engineering student at Brown University working on the school's Formula automotive racing team. He was looking for a natural composite material that might be suitable for their car but repeatedly came up empty-handed, even after locating some obscure flax material providers in Switzerland who couldn't assure him of their products' properties. His university research led him to some of the nearby marine-focused advanced composites shops in Bristol and the IYRS composites program in Newport, Rhode

Island. While they didn't have solutions for sourcing material, Eric Goetz had at least built a display boat with flax fiber before, and Moore Brothers had explored it with a client who didn't move ahead on the project.

"They nurtured my interest in composites because everyone was open to talking," Chapman recalled.

In the spring of his senior year, Chapman asked Greenboats, one of the only sources he had found that seemed to be a supplier of flax composite fabric, if he could bring their material to the United States. They countered by requiring a few months of training at their facility in Bremen before they agreed to bring him on as their man in North America.

Since then, he's been setting up the facility and talking to schools and boatbuilders who might be interested. A handful of programs have committed to taking a couple of rolls of fabric to incorporate in their curriculum.

"We're starting really simply," Chapman said. "The most important products we're bringing are rolls of two-by-two twill fabric and our [+/- 45] biaxial."

He insists that while flax fiber has its peculiarities—it must be infused, not hand

laid—the basics are quite simple. Regarding concerns about the need to keep it in super dry storage, he said, "We don't dry our fibers at all. We store them in a facility with no climate control. The secret is to leave it under solid vacuum pressure for an hour or two before you do the infusion instead of trying to put it in an oven or put it out to dry." During the actual epoxy infusion, "the game is maximizing your time—you want the slowest infusion based on the pot-life of your resin."

While time is often of the essence in production boatbuilding, there's growing industry interest in reducing environmental impacts and creating a better shop-floor experience for build crews. With access to Circular Structures' secure European supply chain, Chapman is confident the time is right to bring flax composites to North American boatbuilders. Ideally, if a market grows on this side of the Atlantic, U.S. farmers (already growing flax for seed oil) could shift varieties to optimize fiber quality.

Circular Structures USA, 1840 Technical St. SE, Roanoke, VA 22903 USA, tel. 434-242-8302, circular-structures.com/en-us

—Aaron Porter



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Lights in the Darkness

Navigation lights, the best protection against nighttime collisions, are worth getting right.

TEXT AND PHOTOGRAPHS BY STEVE D'ANTONIO

In my work inspecting boats, I routinely encounter noncompliant navigation light installations on new and preowned vessels. Often, when I bring this to the builder's attention, they are defensive. The near universal response: "We've been doing it this way for years; you are the first person to point this out." When I share with them the literal chapter and verse from the U.S. Coast Guard Navigation Rules, and/or ABYC's A-16, Electric Navigation Lights, the defensiveness usually gives way to, "How could that be?" and then, "How do we fix this?"

Most are truly cases of not knowing better (exactly what we aim to remedy in these pages), while a few plow their proverbial heads into the sand and insist that their way is fine. I tell them this: "If your vessel, the one you built with noncompliant navigation lights, is involved in a nighttime collision, including being run down even if

yours is legally the stand-on vessel, the operator could be assigned a portion of blame. If there's a serious injury or death, or significant property damage, you'll likely be drawn into the event legally. Why risk this if you can make the lights compliant?"

Compliance means following the rules, but because they are written in what can often be very difficult to understand maritime legalese, I understand why boatbuilders and other industry professionals often get navigation lights wrong. For this article, I had to digest, interpret, and translate these regulations to be sure I had a thorough understanding of the subject. Then, I scrutinized multiple navigation light installations.

It comes as a surprise to many boat owners that boatbuilders are not obligated to install navigation lights. However, if lights are installed by a builder (or a yard or boat owner) and the vessel is sold or operated in

the United States, regardless of where it is manufactured, then those lights must comply with established standards. As for international regulations, they are largely harmonized worldwide, thanks to the Convention on the International Regulations for Preventing Collisions at Sea (72 COLREGS), the international body that establishes guidelines for navigation lights, including how they are displayed, their range, and their construction.

The surest way to avoid a nighttime collision or being run down is to be seen. And being seen is easily accomplished with navigation lights, especially running lights in good working order and compliant with U.S. Coast Guard Navigation Rules and ABYC A-16 guidelines. (These are essentially the same, although only the former is legally binding.)

I'm surprised and disappointed at the number of vessels I inspect whose running lights are inoperable, in a poor state of repair,

obstructed, or improperly installed. In many cases, incorrect placement is the result of boatbuilder errors. You can't assume a boat's navigation lights are correct just because it's new or because navigation lights are original equipment installations.

On a recent inspection of a new vessel at the builder's yard, I found a steaming (masthead) light with range insufficient for the vessel's length. It was a 3-nautical mile (nm) light on a boat exceeding 65' (19.8m), which requires a light with a five-nm range.

Navigation light requirements, including configuration, placement, and intensity or range, are driven by vessel length, with distinct specifications for the following ranges: Up to 7m (23'), from there to 12m (39.4'), from there to 20m (65.6'), and finally, to 50m (164'). For detailed requirements and definitions, consult the full Coast Guard regulations.

Whether or not a designer has provided complete wiring details for all systems, new build and refit yards can plan a basic navigation light installation as needed. First, construct a line drawing of the vessel with the location of each navigation light. Specify and label each light, in addition to the type, size, and number of conductors in each cable. If space permits, when laying out the cable that will lead to the masthead, arch, or cabintop, include additional conductors for likely future installations. For example, it's reasonable to plan that the masthead will be equipped with



Be sure a light's rated range (2 nautical miles in this case) satisfies the Coast Guard's requirements for the vessel length.



The fine print on this stern light specifies its compliance with COLREGS requirements; however, the adjacent stern rail support obscures the full arc of illumination, making the light noncompliant.

tricolor (for sailing vessels) and anchor lights. But your plan should accommodate a strobe or wind indicator illuminator to be added. This would require a cable consisting of five conductors: ground, anchor, tricolor, and two spares for future use.

The gauge of the conductors will depend on the total run, from electrical panel to masthead (in this instance) and back. Note that in vessels equipped with LED navigation lights (and wind indicator illuminators), it's virtually impossible to use a cable that is too small. This light source is so miserly with its electrical consumption, requiring just a fraction of the energy needed for conventional incandescent light bulbs, that even the smallest allowable wire size (ABYC calls for a minimum of 16-gauge wire for most onboard applications) will usually fall within the maximum 3% voltage drop with capacity to spare.

Defects and Other Considerations for Builders

The most frequent installation defects that come straight from boatbuilders are in placement and mounting. To assess a boat's navigation lights, look closely at each light fixture, including those on and at the top of the mast for sailing vessels. Depending on a recreational vessel's size and sail/power configuration, there may be as many as six, including port, starboard, stern, steaming/masthead, tricolor/strobe (for sail), and anchor or all-round. Ensure that none is obstructed. Unanticipated visual interference is common from davit-hung tenders

and other stern-mounted gear, as well as mast-mounted radar domes, antennas, radar reflectors, solar panels, and even flags. In some cases, the transom structure may block a portion of a stern light's arc.

Most navigation light manufacturers specify orientation, either in the installation instructions or with an "UP" or "TOP" marking. Even if the visual effect and light distribution appear to be the same either way up, lights should not be installed upside down, as water may accumulate within.

Builders and buyers should be certain that sidelights are mounted on vertical surfaces, parallel with centerline and level when the vessel is at rest. Stern and masthead lights should be vertical and mounted perpendicular to the vessel's centerline. Sidelights mounted on converging bow rails not parallel with the vessel's centerline have the effect of displaying overlapping red and green arcs ahead, making it seem to traffic at a close forward bearing as if the vessel is bearing directly down on them, when in fact it may not be. I frequently encounter this flaw on tenders whose sidelights are mounted on the curved sides of center consoles. (Sidelights mounted on tender consoles are often also obstructed by passengers.)

Depending on the orientation of the surface they are mounted on, lights may need to be shimmed to ensure they are vertical and parallel to the centerline.

To comply with the 72 COLREGS, the Inland Navigation Rules, and their Annexes, found in the U.S. Code of Federal Regulations (33 CFR Subchapter E), sidelights should be



Left—Sidelights should be installed above the sheerline and be shimmed to ensure proper placement relative to the centerline. **Right**—Sidelights mounted on curved center consoles are often out of alignment and easily obstructed by passengers.

installed above the sheerline (this is the top edge of the hull side defined by the caprail or toerail on many vessels). I strongly recommend avoiding installing sidelights in or on the hull where they are less visible, particularly when heeled, and they are exposed to more spray and immersion, reducing reliability.

I commonly encounter vessels longer than 12m (39') whose builders have installed a single white all-round light, rather than separate masthead and stern lights—a clear violation of regulations.

Remember, as well, that for sailing vessels, tricolor lights can only be used when under sail (not motor-sailing). While under power, conventional deck-level lights must be used, and at no time should both sets of lights shine simultaneously. To avoid this error, consider installing a two-position switch with power supplied by a navigation light circuit breaker that will activate either the steaming or sailing configuration, but not both.

For vessels registered or operating in the United States, when selecting, inspecting, or replacing navigation lights, make certain they carry a U.S. Coast Guard approval permanently stamped, printed, embossed, or debossed on the fixture (it cannot be a decal), and ensure it's appropriate for the vessel's length.

From the U.S. Code of Federal Regulations:

Per 183.810: Boat manufacturers must install navigation lights that meet all technical standards (as proven by testing at a USCG approved laboratory) and bear a permanent and indelible marking "USCG" followed by the certified range in nautical miles (ex. USCG 2nm). The

marking must be visible without removing or disassembling the light.

As a practical consideration, when I contemplate disassembling a light housing with a small screwdriver while hanging over a bow rail or swinging in a bosun's chair, I realize that I prefer fixtures that can be serviced without tools. And during servicing of incandescent fixtures, which are becoming less common, make certain the correct wattage bulb has been fitted.

While modern LED lights are virtually immune to bulb failure, they are no less prone to wiring and connection issues. In any build or refit, be certain all navigation light wiring connections are fully waterproofed with heat-shrink crimped connections and/or sealant. Used in conjunction with dielectric grease, these crimped connections yield a long-lasting, low-resistance, corrosion-resistant connection. The primary drawback to heat-shrink connectors is the suppleness of the heat-sensitive insulation; it can easily be damaged by the incorrect crimping tool or die size. Use caution in performing this task, and inspect your finished work carefully for weathertight integrity.

Most navigation light failures (that aren't a bulb) are related to corroded or stressed connections. Mast-mounted lights are especially prone to the latter. Be sure the considerable weight of the wire is not supported by the light fixture or connection/splice. And, ideally, it should be protected within a conduit inside the spar. Support the wire using wire ties (black if exposed to UV rays) with support-screw provisions or P-clips wherever

Definitions for Navigation Light Regulations

- **Length Overall (LOA)**—The straight-line measurement from the foremost part of the vessel to the aftermost part of the boat, measured parallel to the centerline and to the design waterline. Integrally formed, molded, or welded components and appendages, such as bow pulpits, swim platforms, attachment structures for the propulsion systems, and structural rub rails installed by the builder are included in the length (author's emphasis). Attached bowsprits, pulpits, boomkins, rudders, sails, outboard brackets, handles, railings, and other similar attached extensions are not included in the measurement.
- **All-Round Light**—Unbroken light over an arc of the horizon of 360°.
- **Combination Sidelight**—Navigation light fixture in which sidelights are combined into one lantern.
- **Masthead Light (often called steaming light)**—White light placed over the fore-and-aft centerline showing an unbroken light over an arc of the horizon of 225°, fixed to show the light from dead ahead to 22.5° abaft the beam ($90^\circ + 22.5^\circ = 112.5^\circ$) on both sides of the vessel.
- **Sidelight**—Starboard navigation light showing green, and the port navigation light showing red, from straight ahead to 22.5° abaft the beam ($90^\circ + 22.5^\circ = 112.5^\circ$) on their respective sides.
- **Stern Light**—White light placed as close as practicable to the stern showing an unbroken light over an arc of the horizon of 135° and fixed to show the light 67.5° from directly aft on each side of the vessel.
- **Tricolor Light**—Single navigation light fixture in which sidelights and stern light are combined in one lantern.
- **Strobe**—Flashing strobe lights are not considered navigation lights and may not be used as such. They can be used in emergency scenarios to attract attention of nearby vessels.

—Steve D'Antonio



Wire unions should be properly sealed with heat-shrink crimped connectors to protect them from moisture. These have been compromised by incorrect crimping.

possible. Purpose-made grommets, ample amounts of silicone sealant, a quality electrical tape, and UV-resistant hose are handy aids for wire protection. Chafe is an ever-present threat, particularly where wires are run around hard metal structures such as masts and arches, or metal frames and stringers aboard steel or aluminum vessels.

If the cables exit a mast or arch above the deck, a suitable through-deck fitting must be used—either a chrome-plated brass fitting with rubber packing and a knurled or hex nut, or a modern alternative of high-impact plastic, synthetic rubber, and stainless-steel screws. The latter requires a bit more labor to install, but if done correctly is virtually leak-proof and reduces the likelihood of cable damage. These through-deck fittings are available in several sizes to accommodate everything from RG-58 coaxial cable (about the size of a pencil) and smaller wires, up to larger radar cable sizes. They also work where deck-level navigation light wiring must pass through the hull or deck.

While LEDs have been a boon to the industry, there have been failures, especially among some early marine applications. Check the vintage and functionality of LEDs on client vessels in your care.

With varying degrees of sensitivity among different manufacturers, some LED navigation lights can be damaged by exposure to higher voltages than may be normal from sophisticated, high-output charging systems. Be certain the lights you are using or selecting can handle the highest normally anticipated charging system voltage on the vessel's electrical system. Many, but not all, LED light manufacturers have broadened the acceptable voltage range to remedy this issue in recent years.

While aftermarket replacement bulbs have become popular for converting cabin and other lighting from halogen and incandescent to cooler and more efficient LEDs, replacing a conventional navigation light's incandescent bulb with anything other than what has been specified by the fixture's original equipment manufacturer will, regardless of improved efficiency and lifespan, result in a noncompliant navigation light. That's because the

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Left—Wiring inside of sailboat masts should be run through a conduit. **Right**—This wiring exiting the base of the mast is appropriately bundled and wire-tied but should have chafe protection where it bears against hard metal mast and frame structures.

testing carried out by the Coast Guard yields a certification that is valid for the complete light fixture, with its original equipment bulb. Using anything other than this, regardless of advertised claims of U.S. Coast Guard compliance, will force your navigation light fixture out of compliance. If such an arrangement is being used and a collision occurs, the operator of the vessel with noncompliant lights may be found to bear some fault for the accident even if the lights were fully operational.

