Building the Big Guns

Combining design elements and technologies of high-performance racing yachts and cruising catamarans, Gunboat's first boat rolled out of the shop 12 years ago. The thriving company has built multiple models in South Africa, China, and now at the former Buddy Davis facility in Wanchese, North Carolina.

Text by Ginger Gardiner
Photographs by Billy Black
(except where noted)

Above—*The multiple-part tooling for a Gunboat 55 (16.7m) is unbolted and pulled away to reveal the infused carbon fiber hull at the company's new production facility in Wanchese, North Carolina.*
Right—*Thorough planning to accommodate efficient build techniques, including modular production, was required to deliver a sophisticated racer/cruiser that met the company's demanding standards. Here, poring over complex production schedules as they work on systems design, are, from left: Rick Gotwalls, a consultant from Vectorworks Marine (Titusville, Florida); operations manager Dan Bottjen; and president Peter Johnstone.*

Gunboat International is a company born of a question that vexed its founder, Peter Johnstone, as he pondered his own sailing needs back in 2001: "Can't we build a production boat using high-performance raceboat technology?" A dozen years and 21 boats later, the undeniable answer is yes. It seems that Gunboat's distinctive cruising catamarans have found a lucrative niche market of technology- and performance-oriented customers.

Johnstone combined his business and management experience and a family history of building production sailboats (see "J Is for Johnstone," *Professional BoatBuilder* No. 98) with a skilled Gunboat technical crew, who work to close tolerances infusing complex hull and deck parts in advanced composites. From the outset the team understood the up-front investment in design and engineering, pre-planning, and production capability required to actually achieve the performance

COURTESY GUNBOAT INTERNATIONAL (BOTH)

Since Gunboat's first build in 2001 in South Africa, the company has made its reputation building high-performance cruising catamarans with raceboat materials and production technology—without skimping on comforts and amenities. ***Left—****The Gunboat 66 (20.11m)* Coco de Mer *under way.* ***Above—****The bright and open interior of* Sugar Daddy, *another 66.*

and quality in carbon fiber and European-style high-finish interiors they promised to deliver.

Having successfully established production lines in South Africa and China that meet their demanding standards, the team's latest expansion has been to the United States. They repurposed the former Buddy Davis shop in Wanchese, North Carolina, in 2012 to infuse and assemble all the complex modular parts of the Gunboat 55 (16.7m), as well as build some of the company's other large custom models. Why North Carolina? The facilities and trained workforce there make logistical and economic sense. That conclusion flies in the face of some broadly accepted wisdom that in recent decades has driven numerous North American boat manufacturers to offshore shops in countries like South Africa and China, a phenomenon we have covered in these pages (see "The China Trade," PBB No. 103, "China Revisited," PBB No. 128, and "After Apartheid," PBB No. 83).

Let's take a closer look at the Gunboat niche and the production and market demands that have made boatbuilding in the U.S. so attractive.

And then there are the boats.

Raceboat Technology and Luxury in Production

Gunboat produces its Gunboat 55 in Wanchese, North Carolina, and the Gunboat 60 (18.28m) in Xiamen, China, at Hudson Yachts through a licensing arrangement. Gunboat 78 and 90 (23.7m and 27.4m) models, basically custom boats with carbon-fiber/Nomex-honeycomb-cored hulls and decks, are also completed in North Carolina. Current annual production is ten 55s, four 60s, and a larger boat every year or so.

When asked, "Who is the target Gunboat customer?" Johnstone replies, "I grew up sailing and racing. I had a 70′ [21.3m] keelboat that had won the Transpac, which I converted into a cruiser. While sailing with my

Just out of the molds in Wanchese, the Nigel Irens–designed Gunboat 55 hull is a single, all-carbon-fiber part infused in one shot. Thanks to the properties of the carbon laminate, this model needs no forward crossbeam to support the hulls, thus eliminating windage and minimizing drag.

family in the Caribbean, we saw a production French catamaran that was very heavy, but they were enjoying their lunch, and mine had just made its way back up and over the rail. I realized I could have more comfort, less weight, less systems, and less maintenance in a catamaran than in a keelboat, but there just wasn't a high-performance cruising cat that fit what I wanted. So I started Gunboat. It was the first cruising catamaran to apply racing technology."

While cruising cats are typically built with polyester resin and have all-plywood interiors, and few are cored construction, says Johnstone, "we developed a 62 [18.9m] using carbon and glass fiber, epoxy resin, and foam core that weighed 50% less than the 70′ keelboat I had, and probably got 30% better daily mileage with a lot more comfort." Gunboat since then has had a continuous evolution of reducing weight, adding conveniences—a dishwasher, washing machines, air-conditioning, and generators—and modifying production to achieve the reliability necessary for world cruising.

"With all of the conveniences, it gets increasingly challenging to hit our early performance parameters," says Johnstone. This was one motivation for adopting all-carbon fiber in the 55. He adds, "The new furniture we've developed has also helped." Cored with Divinycell foam, it is half the weight of the previous package and is all cut with computer numerically controlled (CNC) routers and assembled in North Carolina by furniture makers whose specialty is high-end staircases.

Johnstone: "We actually started using all carbon fiber for the last of the 62 series. We used E-glass and carbon in the first Gunboats, but when you're offshore and come off of a wave, the boat would shudder and shake after the impact, and the furniture would squeak and make a lot of noise. After switching to mostly carbon fiber, we saw almost no bending or deflection and no shimmying. The boats were very quiet. Also, E-glass boats started to show a little stress in the paint. With the carbon fiber boats, this went to zero."