Inspecting Navigation Light Wiring

Setting original equipment installation errors aside, if navigation lights fail on a boat in your care, it's time to inspect the entire system and replace any elements necessary. Even if you haven't had problems, an inspection of the wiring and fixtures on an older boat is advisable.

Begin by thoroughly inspecting all visible wiring in the navigation light circuits and fixtures. These include running lights, steaming light, masthead tricolor on sailboats, anchor light, masthead emergency strobe, and while you're checking mast wiring, look at any spreader lights, deck lights, and the VHF antenna, too. Concentrate on terminations, connections, and terminal strips, particularly those that may be exposed to the elements, bilge water splash, or simply the damp environment found adjacent to bilges and other normally closed spaces.

On a modern sailboat, most of these wires will be contained within the mast, preferably in a conduit, or in chases or bundles. In powerboats they will be run under deck or cabin structures to the light fixtures. You can learn a lot by inspecting the visible wiring at each fixture and where it exits at the foot of a mast and around likely chafe points in the wire run.

Look closely at the wiring for clues or indicators that may lead you to the cause of the failure. Is the outer insulation cover gray? If so, unless the jacket is specifically marked as UL Boat Cable, the wiring within is likely not marine grade, which means that conductors are not tinned (tinned wire is good practice but not required for ABYC compliance), their strands may not be fine enough for requisite flexibility, and the insulation is not stable in prolonged direct sunlight. Such wiring, meeting

automotive rather than marine standards, was quite common on boats until the late 1990s. It remains popular with many do-it-yourselfers primarily because it's easily obtained and less expensive than tinned marine wire. This is not to say that non-Boat Cable is unacceptable, but it should be taken into account in your inspection; products that do not meet Boat Cable standards are more likely to succumb to UV-light degradation and corrosion.

No matter the color, if the insulation appears cracked, brittle, chafed, or severely discolored, the wire within may be damaged and therefore unreliable. Replace the cable.

It is prudent to incorporate a "drip" or "service" loop into some fixture installations to allow water to drip off the cable instead of running down into the mast or fixture. And if a connector must be replaced, this service loop will provide that extra inch of cable required to make future repairs. Be sure to make the loop using a generous radius to prevent overstressing the conductors.

Next, focus on the light fixtures themselves. They should be mechanically sound and well-fastened to the mast, rail, cabin, or hull. If the lenses are faded, cracked, or otherwise damaged, or if water has condensed on the inside of the lens, repair or replace them. (Note that LED fixtures are not immune to these failures.)

Check the bulbs. If the glass is loose from its metal base, then it's suspect and should be preemptively replaced, even if it does work.

If the base is bare brass (it may look tarnished but is gold in color), chances are it was designed as an automobile parking light rather than for a life at sea. Dedicated

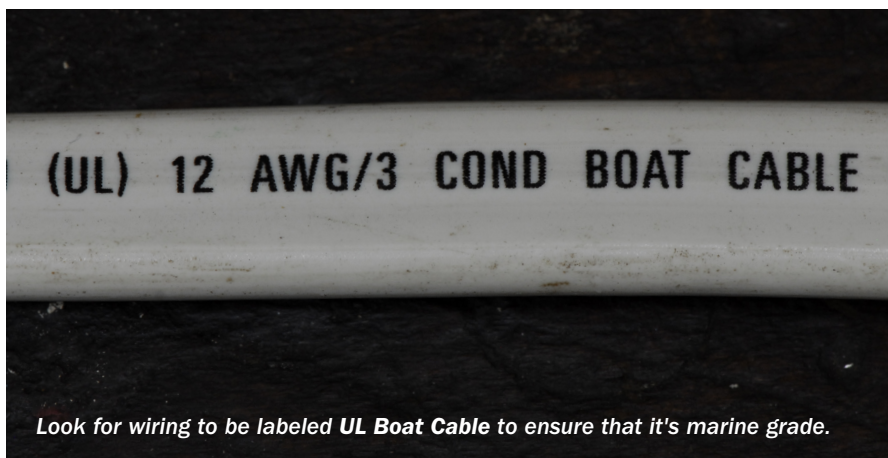
LED Lights, Radio Frequency 'Noise'

The American Boat & Yacht Council's guidance on radio frequency interference from LED navigation lights follows:

"Navigation lights and other deck and mast-mounted lighting equipped with light-emitting diodes (LEDs), including those certified to recognized Electromagnetic Compatibility (EMC) standards, have been found to cause debilitating interference to very high frequency (VHF) radiotelephones and

automatic identification systems (AIS) without operator awareness. Degradation of radio communication and the AIS signal may compromise vessel safety if the problem is not corrected.

Interference to GPS receivers is also possible. Periodic EMC checks are therefore essential, especially after installation of LED-equipped lighting or other systems mounted near antennas susceptible to unintentional interference."



Once you have located the failures and weaknesses and made the necessary corrections and replacements—lights are installed, mast is stepped, arch installed and wired, etc.—test the system thoroughly. Be sure all lights function from their designated switches, and conduct a VHF radio check to a station more than 10 miles away to rule out interference. Lastly, stock spare bulbs for each incandescent light fixture on board. **PBB**

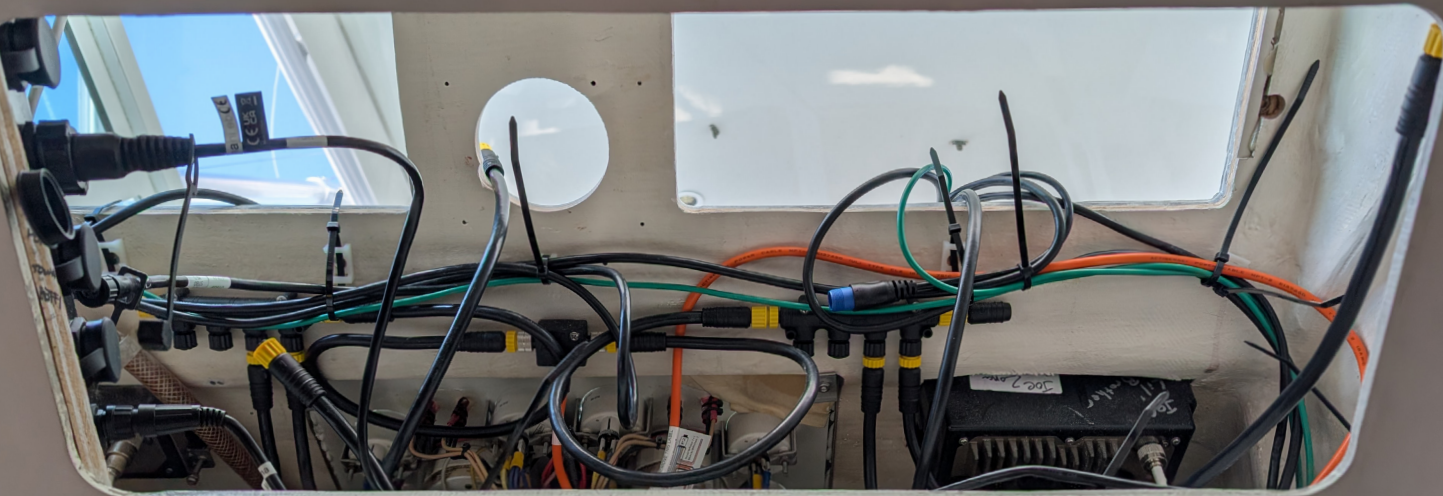
About the Author: For many years a full-service yard manager, Steve now works with boatbuilders and owners and others in the industry as Steve D'Antonio Marine Consulting. He is an ABYC-certified Master Technician and sits on that organization's Engine and Powertrain, Electrical, and Hull Piping Project Technical Committees. He is also technical editor of Professional BoatBuilder.

marine light bulbs always have a silver-colored base that is tin-plated and, therefore, corrosion-resistant. This base will be far more reliable than its untinned counterpart. For further corrosion protection, wipe a

light coating of dielectric grease (clear silicone greases are usually suitable for this purpose) on the bulb's base and contact surfaces. This will exclude air and any moisture that might make its way into the fixture.

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At Your Service

Making boats and their systems more serviceable for boat owners and technicians should be a priority for everyone in the industry.

TEXT AND PHOTOGRAPHS BY JOHN CHADWICK

It is easy at a boat show to be drawn into the excitement of what is new; after all, that's largely why we are there, to learn about our industry's latest innovations. But as I walk the docks and see all the bright and shiny new things glittering in prospective boat owners' eyes, I'm left thinking about that famous line from the 1980s Wendy's ad: "Where's the beef?"

From navigation electronics and lighting systems that dim and change colors to tables and TVs that appear at the press of a button, I'm wondering about the bits and pieces concealed behind consoles and ceilings that make all these modern wonders possible. Among the questions that invariably trouble my mind are: How do I diagnose that? What black box controls that? Where is it, and how do I access it? In a nutshell, how serviceable is this boat?

Serviceability likely isn't the first thing the designer, builder, seller, or buyer considers, but it is a factor that can make modern boat

ownership unaffordable. Frequently, it's a cost that buyers—especially those new to boat ownership—only become aware of well after the purchase, and it can leave a bad taste in their mouths, not just about boating and boat ownership but about the industry as a whole.

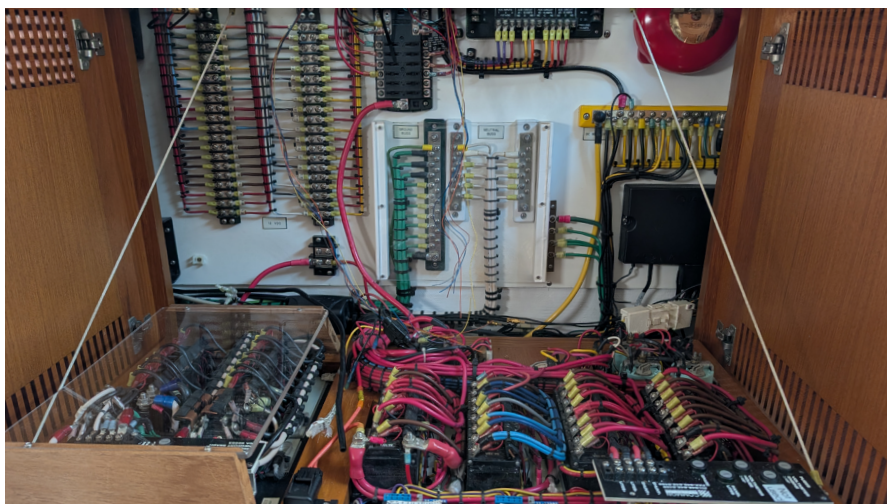
As onboard systems become more complex and abundant, servicing them becomes more expensive and difficult. Advances in technology and equipment are, of course, inevitable, but our industry needs to pay attention to the corollary—the challenges of diagnosing and repairing the systems in today's boats. Along with pricing potential boat owners out of the game, this issue is spoiling the dreams of new boat owners who otherwise might be lifelong repeat customers.

Old Boat vs. New Boat

Back in the day, as they say, boats were much simpler. I grew up in the 1960s in a boating family. We had a 1941 45' (13.7m) Chris-Craft

cabin cruiser, an 8' (2.4m) lapstrake tender, and a 17' (5.2m) lapstrake speedboat. The cabin cruiser had twin 150-hp engines, the tender a 3-hp outboard, and the speedboat a 25-hp outboard. Navigation electronics? The cabin cruiser had a fixed-mount compass at both helms. Navigating at night? No problem. Both compasses were backlit. That was it. The only "feature" on the speedboat was electric start.

Over the years, the boating industry introduced new products to the yachtsman. The early VHF radio was basically a box that would be bracket-mounted either on top of the dashboard or from the overhead. Wiring was exposed, with one cable run to the antenna on deck and the other to a 12V power source. We never had a VHF radio, but we were given a hand-me-down depth sounder, which was a larger box that was bracket-mounted. The wiring consisted of a cable to the transducer and a cable to a 12V power source, both exposed and openly accessible.



Facing Page—A dashboard with ample cutouts accessible from below. **Above**—Wiring behind this easily opened electrical panel includes a readily accessible fuse block.

Older boats were generally built in one place, one at a time. After completing the hull, the builder applied paint and cabinetry; even engines, wiring, and plumbing may have been installed after construction of the boat was complete. By definition, systems installed after a boat is built are accessible; how else could workers install them if they couldn't get them inside the boat? Modern boats are built very differently.

Advances in marine manufacturing and boatbuilding in recent decades have been dramatic. Building on lessons learned in automobile manufacturing, boatbuilders now use subassemblies built in specialty shops, and wiring harnesses made on jigs at purpose-built workstations. And equipment from manufacturers—sometimes custom-configured for the builder—are staged to be installed at the ideal point in the boatbuilding process for efficiency and workplace ergonomics.

Unlike older boats, whose equipment like radios and sounders were mounted in the open with exposed wiring, electronics and gear on much of today's fleet are flush-mounted or installed completely out of sight and operated with a small panel-mounted remote. Increasingly, remote-control capability is built into multifunction displays mounted into the boat's dashboard and/or helm station cabinetry, creating a seamless look and integrated user experience much like that of the modern automobile, smartphone, or tablet. Presented this way, potential buyers immediately see the benefit.

What they don't see is the hidden cost down the road when any of these elements need to be repaired or replaced.

From manufacturing, sales, or initial owner experience perspectives, these new technologies and methods make sense. If one can get past the sticker price, today's boats are often better designed, better built, better equipped, and safer than their predecessors. As much as I loved the boats I grew up on, I don't want to go back. But I do want to look at the modern boat critically and pragmatically—after the honeymoon is over, when one of those magical features fails, the owner seeks diagnostic and repair service, and once again faces sticker shock.

With production-built boats, the builder is rarely directly involved in the diagnosis and repair of problems in the field, unless the problem involves the boat's design or construction. On new vessels, diagnosis and repair of equipment installed on the boat are generally the work of the dealer. But more often, sussing out and fixing an issue is the job of a full-service boatyard or an independent marine service technician. I'm in the latter category. My business is focused not on boat structures and engines, but on the systems installed and running behind the scenes. On most boats today, that means electrical and electronics systems and components.

Let's walk through a relatively simple case I encountered last year on a nice 30' (9.1m) weekender from a large builder with a great reputation. The reported issue was "reliability

problems with SXM Weather." On the boat, I found SXM radio working fine on the stereo but weather working properly on only one of the two multifunction displays (MFDs). The second MFD recognized an SXM receiver was connected, but no weather information was available, and this receiver had a different radio ID number than the SXM receiver that was connected to the first MFD. Apparently, there were two separate SXM receivers installed (we later observed that the two MFDs were part of two redundant, independent navigation systems).

To find the cause, we needed access to the back of the MFDs, the SXM receivers, and their associated wiring, including data networking cables. The first place to look seemed to be behind the dashboard (and in the end, that is where we found all the black boxes), but the builder had made no accommodation for accessing this area. So, we started by looking in every likely locker or panel with a hinge, latch, or visible screw, to no avail. Reluctantly and carefully, we tried removing some adjacent fixed bulkhead, ceiling, and overhead panels in the cabin in hopes one would open without breaking; not all panels are removable.

After opening three such panels, we found the related fuse blocks but no black boxes. The fuses were all good, and the fuse blocks were neatly wired and labeled (very rare). But the difficulty we had accessing the fuses on the stationary boat led me to wonder how an owner could be expected to diagnose and replace something as basic as a fuse when the radar/chartplotter failed in fog while trying to enter a shifting inlet with seas building from an oncoming storm.



This removable panel is better than no access, but the wiring behind it is still crammed in, leaving little workable room.



Left—The SXM receiver is buried somewhere beneath a host of other electronic components; note that none of the cables is labeled. **Right**—To access the SXM receiver, the VHF, AIS, and antenna splitter all must be disconnected and removed.

Eventually, there was no option but to explore behind the dashboard via the dreaded task of removing an MFD. Dreaded, because the bezel covering the mounting screws was very fragile and had been exposed to the elements for several years, the MFD was bedded with a highly adhesive sealant, and the lovely, shiny dashboard—or the MFD itself—could be easily scratched or damaged by a tool in the process of trying to break the adhesive bond.

The multiple black boxes we sought were all behind the dashboard, yet even with both MFDs removed, access to connections and mounting was very limited.

In the end, one of the SXM receivers had failed, quite possibly from heat in the tiny, unvented space the builder provided for these devices. The failed model was no longer available. A new model SXM receiver was available for a reasonable price, but the older MFD would not support the newer receiver. The owners would have to live without the SXM weather receiver until they upgraded the electronics suite. (Normally, the two MFDs could share the SXM Weather data via networking, however this boat's redundant and independent navigation systems precluded that, and they could not be on a common network.)

Now, step back from the details and look at the big picture: The problem was diagnosed but not resolved. We had spent hours on disassembly, a very brief time on actual diagnosis, and a few hours more putting everything back together properly. The customer was billed for a whole lot of work that had nothing

to do with diagnosis and everything to do with lack of system information and access. In short, poor serviceability.

Striving for Serviceability

One way to think about serviceability is to put yourself in a service tech's shoes. Once the problem and symptoms observed are reviewed with the owner, the technician must find the answer to questions that sound simple but almost always present great challenges in the field:

- What components of the system are malfunctioning?
- Where are these components mounted in the vessel?
- What is the power source?
- Where is the fuse or overcurrent protection device?
- How do I gain access to those locations?
- How are those components interconnected?
- How are those interconnections routed through the boat?

Note that none of the questions listed mentions the technology or training required; these obstacles are all about information and access, details that are unique to the particular boat. The answers are generally known only by the builder or aftermarket installer.

These questions may seem trivial, and the answers either unimportant or obvious, but having worked in the field professionally for 22 years, and with a lifetime of working on my own family's boats, I can say without hesitation that they address the primary problems of

escalating ownership costs related to diagnosing and resolving system problems. It's worth repeating that I'm primarily referring to electrical and electronics systems, as there is hardly a single system on a modern boat that doesn't rely on electricity and electronics to function.

Is there a better way? In modern manufacturing, virtually nothing is built before drawings are created and reviewed. We adopt the same protocol in marine systems; before building or installing anything, we design via drawings and review them. In addition to being a valuable reference tool, we recognized long ago it is less expensive to make mistakes on paper than in the field.

For one of our regular customers, several years ago we updated the navigation electronics, audio system, satellite phone, and battery charging systems. Before installing anything, we drew a set of schematics to indicate what components were to be included and how they were interconnected. (Routing of cables was not documented on this boat, as there are only a few routes that are easily found and have access hatches clearly visible.) As we have added equipment over the years, these schematics have saved us a substantial amount of time, and saved the customer money, because we had a roadmap to follow.

Such documentation doesn't just help us. This same customer moved the boat to another region for a month of fishing. When he returned, he told us about an electronics failure he experienced while out of town. When he called a local electronics technician, he supplied

the tech with a copy of the schematics. After looking briefly at them, the technician said, "Oh, this is going to be easy!" The cost of creating the schematics paid for itself with that one service call. More importantly, the owner's problem was quickly diagnosed and resolved, and he was promptly back out on the hot fishing grounds.

Owner's Manual vs. Service Manual

I've owned many boats in my life. When I buy a boat, I usually purchase the service manual for the engine. While the document does not make me an engine mechanic, a service manual provides answers to many key questions involved when servicing an engine system: What components are installed? Where on the engine are they mounted? It provides exploded-view diagrams that indicate what must be removed to gain access to a given piece of equipment, and how. Interconnections are shown, whether

they be mechanical (linkages, drivetrains, etc.), electrical, or even plumbing (cooling water, oil circulation, and the like).

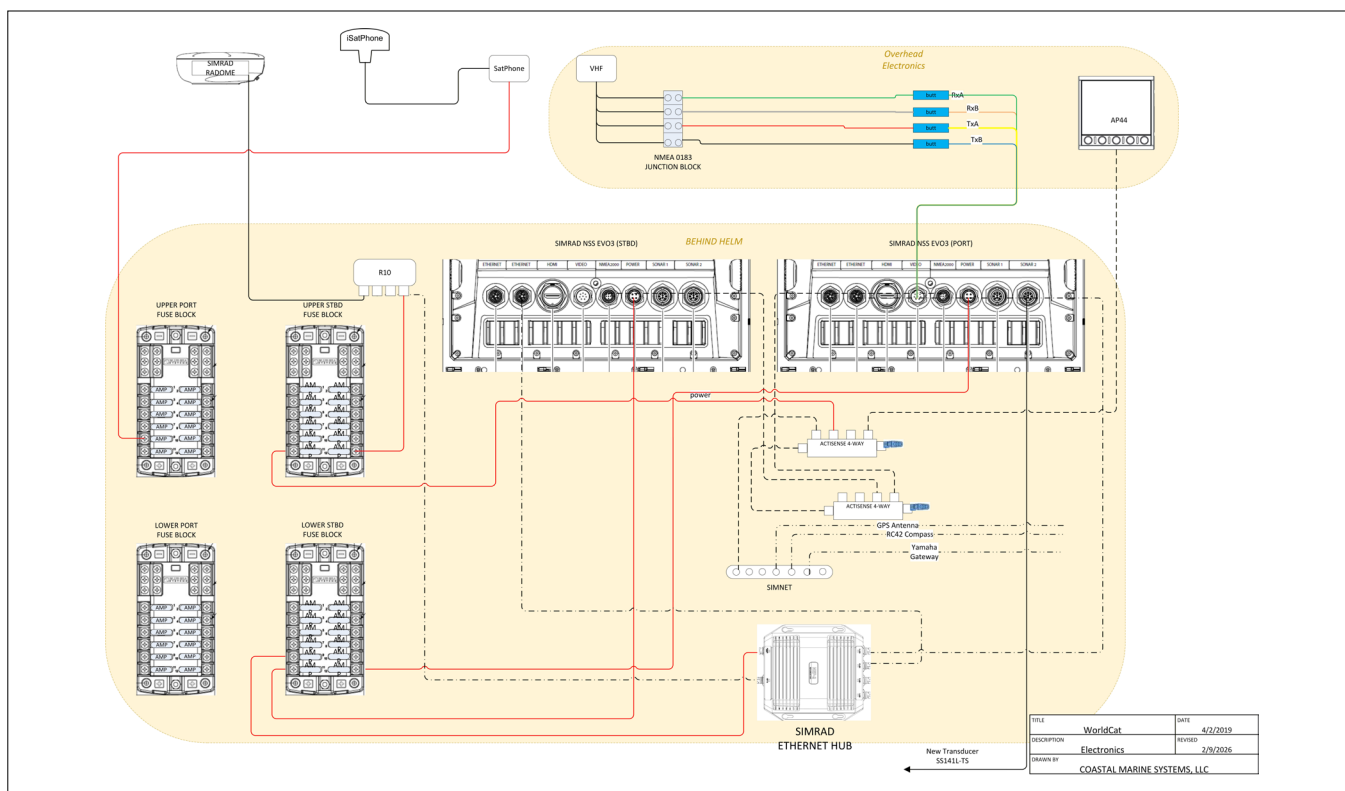
It's this access and interconnection guidance that makes a service manual so valuable and distinct from an owner's manual. Owner's manuals are important, but a modern boat, with its array of integrated systems, needs some sort of service manual for the boat's systems as installed.

Some manufacturers have been doing a better job of creating more useful owner's manuals to help boat owners understand how to operate the systems on the boat at a very high level. Others leave much to be desired. A few years ago, I was called to diagnose an electrical problem on a new 55' (16.8m) Dutch motoryacht. It had arrived at a marina with a recently upgraded shore-power system, and every time the vessel's shore-power cord was plugged into the dock pedestal, the dockside

GFI (ground-fault interrupter) tripped.

The U.S. importer and broker were showing the boat. I asked to see what documentation they had aboard, and I was presented with approximately 10 three-ring binders, each three inches thick. They were filled with the owner's manuals of all the individual pieces of equipment aboard the boat when it left the factory. None of them documented this equipment as a part of systems as installed on the boat.

The builder in the Netherlands would speak only to the salesman, and only via text messages. I had to dictate the request for wiring diagrams for the salesman to key into his phone's text messaging app. Given the difference in time zones, we didn't know when we might get a response or if it would be helpful. The testing required to diagnose this particular problem is rather straightforward; however, somewhere between the shore-power inlet and the AC main panel, an unknown



This diagram is part of the author's schematic for a customer's recreational fishing boat. Note how most of the key questions are answered on this one page: what is installed, where, and how components are interconnected.

device or devices were breaking continuity and inhibiting testing.

Eventually, we received some pertinent schematics, but they were extremely abstract, and with no theory of operation provided, we essentially had to perform reverse engineering to determine what we were looking at, what it represented physically on the boat, and how to bypass it all for testing. In the end, we found the problem: The Seakeeper stabilizer power had been miswired accidentally at the factory. It was quickly corrected, but only after two full days aboard the boat, with each day including six hours of round-trip travel.

Modern boats are complex, integrated systems. They need as-installed documentation—in other words, service manuals.

Thinking Beyond the Build

Much goes into the design of how a boat will be built. But how much thought goes into how the boat will be serviced once the boat is in the hands of an owner? We discussed how wiring harnesses are often installed most efficiently

early in the build. Consequently, they are often routed behind permanent structures where they can never again be accessed, or they are secured to that structure during installation and so can never be pulled out. And frequently there is no means to run a snake or fish tape to pull a replacement cable.

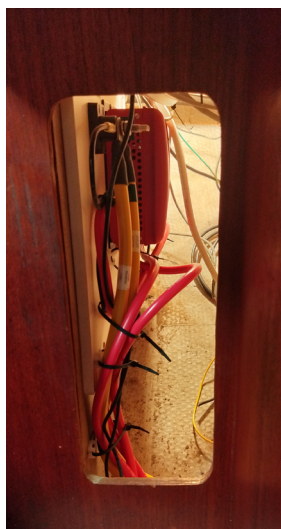
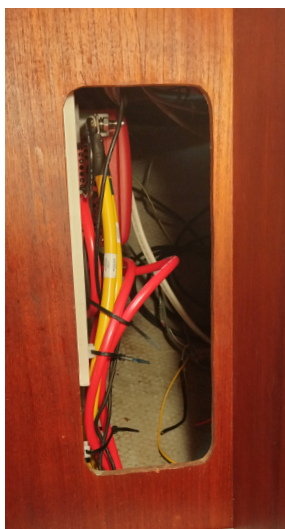
Designers and builders should plan for how any piece of equipment installed will be serviced in the field by answering a battery of questions: How accessible are the key service points? Can enclosures be physically removed in the available space? Can a technician get into a position where he can see what he is working on while also getting two hands on it? And can a technician do all that safely?

We faced such a consideration two years ago retrofitting DC power equipment in a 1960 vintage 41' (12.5m) sailboat. The only feasible location for the equipment was in a place that would only permit the technician to reach it with one hand, and the service points (electrical connections) would mostly be out of sight. Our solution to the problem was to

pre-mount the components on a removable mounting board, make all the connections prior to installing the assembly, and leave a long enough service loop for the external wiring to allow the whole assembly to be easily slid into place and secured. Servicing the equipment now is accomplished by sliding the mounted unit out for access.

Another customer's boat, a 65' (19.8m) motoryacht, had cameras installed to allow the helmsman to monitor guests in the salon and on the aft and upper decks while under way. The salon camera failed, and the replacement camera was not working due to low voltage at the camera. The owner had young grandchildren, so a solution was a safety priority for him.

Because the camera wiring had been installed in the boat before the extensive hardwood interior was built there was no means of access. The builder was helpful but offered no practical solutions, given how the wiring was installed. Further, the interior was built in a manner that left no alternative wiring paths.



Left—Only one hand at a time can reach the essential electrical system components and connections in this compartment. **Center**—To improve access, the author installed the new equipment with extra wire length on a mounting panel. **Right**—Now, the new gear can be housed in the same space but be easily serviced by removing the panel.

Over a period of weeks, we worked multiple days attempting to diagnose the problem.

During that time, we were also trying to locate the power supply that fed the camera, but the builder couldn't provide advice on that either. Tracing wiring was always futile, as it disappeared into structure. Eventually, while working on another project, I came across some mysterious power supplies under the helm, hidden behind some air conditioning equipment. Testing proved them to be the camera power supplies, and one was only putting out 7VDC.

We replaced cheap 120VAC-12VDC power supplies for all four cameras with a dedicated camera fuse block fed by the boat's existing 12VDC power system. Rather than hiding the fuse block behind the air conditioning system, we installed it 2' (.6m) away on an empty, accessible expanse of bulkhead. The fuse block and wiring are now labeled, the location has



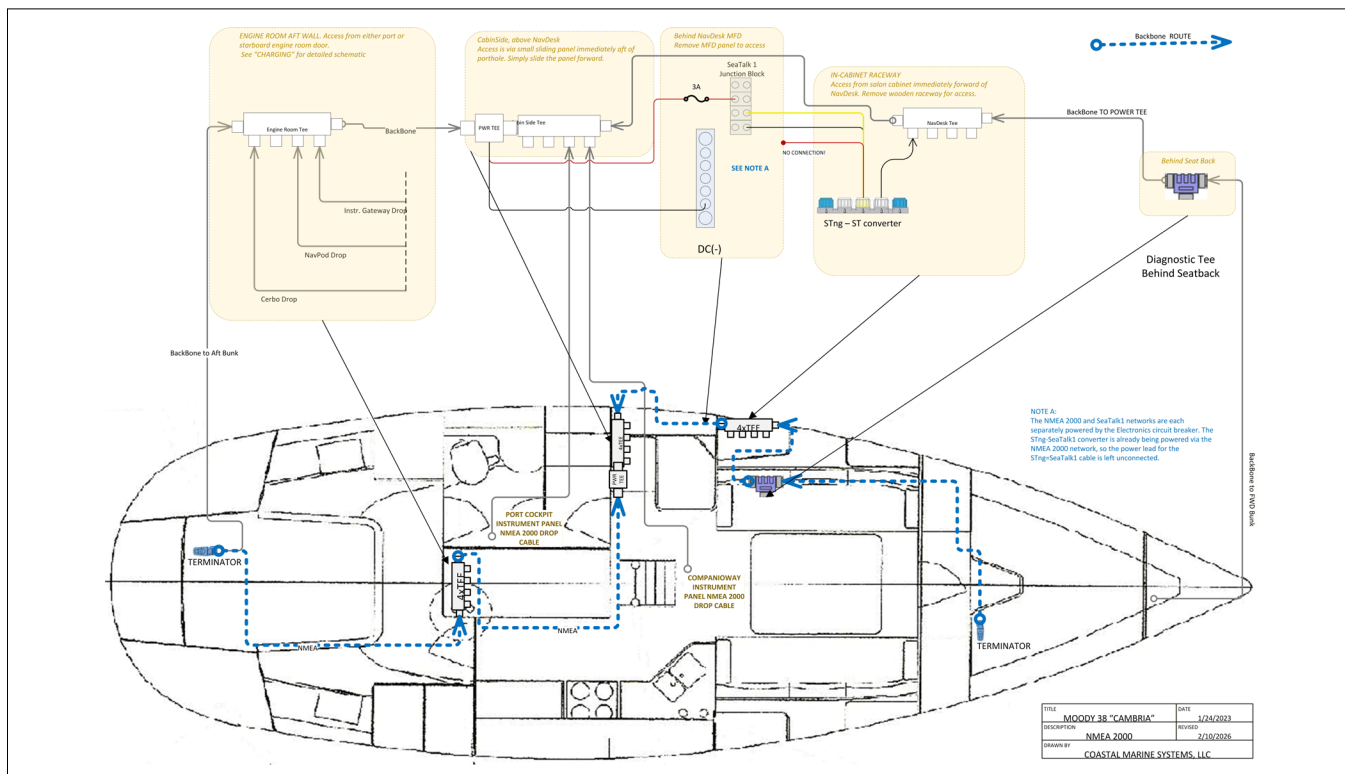
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This schematic created for a Moody 38 shows the NMEA 2000 wire and cable routing and related equipment locations. Up-to-date records like these are helpful to boat owners and service technicians.

been photographed, and the circuits have been added to the boat's collection of schematics.

Modern boats are, like modern automobiles, becoming integrated systems of systems. Auto manufacturers develop a detailed service plan before any car goes into production. Boatbuilders need to do the same. This includes making appropriate documentation available to the technicians who need this information to efficiently and effectively diagnose and repair systems in the field.

But service planning is not just the responsibility of the boatbuilders. We all have a role to play. Systems integrators design, program, and sometimes install complex systems on behalf of boatbuilders and/or major retrofit boatyards. They must include service planning in the systems that they design, and they must create the supporting documentation and make it available to the technicians who diagnose, repair, and add to these systems in the field. Installers also have a role to play, as the as-installed schematic on page 28 illustrates.

And let's not forget the manufacturers of marine equipment. If you've recently installed

a navigation light on a boat, then you probably understand the challenge of making a reliable connection to the fixture's pigtails that are too short to work with and too thin to effect a solid and reliable crimp connection in the field, especially when the boatbuilder installed exactly enough wire to reach the original fixture's pigtails, and not one millimeter more.

Making Serviceability an Industry Conversation

In a recent *Soundings Trade Only* article, American Boat & Yacht Council President John Adey said, "A smart system anticipates upgrades and improvements." He was writing about marine power sources, but his comment is absolutely pertinent to this discussion.

In the same magazine, Correct Craft's Bill Yeargin noted, "Substantially growing your organization likely won't come just from getting better; it will come from meeting unmet needs." I cannot think of a single greater unmet need in the boating industry than resolving the problems of serviceability in the modern boat.

Whether you are builder, installer, or systems integrator, what do you do to ensure that your end product will be easily serviceable in the field? What documentation do you create to enhance serviceability? How do you make it available to your customers and the field technicians who support them? Let me know. I want this article to be the beginning of a constructive conversation in our industry, and I want to spread our collective thoughts and practical solutions in future issues of *Professional BoatBuilder*. **PBB**

About the Author: With a degree in electrical and computer engineering, John Chadwick began his career designing systems for defense contractors, later working for a dot-com startup on Wall Street. When the bubble burst, he redesigned and rebuilt the electrical and electronic navigation systems on a 1986 Tartan 40 he had purchased. This grew into a new business, Coastal Marine Systems LLC, where he continues to design, document, install, and configure custom marine electrical and electronic systems for boat owners and boatyards.



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After hours of work preparing the hull surface as well as the paint itself, technicians spray topcoat on a boat at Front Street Shipyard in Belfast, Maine.



SHOOTING FOR True Colors

Meeting today's topside paint challenges is as much about navigating unanticipated changes in paint chemistry as honing technical skills.

BY NICOLE JACQUES

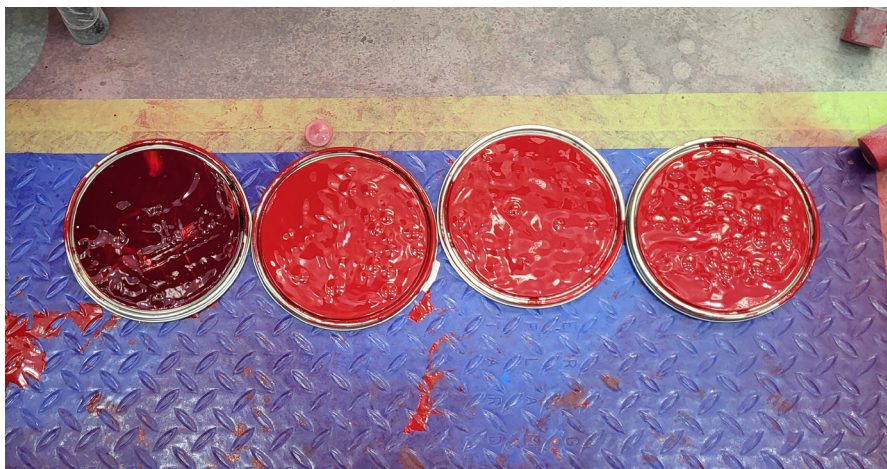
The afternoon before the first coat of topside paint went on a 100' (30.5m) sloop, the crew of applicators at Front Street Shipyard in Belfast, Maine, gathered to talk through the spray plan. They prepped their tools, surveyed the plastic tenting, and documented the products to be used. Thirteen containers of an off-the-shelf shade of red acrylic paint were stacked inside the tent; the hull would take roughly six gallons per coat, with two full coats planned. As the painters pried open the first cans, anticipation turned to alarm. The shades of red inside were wildly different—some

deep and muted, others shockingly bright. Despite the identical labels, it was clear: These were not the same color.

If the painters had sprayed straight from the cans, the result would have been a splotchy, tie-dyed mess on the hull. The color variations were far too extreme to produce a uniform finish. Fortunately, this veteran crew had seen it before, which is exactly why they opened all the cans before loading a single one into the spray gun. Their resourceful solution is called “boxing”—pouring all 13 gallons into one oversized tub, mixing thoroughly until the hue evens

out, then redistributing the blended paint back into the cans. Now, every tin held the same bright crimson tone the owner had envisioned. They could start the first spray.

Boxing isn't a new technique, but its necessity—as well as other methods to manage variations in topside coatings—is becoming increasingly part of the equation for boatyards and other professionals working for customers who expect a flawless finish. Evolving paint formulations, changes in chemistry, extended cure times, fine-print warranties—all require applicators to plan, document, and manage a paint job well



Before boxing, four can lids from the same red paint show slight and dramatic color differences. Other variations can include viscosity, gloss, and tone.

beyond the technical skills needed to apply paint itself. Learning how to respond effectively to a paint chemistry landscape that is constantly changing, often without warning, is arguably the hardest part of the job.

The seasoned pro who led the sloop's paint team was Juan Carlos España of Peake Coating, a Virginia-based coatings application company that brings skilled painters into boatyards along the East Coast for short-term, subcontracted projects, usually for high-value yachts. España has painted hundreds of boats throughout his 30-plus-year career, ranging from tenders to superyachts. Over the decades, he's learned and developed countless adaptations to application methods that improve his own efficiency and project outcomes, especially as the chemical makeup of paints has evolved over the years.

Generally, a paint technician starts the boxing process by shaking and opening every container of paint. Before mixing anything, he works his way down the row of lids, dragging a stir stick through the paint that's collected on each one. In the same way a sommelier might read the legs on a wine glass, a technician can read the paint—its tone, viscosity, and gloss—and subtle differences often jump out immediately. A greenish cast in one lid among several blue hues is enough to prompt a closer look.

When a can looks too far off, he may pull it from the lineup before it ever reaches the mix. Only after every container passes

inspection does he combine the paint into a single batch, ensuring one uniform, predictable coating before the gun ever comes out.

España started incorporating the boxing technique into all his coatings work more than 15 years ago as metallic paints were rising in popularity. Achieving a consistent metallic flake density across the entire surface of the hull required evenly premixing all the cans of paint and flakes together in a single vat before application. España quickly realized boxing would defend against other potential inconsistencies beyond flake density, so it became a standard practice in his coatings process. Working across nearly every major marine urethane system, he boxes all paint products—acrylics and polyesters alike—regardless of manufacturer.

For him, boxing is as much about risk management as craftsmanship. By uncovering as many challenges with the paint's color, viscosity, and composition as he can before a spray gun is ever loaded, he reduces his own exposure. It's España's commitment to protecting his hard-won professional reputation that drives his attention to detail and record keeping. If the finished paintwork fails, he believes the customer will hold him responsible—even in instances when the cause traces back to the paint's chemistry.

"In my experience, an unhappy customer will never point his finger at the paint maker," España says. "He'll blame it on the boatyard."

Consistency isn't an issue with just one brand, so España declines to nitpick specific products. "All paint brands come with their own quirks," he says. His growing concern, however, is the increasing frequency of color inconsistencies in cans he opens across boatyards nationwide. What were once occasional anomalies have become routine, and he feels he has no recourse with the manufacturers.

"Either you warranty your product or you don't," España says of the paint vendors. "When I read a paint label that says 'color variation is possible,' it seems like there's no guarantee. How can I use that product on an expensive yacht?"

Reading the Technical Data Sheet (TDS) for any modern paint can be surprising. España points to one TDS that now warns against buffing and polishing for "certain color shades," although no specific hues are identified. Explaining to an owner fresh off a major repaint that the finish can no longer be buffed or polished is an unrealistic message to deliver. Carefully reviewing the TDS for every paint product each time it's used is essential, because the manufacturer's information can change between batches.



Top—Several gallons of midnight blue paint are opened and ready to be boxed. **Bottom**—A close-up of these two cans reveals clear color differences.



Left—At Front Street Shipyard, an applicator sprays individual boat parts, which offers an opportunity to test paint color and behavior before shooting a complete hull or house structure. **Above**—When boxing paint, applicators combine and mix all cans for a spray job ahead of time to even out any variations.

Control What You Can

To head off paint problems that increasingly feel inevitable, boatyards have started shouldering more overhead in time, cost, and liability. Forward-thinking managers may even be recognizing the need to raise paint pricing to reflect the expanded preventive measures that applicators like España now consider essential. Boxing paint is only the beginning; exhaustive documentation, prolonged curing, and extended sourcing timelines have become standard. Some of these efforts stave off potential problems, while others are simply to establish some recourse when things still go wrong.

The best preventative measure is keeping time-coded and dated records that provide a comprehensive account of environmental conditions, including ambient, surface, and material temperatures; humidity and dew points; and airflow management. Critical documentation also includes all materials used from the first day of hull or deck preparation through final topcoat application, repair compounds, high-build primers, inks, and sandpaper grits. Every paint container's data—particularly batch numbers and expiration dates—are included. The guiding principle: No detail is too small.

Since España is usually on the road without a conventional office, he keeps a handwritten journal for each job. His phone's photo roll is also filled with time-stamped shots of every project in each stage of the prep and paint process from all angles. España frequently teams up with Bill Robishaw, paint department manager at Safe Harbor Front Street (formerly Front Street Shipyard), for major projects. On those jobs, documentation is effectively doubled, with Robishaw keeping his own comprehensive coatings report as a spreadsheet saved to his computer. When issues arise during a spray, the first move is to compare notes. A systemic problem should reveal itself in the documentation, although given the number of variables involved, pinpointing the source is seldom straightforward. When the documentation affirms that every protocol has been followed to the letter, the paint product itself becomes the likely suspect.

Robishaw also maintains the same detailed records on test panels, which have become an increasingly important tool for catching potential issues before the actual spray. Regardless of the marine paint system he's applying—most commonly acrylic or polyester, with enamel used by rare request—test panels offer an early indication of how the

coating will lay down and its expected cure time. Even if it's a product he uses frequently under controlled paint-booth conditions, he doesn't feel confident the paint from one batch will behave the same as paint from another since product inconsistencies have become so common. One issue he frequently detects on test panels is variation in cure times, which he feels could be a possible harbinger of deeper problems.

"Cure times for some products are getting a lot longer than they used to be," Robishaw says. "We sometimes even need to apply additional heat to speed it up." Reluctant to rely on the cure time stated in a product's TDS—some of which now extend to three weeks—he sets up his own science experiment inside the paint bay to verify the completed cure. Using a test panel sprayed alongside the boat's topsides, he applies and removes masking tape each morning following the application to determine more precisely when the paint is real-world ready for additional detailing, such as a cove stripe or pinstripe. He notes that acrylic coatings have long required at least twice the cure time of polyester, and that those cure windows now appear to be extending even further.

Longer cure times that keep boats in the paint bay are only part of what's slowing

paint schedules overall. Applicators face a growing list of time-consuming steps to ensure the best possible finish, starting with where to buy the material. For his most exacting customers, Robishaw says one way he reduces the risk of inconsistency is by cutting out the middlemen in the supply chain. Factory-direct paints tend to offer greater consistency than those mixed and delivered by distributors. Most brands are willing to facilitate factory-direct purchases upon request, but delivery times usually increase significantly.

The longest delays occur when every preventative step fails and the finish develops discoloration, dust, sags, or adhesion problems that demand a full rework. Sanding off the coating and re-prepping the surface for another spray consumes several days and dozens of labor hours. Then the coatings team reviews the documentation,

makes adjustments to the product or process, and sprays again.

Regardless of whether the failure originates with the material or the method, customers aren't willing to pay extra for anyone's mistake. And few boatyards have the time, leverage, or resources to challenge a paint manufacturer. The result is almost always the same: The cost of a re-shoot falls squarely on the boatyard, turning the project into a financial loss.

"No one estimates a job to do things twice," says Robishaw.

Best case, an applicator catches a problem as it emerges early in the spray and then adjusts tools, materials, or environmental conditions before proceeding. Experienced applicators rely on powerful, handheld LED flashlights to read the surface in real time. With a spray gun in one hand and the light in the other, they watch how the

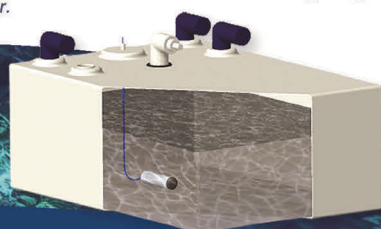


Days of prep work, including precise taping of bootstripes and meticulous hull sanding and priming, is critical to a paint job's positive outcome.



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paint lays down against the hull or deck, looking for anything out of the ordinary. Robishaw explains that a polyester urethane should hit the surface already resembling the finished product. When the reflected light on the area shows a clean, uniform gloss, it's time to move the gun to the next area. Acrylic urethanes behave differently, appearing first as fine beads that gradually flow together as they cure—a characteristic that makes them slightly more forgiving during application. Any anomaly in the paint's behavior during the spray should immediately raise a red flag.

Some warning signs get missed. Robishaw recalls a hard-won lesson from a paint job on a RIB several years ago managed by a colleague. With three coats planned, the crew prepped the hull, boxed the paint, documented every step, and started spraying. Near the end of the third coat, they ran out of material, leaving them with no other option except to open a new container of paint labeled as the same color. As the hull cured, the port bow quarter dried to a noticeably different shade. The only remedy was to sand the hull and start over. Since then, Robishaw has intentionally overestimated material quantities, ensuring an extra gallon or two of paint is available for touch-ups or repairs down the line.

Having a leftover gallon of boxed paint can be a lifesaver for owners. The odds are high that a boat will eventually brush a dock or worse and require a touch-up or localized repair. Some owners take a spare gallon with them when they leave, but many prefer not to store chemicals aboard or at home, opting instead to leave the paint with the yard.

Robishaw sees this as part of his responsibility to help customers maintain their finishes, so his shop houses rows of chemical cabinets filled with paint—clearly labeled with each vessel's name—reserved for those inevitable repairs. That service, however, comes at a cost: valuable space in an already crowded boatyard.

"Ever since we started boxing, storage has become an issue," explains Robishaw. "Now we have to buy more chemical cabinets to store it all, even though we don't currently charge for paint storage."

In most cases where a spare gallon isn't available, a repair relies on the boatyard's paint technician to color-match the existing finish. Even with records of the original paint formula, applicators can no longer expect a perfect match from the manufacturer, given the growing inconsistency in color. Whether the applicator requests a color match from the factory or uses toners to dial it in by hand, the application process is critical to achieving a seamless blend. Every experienced technician develops personalized methods for achieving the best possible result. Robishaw relies on a specific blending solvent during repairs, which he feels produces excellent results with urethane paints.

"I have my method, and other people have tricks like putting excessive reducer in their final coat of a repair to make it easier to blend," he says. "None of it is perfect."

Some paint pros turn to a spectrophotometer to help match existing colors. Used in all types of color matching from boats to cars to walls, a digital spectrophotometer is a handheld electronic device that shines a light onto a color sample and then measures the wavelengths of light reflected back. The device then translates wavelength data into a numerical value the paint technician can use to establish a color mixing formula. When assessing how well a sample color

matches the boat's existing color, a digital spectrophotometer can produce a second, critical metric called the Delta E, which quantifies the color difference between the hull and the repair. A paint technician will work to get the Delta E as close to zero as possible.

Quest for Consistency

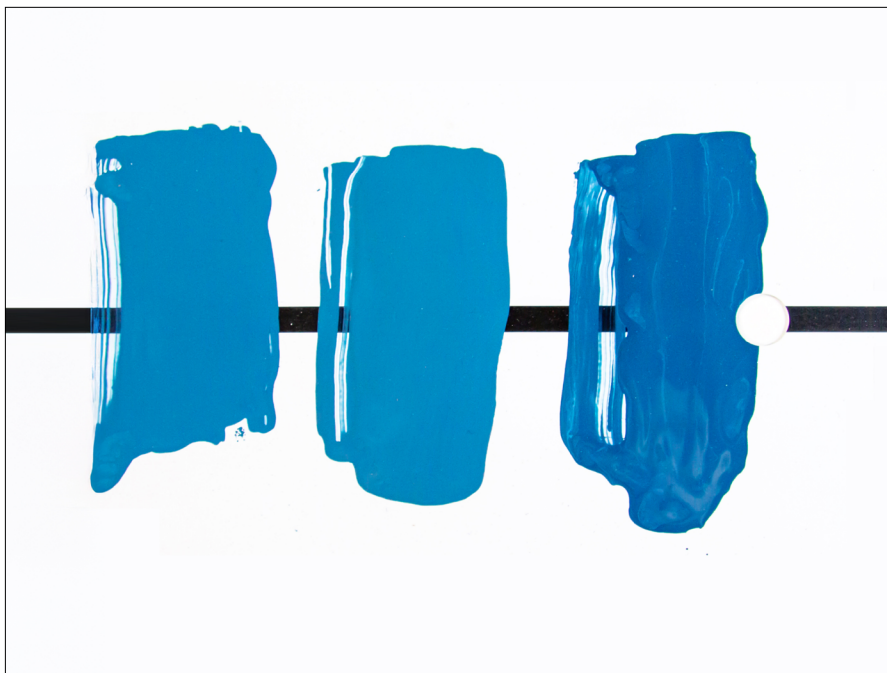
Boatyards are doing more and more to work around paint inconsistencies, but those fixes aren't free, and the costs are often getting absorbed by the business, shaving down already thin margins. At some point, the industry has to ask whether these problems should be solved in the paint bay or, instead, at the factory.

Some degree of inconsistency is unavoidable, according to Chris Toole, product manager at Hempel UK Ltd. and a certified coatings inspector with the Association for Materials Protection and Performance. Toole has quite literally written the book on the subject as a co-author of "Paint Colour Guide: Yacht Coating Technical Guidelines," a white paper published by the International Council of Marine Industry Associations. His advice to boatyards echoes what España and Robishaw emphasize: Work with reputable suppliers that maintain rigorous quality controls, box paints before application,



A miscalculation in needed paint quantity led to slight variations in the gray topcoat on this RIB.

PHOTO: FRONT STREET SHIPYARD



Three samples of one paint brand's Flag Blue reveal color variations. Paint manufacturers face challenges when regulations for pigments essential to the color formula change.

and retain spare material for future repairs. These precautions are essential, not necessarily because problems are likely, but because minor variations are inevitable.

A paint technician confronting these issues day after day might reasonably question whether today's coatings are falling short of expectations. But it's important to distinguish between a standard and a tolerance. Take Flag Blue, for example. The color is assigned a numerical value within a manufacturer's color system, and that value represents the standard reading on a spectrophotometer. Each batch, however, is produced within an allowable (Delta E) tolerance around that standard.

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Those allowable tolerances vary by manufacturer. As a result, two paints from the same brand labeled the same color can still differ subtly, even when both technically meet specification.

When asked how modern paint formulas are affecting color consistency, Toole reframes the question: "It is more accurate to ask, 'How [are] regulation and health and safety affecting the quality and consistency of applications?'" Toole explains that in an effort to maintain uniformity, manufacturers typically rely on single-source suppliers for raw materials. When international regulations governing those materials change, or when their supply chain availability is disrupted, manufacturers are often forced to reformulate, introducing variables that can affect consistency from batch to batch.

"It is fair to say that most of these changes are negatively affecting the quality," Toole acknowledges.

By way of example, Toole points to blue pigments that have been heavily regulated due to their chemical composition. As those materials were restricted, manufacturers were forced to adopt alternative, more naturally derived substitutes, which simply weren't as vibrant. Carbon black has also experienced periods of limited availability, affecting a wide range of colors. Titanium dioxide faced similar pressure; it was under regulatory scrutiny for years and at one point appeared likely to be banned, a disastrous scenario given its widespread use in white paints. Although that legislation was ultimately overturned, Toole recalls titanium dioxide shortages several years ago created many of the same challenges as an outright ban.

"At one point," says Toole, "I believe one major paint company either purchased, or was about to purchase, their own titanium dioxide plant."

Toole offers some reassurance that most consistency issues such as color variation or extended cure times are unlikely to compromise a product's overall performance. Longer curing, for example, may be inconvenient, but it's typically a function of the coating's chemistry, mix ratios, temperature, and

other application variables, rather than a symptom of product failure.

"If quality is measured by the in-service performance, then it can be the quality of the formulation, raw materials, substrate prep, and other factors that will define 'quality,' but not the cure time."

Some paint technicians—and even distributors—believe manufacturers should be more transparent about formulation changes when a supply-chain issue requires a chemical modification. Every time factories adjust formulations, those changed products arrive at boatyards without notice or explanation on the label. A product delivered today may differ significantly from one with the same label received just weeks earlier—something experienced applicators notice immediately. Compounding the issue, many warranties exclude coverage unless a long list of specific conditions is met.

Tim Walenga, technical sales representative at Midwest Industrial Coatings Inc., says the steady drip of small, undocumented changes is eroding trust between brands and their users.

"How about making sure I have a good product on the front end so I don't need a warranty later?" he asks.

Walenga has spent 38 years in the paint industry, witnessing the evolution from single-stage coatings to intermix systems and, ultimately, to today's two-part polyester and acrylic paints. He currently mixes and distributes products from four major marine paint brands, along with liquid, powder, and electrodeposition coatings for agricultural and industrial markets. He has strong confidence in his operation, where batches of up to 250 gallons are blended in a single vat, an approach that helps ensure consistent color from can to can. Smaller mixing facilities around the country, by contrast, may only be able to blend five gallons at a time, increasing the likelihood that paints shipped to boatyards will show noticeable color variation and require boxing.

In his role, Walenga hears frustrations from both sides of the equation, boatyards and manufacturers alike. He tries to convey his customers' concerns to the

brands, hoping they'll take concrete steps to improve consistency. Still, he doesn't anticipate any sweeping changes to paint chemistry in the near term.

"I wouldn't say there will be a huge reformulation anytime soon," he says. "I just see the big companies getting feedback from their customers to make what they have better."

Those customers are hopeful that manufacturers are listening. Back at Safe Harbor Front Street, Robishaw has begun steering owners away from products he once favored. Acrylics, which he long recommended for their ease of application and long-term repairability, no longer perform as they once did—an observation echoed throughout the industry, according to Walenga. Despite carrying the same labels, applicators are finding today's acrylics far more difficult to repair, effectively eliminating the very advantage that made them a go-to choice.

"When a manufacturer changes their product, we find out the hard way through application," Robishaw explains. "If we then decide we don't like the new chemical makeup of a brand that we've been using for a while, we need to find another product to fill that void."

Across the country, applicators increasingly feel that products they once trusted have become high-stakes experiments on very expensive boats. And if, as Walenga suggests, there is no breakthrough chemistry on the horizon to replace what once worked reliably, the industry's path forward lies in improving the consistency of the products already in use. Paint technicians aren't asking for miracles—they're asking for transparency when formulas change, meaningful technical support when problems arise, and warranties that acknowledge the realities of today's application environment. **PBB**

About the Author: *Nicole Jacques is a communications professional with more than 20 years of experience helping boatyards and marine businesses tell their stories. She serves on the board of the American Boat Builders & Repairers Association and is an active sailor and industry advocate.*

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UNMANNING *THE FLEET*

PHOTO ZEROUSSV



Facing Page—The latest Oceanus 12 in Plymouth. **Left**—The interior reveals accommodations for the 350 cables that snake through the hull connecting generators, batteries, sensors, communications components, computers, and actuators, but no crew.

What it takes to keep pace in the race for commercially viable autonomous vessels.

BY NIC COMPTON

This one is painted in something called Dazzle,” says Matthew Ratsey, managing director of ZeroUSV in the U.K. “It’s a throw-back to World War I, when they painted the frigates in dazzle camouflage effect to confuse attacking U-boats. We thought it’d be a bit of fun, and that it might appeal to our defense customers.”

We are standing on the quay at Turnchapel Wharf in Plymouth, Devon. The tide is out, and we are gazing at a strange-looking vessel moored alongside the floating dock. With her long, lean hull, she could be a sailboat or perhaps an electric launch, but her rugged finish and hard-chine hull suggest another story. This is clearly a working boat of some description.

But perhaps the strangest thing about her is how little clutter there is on deck. There are a few cleats, some hatches, but apart from an A-frame mast festooned with aerials and radar domes, there’s very little else. Not even a wheel or tiller or any engine controls.

I’m slightly nonplussed, or possibly dazzled, as we stroll down the gangplank toward the boat. It’s only when I’m on board and I look down one of the open hatches that I fully understand the nature of the beast. The whole front half of the boat is packed full of machinery. The bow section houses two rows of computers, with all the associated fuses

and cabling, while the middle section has two identical power-generating systems. Aft of the main bulkhead, the two 21-kWh battery packs and two 40-kW electric outboards are hidden under the checker plate metal floors. Ratsey later tells me there are about 350 cables snaking around the inside of the boat, like so many veins in the body.

When we arrive, four people are crawling around the boat, two of them with spanners (wrenches) in their hands, the other two with laptops at their fingertips. All play an equally important role in the running of this highly specialized piece of equipment.

This is the Oceanus 12, an autonomous vessel designed to go to sea for up to 25 days, potentially without any human contact. Given that it will be out in all weather with no recourse to quick fixes, all the systems must be protected from the elements as much as possible. Even the outboards, I notice, are fitted under bolted-down plates instead of easy-access hatches. If access is required, that will probably mean the end of the mission.

Ratsey learned this lesson the hard way, while working on a previous project: the 50’ (15.2m) *Mayflower Autonomous Ship* (MAS400), which sailed from Plymouth, U.K., to Plymouth, Massachusetts, to celebrate the 400th anniversary of the original

Mayflower. The boat’s first attempted Atlantic crossing in 2021 was abandoned due to mechanical failure, and even when the mission succeeded the following year, it had to pull in twice for repairs.

“The thing about USVs [unmanned surface vessels] is that a small engineering problem becomes a massive deal because you haven’t got someone with a spanner on board,” says Ratsey. “So, we had a raw-water impeller which broke. That’s game over. The generator can’t run; you can’t charge the batteries. Now, ordinarily on a boat, that would take you 20 minutes to change.

“So, that is why, in the Oceanus 12, we’ve gone for two generators. We’ve got rid of the raw-water pump, so we don’t have an external raw-water feed and have gone to skin-tank cooling. We’ve got a closed-loop glycol cooling system, which isn’t going to get blocked—no krill, no prawns, no plastic bags. The impeller in the pump is stainless steel, et cetera, et cetera. So, you learn from these things.”

Ratsey learned all about the destructive power of the sea early in his career. After studying naval architecture at Southampton University, he got a job with Chay Blyth, the man who famously sailed singlehanded “the wrong way” (east to west) around the world in the 1970s. Blyth went on to found the Global Challenge, in which a fleet of 10 67’ (20.4m) boats with amateur crews raced around the world by the same route.

By the time Ratsey joined the project, it was being upgraded to a fleet of 72-footers (21.9m) designed by Rob Humphreys and built from flat-pack laser-cut steel panels. Ratsey acted as the interface or project manager between the designer and the boatyards (10 boats were built in Plymouth and two in China). He then stayed on for another 10 years to help run the fleet, learning all about reliability and resilience of maritime systems.

After Global Challenge shut down in 2006, Ratsey worked for a Chinese sail-making company, outsourcing digital sail

designs long before that became the norm in the industry. Next, he joined MSubs (also based in Plymouth) building submarines for, among others, the U.S. Navy Seals. The company is owned by the U.S.-based Submergence Group. MSubs' most recent contract was a £21.5 million (\$29 million) autonomous submarine for the Royal Navy, the biggest unmanned submersible operated by any navy in Europe.

So far, so high-tech, and Ratsey's career was to continue on that trajectory. His next appointment was as managing director of MarineAI, another Plymouth-based company, which designs software for commercial and naval vessels, including the U.S. Navy. Sister company of MSubs, MarineAI provided the software for the MAS400 project, which in 2022 resulted in the first crossing of the Atlantic by a full-size (50-foot) unmanned vessel. As well as pushing the limits of what is possible with USVs, the ship was fitted with a range of sensors and scientific instruments that provided valuable data for research into climate change and marine biodiversity. It was the perfect steppingstone to setting up a company purely focused on USVs.

A Hot Market

Unmanned surface vessels are one of the biggest growth areas in maritime industries for multiple reasons, not least the improvements in technology that make the reality of unmanned vessels so much more viable. There's also been a push for greater defense capability, while at the same time a desire to reduce risks to human life. A USV can perform potentially dangerous tasks without endangering personnel. Additionally, those propelled by electric or hybrid systems are virtually silent—invaluable on a reconnaissance mission.

Environmental factors have also contributed to this surge of interest, with USVs providing an ideal way of conducting detailed ocean surveys, often in remote and inhospitable regions, without involving numerous human crewmembers working around the clock in challenging conditions. Quite simply, despite the large upfront costs, a USV is usually cheaper to operate than a manned vessel.



The Oceanus 12's narrow, long lines borrow from sailboat design to create an easily driven hull for maximum fuel efficiency and long distance capability.

The possibilities, it seems, are endless. Ratsey cites conversations with potential clients from across the spectrum.

"We've had approaches from large fishing fleets which want a vessel which can go out and locate where the fish might be," he says. "That way, they keep their boats, which are expensive to run, in harbor and only deploy them when the USV has found fish. Simple as that. Ten of these vessels could completely cover the English Channel and give a much better situational awareness picture. You could also load them with canister-launching systems for life rafts, so if there was a problem with a nearby manned vessel, you could launch one.

"We've had a demo recently for some people who potentially want to use our vessels to deliver spares and post [mail] to oil rigs. They're currently using a helicopter, which is very expensive. The price of crude is down to about \$65 a barrel, so there's pressure on margins and they're being told to find another solution; so, how about using an autonomous vessel?

"Fire safety boats are another possible use. Why on earth, in this day and age, would you have a fire safety boat run by people? Why put lives at risk? At minimum, you want that to be remote controlled."

Much of the USV development has been driven by navies—the U.S. Navy in particular—with the result that many USVs on the market are for military applications. Companies such as L3Harris Technologies and Textron Systems in the U.S. and Exail Technologies in France are building high-powered military USVs with attack capabilities. In 2016, the U.S. launched *Sea Hunter*, a 132' (39.6m) unmanned trimaran with a range of 10,000 nautical miles (nm), which could ultimately be fitted with weapons. There's absolutely no doubt that we are at the start of a new era in remote, sea-based warfare already being played out in the Black Sea.

One of the first companies to see the potential of USVs for maritime survey use was Saildrone, founded in Alameda, California, in 2012 (for more on Saildrone, see Dieter Loibner's **Rovings**

article in *Professional BoatBuilder* No. 210, page 15). This company builds USVs in three sizes—23' (7m), 33' (10.1m), and 65' (19.8m)—powered by small, solid sails and solar panels, allowing them to operate autonomously for up to a year. They've been used by the National Aeronautics and Space Administration (NASA), the U.S. Navy, the U.S. Coast Guard, and numerous research organizations around the world, with around 100 vessels launched as of 2024. Their main limitation, of course, is that they are wind-driven and, therefore, subject to local conditions, making it difficult to hold to a reliable schedule.

Close on their heels, a Norwegian company launched its own sail-driven 2m (6.6') USV Sailbuoy, which in 2018 became the first unmanned vessel to cross the Atlantic, sailing from Newfoundland to Ireland in 28 days.

In such a crowded marketplace, ZeroUSV was launched with a very particular vision. Ratsey's idea was to create multifunctional boats that could be chartered to different entities in the defense and commercial sectors to perform a variety of tasks. This would give companies that can't afford to

build their own USVs access to the fast-developing technology.

"Unmanned vessels are no longer the stuff of sci-fi," he says. "We have the technology here now. We're past the point of thinking how clever it is. It's not about whether to have a USV, because lots of people have them. It's about whether you've got the ability to quickly change that configuration, to put on specific payloads that are useful for defense, so you can use it for listening or whatever it is you might be doing, and you can then reconfigure the boat quickly and easily so that you can run it in hydrographic mode. That's what we believe we've come up with in our design of vessel."

Efficient by Design

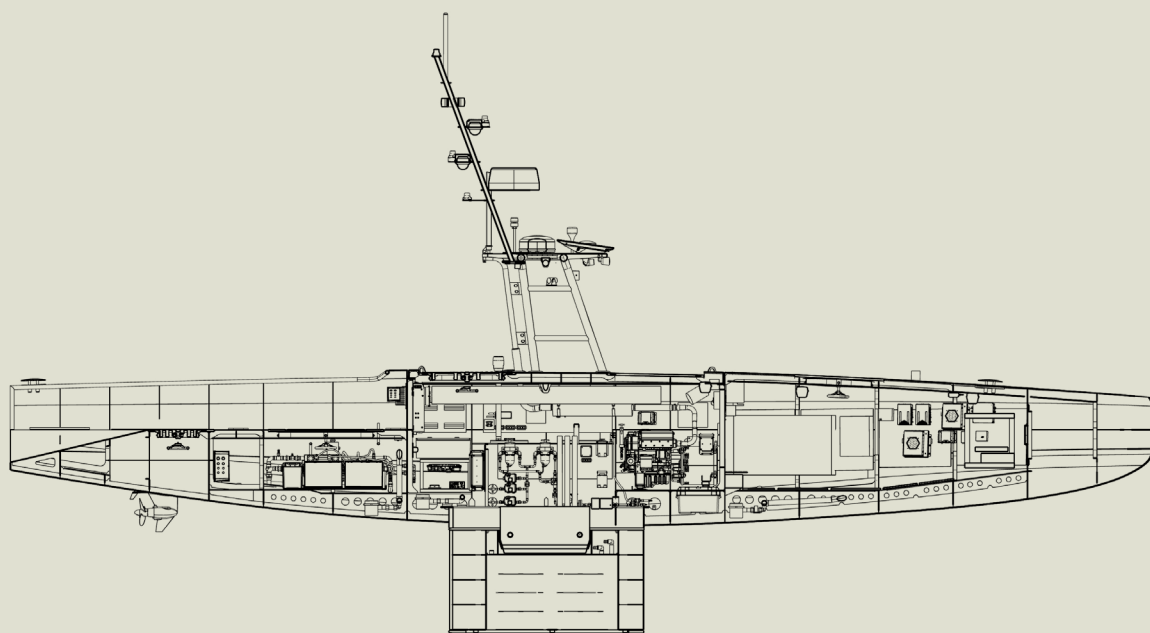
Looking at some of the companies now building USVs, there's a bewildering variety of designs available, from what look like typical speedboats with a box of tricks bolted onto them to full-fledged submersible robots. So, what exactly are the design parameters for such a particular type of craft, and why does the Oceanus 12 look like it could quite happily be fitted with a mast and sails?

"Well, because one of the most efficient hull forms is long and narrow, and that is generally what a lot of sailboats were like, before the modern trend for wide transoms," Ratsey says. "We went for a long narrow boat for two reasons. One, we wanted to be very fuel efficient. Two, we wanted to fit in a 40-foot container, which meant we were obviously restricted on beam and length. So, we've got a length of 11.55m (37.8') overall and a 2.35m (7.7') beam. That gives a beam-to-length ratio of about 1:4.5, which is really quite high compared to a typical modern yacht, which might be around 1:3.2."

Another key factor in the boat's design is its power source: a pair of 40-kW RAD electric outboards, powered by two 21-kWh battery packs charged by two 22-kW three-phase generators (plus two token solar panels). With long-distance capability a key issue, an efficient, easily driven hull shape was an essential part of the brief.

"Up to six knots, the boat uses very little power at all. That's obviously the sweet spot," says Ratsey. "At that point, the curve is more or less flat, but as you go faster, it's exponential because all you're doing is digging a hole in the water. The boat can

Figure 1. Cutaway profile of Oceanus 12



sprint at 12 knots, but the optimum cruising speed is six. We wanted a very efficient hullform to ensure the boat uses the minimum amount of power to get the maximum amount of duration at sea.”

Getting to the nitty-gritty, the Oceanus 12’s generators each consume three liters (0.8 gallons) of diesel per hour. To power the boat along at six knots, the generators alternate, each running a total of six to eight hours per day. Between them, they consume about 48 liters (12.7 gallons) of fuel per day. Given the boat carries 1,200 liters (317 gallons) of fuel, that gives you 25 days at sea—more if you go a bit slower, less if you go faster.

As for the solar panels fitted to the two most recent boats, it seems they are there largely for decorative purposes—and to give the company’s lead engineer Henry Person a break.

“We got so bored with people saying, ‘Has it got solar?’ [that] we decided it would be simpler just to fit them and say yes,” says Person. “It works out cheaper, if you add up all the time we had to spend explaining why we didn’t have solar panels.”

More seriously, the panels do offer some extreme scenario redundancy. If both generators failed, there would be enough power to charge the emergency battery and send the vessel’s position back to base.



The keel of the Oceanus 12 is largely for holding the skin cooling tanks for the boat’s generators.



Belowdecks, the Oceanus 12 is 100% business—every system designed to operate autonomously.

Another surprising (and sailboat-like) feature of the Oceanus 12 is that it has a keel, though its main purpose is to hold the skin cooling tanks—one for the port generator and one for the starboard. It also has a plate on the bottom so payloads, such as multibeam sensors for underwater surveying, can be attached quickly and easily. Fixed standpipes that run through the boat allow cables to be run from whatever device is fixed onto the keel straight into the boat without having to take it out of the water.

As for the boat’s brains, all the Oceanus 12s are operated by the GuardianAI program developed by ZeroUSV’s sister company MarineAI. Crucially, this allows the boat to embark on complex missions not simply as an unmanned vessel but with complete autonomy, as in, no ongoing human input. In theory, once the boat is programmed to perform the required tasks, it can disappear over the horizon, returning 25 days later once its mission has been completed. All the while, the boat’s home base can harvest real-time data and closely monitor its progress.

Construction of the vessel was farmed out to Manor Marine in Portland, Dorset, U.K., using pre-cut aluminum panels from a specialist company in the Netherlands.

Despite ZeroUSV’s initial intention of chartering the fleet, their second boat was sold within weeks of being built to a

Canadian company that leases survey ships. Leeway Marine has a fleet of seven vessels, ranging from a 37m (121.4’) aluminum oceanographic research ship to a 7m (23’) open workboat, which it hires out to a variety of clients, including the Canadian Navy. The Oceanus 12 is its first USV and, painted all black, has been renamed *Viper* as part of its new Serpent Class.

Leeway Marine’s list of mission capabilities for its new boat is instructive and remarkably wide ranging: hydrographic and geophysical surveys; environmental and oceanographic monitoring; port and coastal infrastructure inspection; offshore wind and subsea cable surveys; Arctic ice observation and navigation; fisheries research; and intelligence, surveillance, and reconnaissance. The advertised range for *Viper* is 2,500 nm at 7 knots or 3,400 nm at 3.5 knots.

In September 2025, ZeroUSV took part in the REPMUS (Robotic Experimentation and Prototyping with Maritime Unmanned Systems) exercises off Portugal, under the aegis of the Royal Navy. The annual event is organized by NATO to test and develop the latest unmanned systems, involving 3,700 personnel from 24 countries over a period of nearly three weeks.

ZeroUSV and Oceanus 12 were tasked with two main missions. One was to deploy and recover a 150m (492’) towed

hydrophone autonomously, meaning the boat was programmed to do the job rather than being remotely controlled by a human operator. The other was to develop a sonar buoy launching system and launch the device autonomously. According to Ratsey, both were “world firsts,” and both were achieved successfully.

It’s an impressive timeline, from the company being created in January 2024, taking on its first employee in October 2024, having its first two boats launched in March 2025, and selling its first boat in June 2025. By the time I visited its offices in January, the company was employing 10 people, its fourth boat had just been launched (though it was still at the boatyard in Dorset receiving its finishing touches), and it was well into the construction of its next, much bigger boat: a 17m (55.8’) USV capable of at least 50 days at sea. Not bad



Left—A Netherlands company pre-cuts the aluminum panels from which the hulls are assembled in Dorset. **Above**—Leeway Marine in Nova Scotia, Canada, bought the second Oceanus 12 for its fleet of charterable research and service vessels. Listed missions range from fisheries research to surveillance.

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As part of its test mission at the REPMUS exercises off Portugal, this Oceanus 12 was fitted with a winch to deploy and recover a hydrophone.

for a startup of just two years, and more proof, if it was needed, of the strength in this market sector.

The Next Wave

Back at the ZeroUSV office on Turnchapel Wharf, Ratsey and the company's CAD engineer, Nathaniel Serpell-Stevens, walked me through the drawings for the new boat. The design process was rather unusual and apparently falls under the category of what is currently known as "spiral development."

"We used oversized engines on the Oceanus 12," says Ratsey. "They are 40 kW, when we only really needed 20 kW. So, this time we've taken exactly the same package and thought, 'What's the largest vessel we can wrap around that?' The answer was pretty close to 17m

[55.8']. That allowed us to concentrate on getting the design done and getting to market that much quicker, because having to design the whole thing from scratch would have taken another year. The only change is that we've gone for the 60-kWh battery pack, as the engines are going to be working harder because it's a bigger, heavier boat."

This time, there's no question of trying to fit the boat into a container. Instead, they've gone for the maximum size you can fit on a trailer and tow onto a ro-ro ferry—which is what they ended up doing in practice with the Oceanus 12 anyway.

The result is a boat almost identical in shape to its predecessor, while being slightly narrower proportionally. Most of the extra length is in the longer payload area, which

is now big enough to fit a 20' (6.1m) container—not that they expect the boat to carry an actual container, but it might be required to carry one's contents.

The new boat carries 3,000 liters (792.5 gallons) of fuel, which according to their calculations should double the range of the smaller boat, while carrying a much bigger payload of 4 tons (8,960 lbs)—more than five times the Oceanus 12's capacity of 750 kilograms (1,653 lbs). It's no coincidence that this payload more than matches the requirement of the larger systems regularly used by the Royal Navy. The boat also has a bow thruster, partly for positioning but also to maneuver out of tight spots.

It's a measure of how fast this company moves that the aluminum panels for the

Oceanus 17 were cut at the end of December 2025, and the boat was expected to launch in June 2026, ready to be shown at the Sea-work commercial boat show at Southampton in June 2026. That's less than a year from gestation to operation.

It's not all sunshine and rainbows, however. British regulations mean that unlicensed USVs are only allowed to be deployed in "categorized waters," which in Plymouth's case are two small areas on either side of Plymouth Sound, usually frequented by large numbers of pleasure boats—not ideal for serious USV testing. Getting a license is a complicated process, which so far has involved submitting 400 pages of documentation, even though the hull structure itself has already been signed off by the relevant authority. By contrast, the company had to submit just 50 pages

of drawings and information to the Canadian authorities, and within three months, Leeway Marine's boat was licensed to work up to 200 miles offshore.

Likewise, when ZeroUSV took part in the REPMUS exercise off Portugal, they were given free rein and used that time to their advantage.

"We achieved more and learned more being there for three weeks than we had in four months in Plymouth," says Ratsey. "The reality is that we have, I believe, a small technical advantage here in the U.K. with our product development. But if we are not allowed or not able to carry on developing that at the pace we need to develop to meet the aspirations of the world, we will be left behind in short order. And the reality is that other countries are pouring hundreds of millions of dollars into companies like ours,

right now, this second. They are moving very rapidly to catch up with us, and they will overtake us if we don't carry on developing."

The clock is ticking, and Ratsey and his team are determined to remain at the forefront of this brave new world that is emerging as we speak. They are in a strong position to continue to dazzle the marine sector with their on-water performance and retro paint jobs, provided they don't get tangled in red tape. **PBB**

About the Author: Nic Compton is a freelance writer/photographer based in Devon, U.K. He lived on boats in the Mediterranean until the age of 15 and worked as a boat-builder for many years before swapping his chisel for a pen and his router for a computer. He sails a Rhode Island-built Freedom 33, currently based in Greece.



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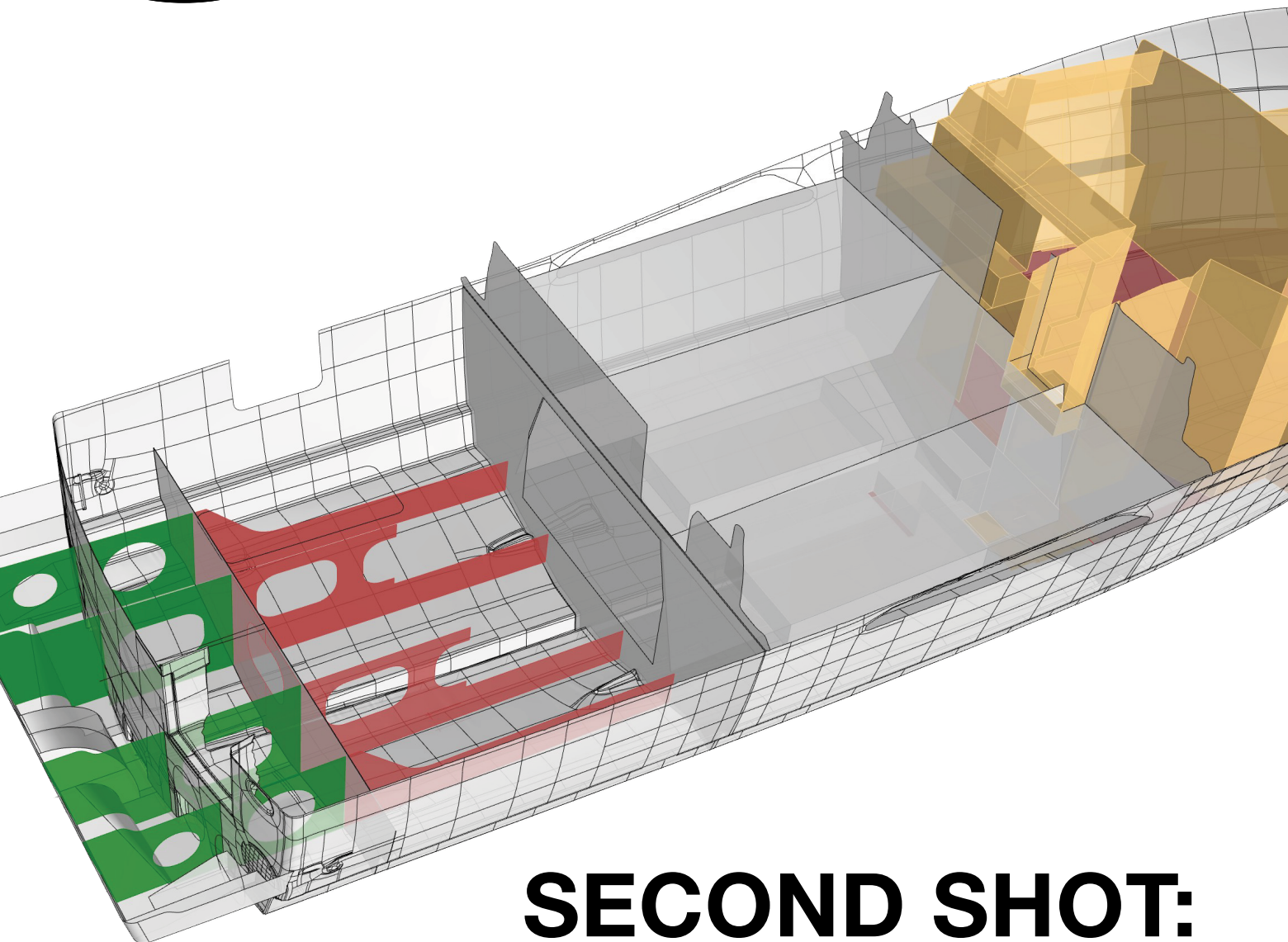
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SECOND SHOT: The Six Guns Project

Nova Boats converts a 50' sportfisherman to outboard power and a new life.

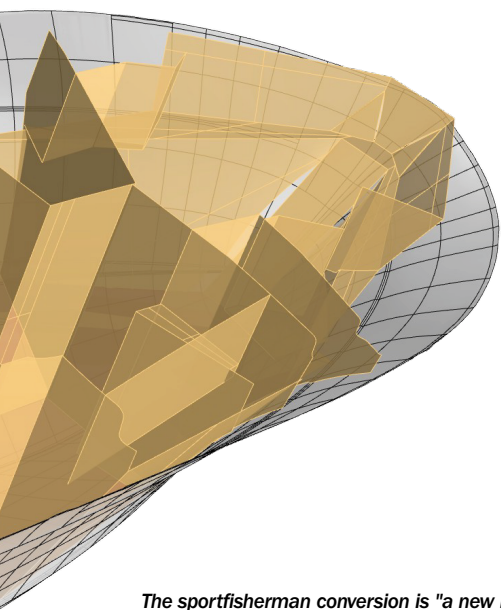
BY AARON PORTER

I knew nothing about José Abella and Nova Boats before excited word of his Six Guns project crossed my desk from two reliable high-speed boat whisperers: the late Alan “Brownie” Brown and Scott Porta of Porta Performance. Brown called my colleague Dan Spurr back in 2024 to introduce him to Abella and the then-nascent conversion of a 50' (15.2m) Viking sportfisherman to quad 600-hp Mercury outboards, reducing draft by two feet, increasing fuel capacity from 800 gallons (3,028 liters) to 1,200 gallons (4,542 liters), and reconfiguring accommodations and onboard systems to suit. It wasn't far enough along to warrant a visit then, but in 2025, Porta—who was building a custom outboard bracket that's

essential to the modifications Abella and his team are making to the propulsion system—gave me a project update and praised Abella's work transforming the old Viking.

“It's a conversion, not a retrofit,” Abella insisted when I visited him last November. “We have built a new boat inside an old boat,” he explained as we walked around the unmistakable Viking hull shrouded under a temporary shelter outside his Miami Gardens shop, where the jets fly in low to land at Opa-Locka Executive Airport.

Bow on, it looked like a sunblasted veteran of some exhausting fishing campaigns. From aft, it was a scene from Dr. Frankenstein's laboratory of a creature partway through a



The sportfisherman conversion is "a new boat inside an old boat," says Nova Boats' José Abella.

radical physical transformation. The stern had been reworked with a new buoyant section and low transom projecting a few feet beyond where the old transom had been, married deliberately to the original running surface, chine flats, and hull sides. The crew was awaiting installation of the Porta bracket before the four big outboards could be hung to complete the conversion vision.

Inside the Nova Boats shop (also home to Abella's Prop It Rite Consulting and Aquaglide Technology), a custom Ferrari-red Doug

Wright 48 *Scaramouche* and a Nova 39 production model testified to the quality of design and build work the shop delivers. The former was a showcase of flawless custom metal work, hardware attached with hidden fasteners, and immaculate engine room design and execution. The latter, a working display of the good ideas about high-speed offshore boats Abella has picked up during a lifetime in the industry.

It's no surprise that Abella grew up in the trade. His family fled Cuba in a boat when José was 9, landing first in Puerto Rico and settling in Miami a few years later where his father got a job working at Magnum Marine, and later at North American Boats in Fort Lauderdale. At home, the young Abella had access to boatbuilding materials and his father's encouragement. Early on, he started specializing in mechanical work and rigging at North American, then on to SeaVee and a stint at Frank and Jimmy's Propeller Shop. Eventually, he struck out on his own doing independent projects with Brownie, customizing and converting 53 Magnums and 45 Carys for clients in the Middle East and South America and consulting for companies like Jaguar Powerboats.

In the early aughts, Abella, an experience- and intuition-driven designer, started working closely with Washington-based naval architect Wayne Wingate (Wingate Marine LLC) making those conversions. They

initially met at Frank and Jimmy's Propeller Shop where Wayne was the naval architect for Marine Diagnostics providing naval architect services and full data acquisition sea trials including vibration analysis and shaft torque measurement.

"I don't like to cut corners, and I don't like to guess," Abella said. "When I have to guess, I need to stop and figure things out." Wingate has been his collaborator with the computer savvy and formal naval architecture training to help figure things out and document the solutions they develop. The two have nine patents together, as well as having designed the Nova 39.

"A lot of times he makes me scratch my head. Other times, I do it to him," Abella said.

Six Guns Project

"Boaters are a very special breed. To some of them, it's the joy and pride of having the only one," said Abella. That's what motivates the client for the Viking conversion, who is guaranteed to have a unique boat on a production-built hull. He already owns a couple of other smaller high-speed boats with multiple outboards.

"But you have no space," the client complained to Abella at the beginning of the project. He wanted something that could accommodate his family and carry them to and from their property in the Bahamas. The conversion



Left—For José Abella, converting the Viking is a hands-on exercise in experience- and intuition-driven design. **Right**—Accommodating four Mercury 600 outboards on a custom Porta bracket, the new transom also adds buoyancy and better lift when backing down.



The added buoyancy and unique shape of the new after section were clearly visible before the deck and internal structure were installed.

to outboard power is driven in part by a desire to reduce draft, always a good idea in that skinny Bahamian water. Plus, “he wants to be able to beach this boat,” Abella said. While the Viking certainly had the physical capacity the owner wants, Abella knew accommodating all that and converting to outboard power would be the primary challenge.

“He said he didn’t want something that looks like we just hung it there, he wanted it to look like it came with the boat,” Abella said. “It’s better to build new from the ground up, but that’s not the case. Here, we have to build the new on top of something that’s already there and then make as much sense as possible.”

Structure

The first step was to laser scan the 2002-vintage hull so Wingate would have the true hull shape to work with. By computer modeling the hull, they could remove the twin 1,100-hp V10s from the equation and add the weight of quad Mercury 600s at 1,300 pounds (589.7 kg) per outboard. They confirmed that they were going to need to move weight forward and build in more buoyancy aft to support the engine weight that had moved from the engineroom at the center of the boat to aft of the transom. But first, they needed to consider the structural changes repowering would require.

Wingate recalled the key takeaways from an IBEX seminar about designing boats for high-power outboards. Beefy grid structures as well as thicker transoms were important

to accommodate those engines. Finite element analysis (FEA) was essential for modeling the thrust forces and their distribution in the hull structure.

“We locked in the structure first, then we did the weight analysis,” he said. “We made conservative assumptions to be sure we weren’t cutting anything close.”

They removed most of the plywood bulkheads and compromised balsa core in the decks that had suffered from water intrusion, replacing them with 28-lb Coosa board and Corecell foam. “No more chances to rot,” Abella said.

Removing engines and fuel tanks left them with a big open space in what had been the engineroom. The stout stringers where the engines had been mounted offered a prime location amidships for the gyro-stabilizer, and a low transverse bulkhead aft of that “turned the whole thing into a box that’s extremely strong,” Abella said. Next, “We basically cut the transom, we made the mold, and we installed the mold on the boat.” The new transom is built with two layers of 2” (51mm) Coosa with ½” (13mm) of heavy fiberglass laminate on both sides. Inside, the converted stern structure comprises a complex composite grid of Corecell stringers clad in vacuum-bagged carbon fiber and S-glass epoxy skins that supports the cockpit sole, absorbs bottom loads, and transfers propulsion loads from the transom to the bulkhead and old main stringers in the former engineroom.

While that new stern section looks like it might have come from the factory, it was the

product of some refined design work balancing multiple performance necessities to make the boat run well in her new configuration.

“These boats weren’t made to hang an engine on the transom. Because we were putting so much weight back there, we needed to add buoyancy,” Wingate said. The new section “gave us structure, it gave us better flow going astern, and it gave us additional buoyancy where we need it.”

As well as adding buoyancy and extending the running surface, the sloped shape of the trailing edge promises to improve performance when backing down.

Abella points out, “Most boats with a 12° shaft angle, when you back down on a fish, the stern just goes down. What’s going to happen here is the stern’s going to lift from redirecting the water.”

Using Simerics and Orca3D software, Wingate ran CFD of the boat running at 45 knots. While there is slight bow-up moment, the boat will sit fairly level, he said. Models confirmed that two 12” (305mm) interceptors installed on that complex stern section are adequate to impart 2° of bow-down trim. He said they’ll primarily be there for port to starboard leveling.

Wingate noted the importance of computer modeling to the conversion. “If we didn’t have the tools that are accessible now—laser scan, CFD, FEA—I don’t know that it would be feasible,” he said. “You can digitize the real world, do your modifications, and then bring it back and do the construction side of it.”

Weight

The goal is for the boat to weigh 45,000 lbs (20,412 kg) and to run at 45 knots with 2,200 hp on the transom. Abella said she could run at 35 knots and weighed 65,000 lbs (29,484 kg) loaded in her original twin-diesel configuration.

By removing significant weight and relocating such a high proportion of what remains on the transom, it was important to calculate the trim measures to keep the boat level.

"The biggest thing we concentrated on was the engineroom conversion," Wingate said. That's where two new 600-gallon (2,271-liter) fuel tanks were to be located, but he had to determine exact location to optimize performance. The original configuration carried 800 gallons of diesel aft of the engineroom.

"Typically, you get a big trim difference between full and empty," he said, which is especially true if the tank is located aft of conventional inboard engines. But with all the space freed up in the middle of the boat, "our biggest focus was to get the fuel near the longitudinal waterplane center of flotation of the boat," Wingate said.

With the help of computer modeling, the two new gasoline tanks on the outboard sides of the hull in the old engineroom are positioned to have little trim effect. And in the space between them—forward of the converted mechanical space that houses the generator and its 150-gallon (568-liter) diesel tank, gyro, batteries, and other onboard systems—a new cabin for the owner's children can be accessed from the main saloon.

Engine and Rigging

The new Mercury 600s have pressurized fuel systems, big return lines, and integral vapor separator tanks. As an example of Nova's attention to high-performance details, to help keep the fuel as cool as possible, the return line dumps fuel in the forward end of each of the two new tanks while each pickup is all the way aft, giving the warm returned fuel every opportunity to mix with the cool residual fuel in the tank.

The engines themselves will be far more versatile than the fixed inboards they replace. Their installation on the hydraulic Porta bracket makes them very adjustable in height and angle.

"We're counting on the bracket to get the maximum out of them," Abella said. "We're going to be able to bring the motors aft and up and trim them."

Wingate noted that the transom angle is 14° and the hydraulically adjustable Porta bracket can add another two. "That'll really allow us to tuck the outboards in and help get it up on a plane," he said. Additionally, because the lower units can act independently, Wingate designed a gap

between the port and starboard engine pairs providing great vectors for joystick-controlled maneuvering.

The owner is also looking for flexibility to run on just two of the four motors at a time. Abella explained that when operating with the two inner motors shut down and out of the water, the big Viking, powered by the two outer motors that can be trimmed to run with the least draft, will be able to get to the beach and fish the shallows as the owner envisages. Conversely, coming back to Florida across the Gulf Stream, the operator can choose to save fuel by running on the inner pair of motors with the outer units clear of the water.

"Can you imagine how much range you would gain being able to run on two motors?" Abella wondered aloud. The flexibility also reduces wear on the engines, enhancing their longevity.

Of course, the throttle and steering control system for that application doesn't come straight from the factory.

"We need to bypass the conventional systems to be able to run two or two," Abella said. It helps that these engines with fixed upper units are not tied together by mechanical steering controls. Instead, the steerable gearcase on each motor is actuated through electro-hydraulic controls. He's working on the steering customization with input from TNT Custom Marine.

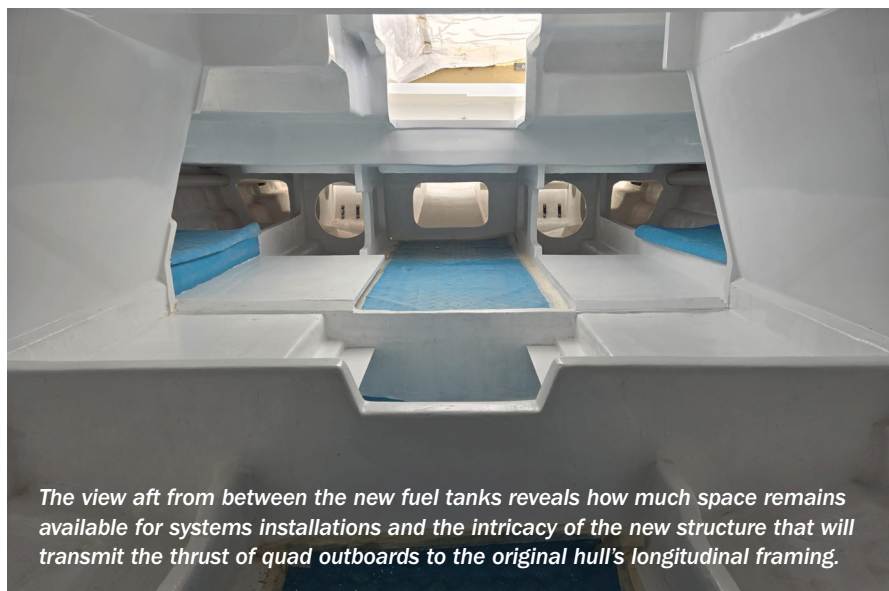
Conclusion

Boats are some of the most enduring of the durable goods we still manufacture in 2026. To an economist, durable goods are any tangible products that last at least three years, so even with its built-in obsolescence, your disappointingly short-lived cell phone qualifies. Recreational boats land at the other end of the spectrum where even the humblest production models have an expected useful life of at least 25 years, and many serve ably for more than a century. Such longevity depends on rigorous maintenance, updating of onboard systems, as well as structural and aesthetic refits. It's why the boatbuilding industry includes an inordinately high proportion of service, repair, and refit workers.

In a decade when backlash against throw-away culture has spurred a proliferation of right-to-repair laws that ensure consumer goods can be fixed and reused, boats look good. Abella's Viking conversion is an instructive example of the value that keeping old boats in service brings to the boatbuilding industry by making them virtually new again.

"This is not a cheap endeavor, but there's also nothing like this configuration out there," Wingate said. **PBB**

About the Author: Aaron Porter is editor of Professional BoatBuilder.



The view aft from between the new fuel tanks reveals how much space remains available for systems installations and the intricacy of the new structure that will transmit the thrust of quad outboards to the original hull's longitudinal framing.

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The Promise and Perils of Laminated Teak

BY RICHARD STRAUSS

There's a deep-rooted ethos here at Teak-decking Systems (TDS): Test, test, test, and then test again. Through 43 years in the deck business, our backyard in Sarasota, Florida, has served as our testing ground. It's where we lay out teak and other wood decking material samples from all over the world and then wait, observe, and allow time to do its worst.

Sample test panels sit outdoors for years subjected to the full range of Florida's challenging elements—extreme ultraviolet exposure and high temperatures, relentless humidity, and hurricanes. Only after years out there does the team decide whether a tested wood makes the cut. Many don't, which means they won't appear in our menu of deck material options.

The quest for alternative wood suitable for boat decking has become more urgent in recent years, as supplies of 100-year-old teak from Myanmar, long regarded as the gold standard for decks, falter. The traditional teak market has undergone enormous change following the sanctions placed on Myanmar to prevent the sale of illegally harvested timber after 2021's military coup. Its importation into the EU has been illegal since 2013, and in 2021, the ban was extended to the U.S. in an effort to mitigate human rights violations and deforestation. Particularly in Europe, teak is subjected to intense scrutiny regarding its provenance and legality, and this in turn has placed timber traders in a difficult position as they scramble to offer viable alternatives to the marine market.

During the 2025 Metstrade show in Amsterdam, we displayed one of the time-tested alternatives we had approved—a beautiful caprail made of Green Teak. This substitute for old-growth wood is manufactured by a Thai company that produces teak planks from teak veneers laminated together using a proprietary process and adhesive. While it's clearly not conventional teak decking material, the laminated wood has a similar look and feel.

One enthusiastic visitor to our booth observed that he could replicate what we had

on display, using a standard plywood wood glue. Alarm bells immediately started ringing. We knew from testing and consultation with Green Teak that it's not that simple, and we know from experience what happens when suppliers bring modified woods to market before completing long-term testing. The results have been disastrous for deck builders and ultimately for the end clients, who find themselves replacing newly installed decks far sooner than expected. If done poorly, new laminated teak products have the potential to repeat some of those experiences.

Green Teak entered the market years before its time, offering a laminated teak product that took years to fully develop. It is visually attractive, with veneers similar to the vertical grain of natural teak, delivering a plank-like finish. Our tests indicate excellent durability, as the laminating process enhances its dimensional stability and integrity. As a result, it has rapidly gained a strong presence in the market, and demand is growing quickly within the pleasure boat and superyacht sectors.

To make the laminated hardwood planks, teak is sliced into thin veneers and glued together. The process uses parts of 30- to 40-year-old trees that would normally be rejected due to knots and imperfections. It achieves a very high yield from these logs when making battens or planks, and contrasts starkly with the 15-30% yield rates from traditional teak where only the vertical grain is cut. The manufacturing process results in less waste, creating planks as long as 4m (13.1'), and under current market conditions, the price of a laminated teak deck is slightly lower than that of a traditional teak vertical grain deck.

We have found it an excellent product and a viable alternative for clients looking to move away from traditional teak. While gluing up teak veneers may seem like a straightforward concept, the practical realities of producing a consistently durable and reliable laminated decking material are complex. Boatbuilders and deck specialists should be aware that not all laminated teak is the same, as it requires an

enormous amount of research and testing to manufacture it properly.

We see suppliers entering the market with laminated wood that has undergone approximately three to five years of development. In contrast, we've been testing and working with this specific laminated teak for approximately 11 years, and the early versions had high failure rates. In our experience, the complexity of the adhesive and bonding process is what separates most quality laminated teak from inferior offerings. Many companies think you can just glue laminate strips together. They don't appreciate the 10-plus years of adhesive and manufacturing development required.

We have a genuine concern within the industry about companies launching laminated teak without properly testing and vetting their products. Our message to any potential buyer considering a laminated teak deck is to be extremely cautious before committing, be a skeptical consumer, and ask the right questions. As you choose a supplier, consider the following carefully.

Once installed, any type of teak deck will expand and contract. If it's not manufactured properly, the bonds between battens in a laminate decking can fail, and you will find yourself back in the market for a new deck.

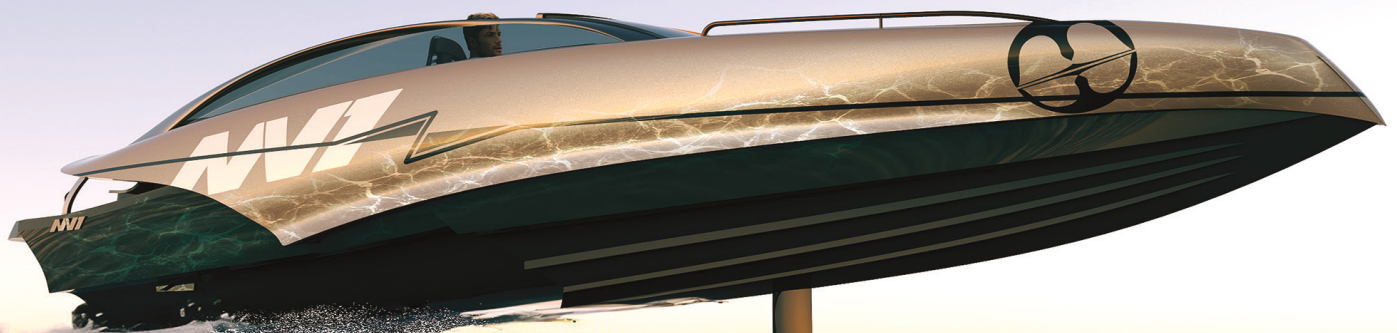
If you are considering a laminated teak deck, it's essential that you conduct thorough due diligence and research to understand who the manufacturer is, their history, and how long they have truly been testing and developing the product.

The key lesson here is that a properly developed and manufactured 20mm (.9") laminated teak plank offers great potential as a marine decking material. However, in the wrong hands with the wrong adhesive or inconsistent or incomplete manufacturing process controls, it has equal potential to be a failure. Boatyards and owners must understand that the results of long-term testing, proven adhesive technology, and a verified track record are not optional, they are essential. **PBB**



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