Assuring reliability and durability over time is a priority for Johnstone. "Our owners log an average of 10,000 miles per year, and we just don't want any issues long term." At the outset the company wet-bagged its epoxy laminate skins over Nomex

Where in the World?

Building in a Global Marketplace

Gunboat's production of high-performance cruising catamarans began in 2000 with the first two 62s (18.9m), built at Harvey Yachts in Cape Town, South Africa. "Phil and Laura [Harvey] already had a reputation as excellent racing-sailboat builders," says Gunboat president Peter Johnstone. The Harveys then sold their company to Jaz Marine, which built the next two 62s. Meanwhile, Johnstone contracted with nearby Acheson Rossa Custom Yachts to produce Gunboat 48s (14.6m). He bought that yard after it became insolvent, and then merged it with Latitude Yachting to form Gunboat South Africa in 2005.

Gunboat production in China started in 2009. Johnstone recalls, "I could tell costs in Cape Town were making us noncompetitive versus custom yards in the U.S. and Europe. Our biggest cost component at that time was labor. So I started to pursue lower-cost labor options in Asia." In addition, he was impressed that the single largest potential for growth in the next 10 years was the Asian market, with its attractive combination of wealth and spectacular cruising grounds in Thailand, Indonesia, and Malaysia.

Gunboat closed the Cape Town factory in 2011, primarily due to labor union demands. Johnstone says of the postmortem: "By law, once a company employs 50 to 80 people, you must have unions. Until then, we had a cost-effective shop. The unions then demanded a 32% wage increase four years in a row. By law, companies must pay union members a thirteenth month as a bonus, as well as 18 paid sick days and six weeks of vacation. So we were paying 13 months of wages but only getting nine months of work. These numbers simply aren't sustainable for a business."

Also in South Africa, employers must pay six to eight months of wages to let a worker go. This was a factor in Gunboat's choosing North Carolina—a right-to-work state—for its latest factory. Johnstone says, "As a boatbuilder, when there are economic downturns, you must be able to contract your workforce to a level that enables you to survive until things turn around."

Meanwhile, navigating the Chinese market was challenging. "China is like the Wild West, but if you find the right people to partner with, it's terrific," says Johnstone. Hudson Yacht & Marine—a Taiwanese company working in China—had been building J/80s for five years, and had demonstrated a commitment to maintaining a high level of quality and to having the right people on

The Gunboat production line at Hudson Yacht & Marine, in Xiamen, China, continues to build the company's 60′ (18.3m) model.

COURTESY GUNBOAT INTERNATIONAL

honeycomb core, but with infusion has switched to foam core—Corecell M-Foam, specifically—which it believes will also provide better longevity.

Aaron Croswait, Gunboat's infusion leader, explains that core density varies throughout the 55, much like in a raceboat. "We're using high-density core in the bow below the waterline, and then it gets lighter further back. We use a thicker core on the topsides outboard but keep the same skin laminates, and high-density cores again in the forward area of the bridge deck, around the mast bulkhead, and in all of the main bulkheads."

He says they tested plain core, perforated core, and knife-cut core cut on both sides of the panel, with the last of these yielding the best results: "It reduces the amount of excess resin but still provides a path to help with resin flow during infusion."

Tooling the 55

The Gunboat 55 is unique in several ways. While most catamarans are built in multiple parts and then tabbed together, this model's two hulls and bridge are molded as one part with no joints. "Our goal was to move [the 55] from custom to full production," says Johnstone. "Our means of achieving this was to fabricate large composite parts and minimize assembly. It makes the boat much lighter, reduces issues with alignment and movement, and also makes it easier to produce each boat identically."

Gotwalls and Bottjen check the systems being installed in the hull of a Gunboat 55. Modular construction and reliance on precise molds require that complete mechanical, electrical, and water systems are designed prior to cutting the tooling, so that gutters, wire runs, and through-hulls are included.

hand. According to Johnstone, the Taiwanese have values similar to Americans' and a long history of manufacturing partnerships with U.S. companies. Hudson's main industrial campus in Xiamen, China, produces 80% of the aluminum baseball bats sold in the U.S., as well as stainless steel grills for Lowes and other long-term customers.

To assure consistency in Gunboat production, Johnstone had Phil and Laura Harvey set up the company's factory, also in Xiamen, while working as employees of Hudson Yacht. "They knew the level of quality and finish needed for a Gunboat, and that it was not possible to achieve this by cutting corners on materials."

Reliable sources of consistent materials are key to successful production boatbuilding, regardless of location. "Your supply chain is critical," says Johnstone. "Vietnam has a low labor cost, but no supply chain for composite boatbuilding; everything is imported." He says the supply chain in China is good thanks to the aerospace industry and boatbuilders already established there, but warns that parts from the West require six-month lead times, so you must plan for this. "If you are building in Asia, you've got to be on top of your game with specifications and project management, or import and freight costs will eat you alive. Your design and engineering must be 100% buttoned up before you start, which requires a massive investment before cash flow begins. That can be a benefit if you've got the organization and capital, but most small companies don't have that."

And then there's shipping. Johnstone asserts that in China, even though you can save one-quarter of the cost of labor if you're exceptionally well organized, you still have to factor in shipping. For example, it costs $130,000 to pack a Gunboat 60 on a cradle, load it, ship it, unload it, and pay commission. "That pays for a lot of labor in the U.S.," notes Johnstone. However, shipping becomes more attractive for boats that fit into a container.

And low-cost labor goes only so far. Johnstone says, "In China, labor with overhead is roughly 12 to 14 dollars an hour with a proper modern facility and management. In Wanchese [North Carolina] it's roughly three to four times that, which has to be the most cost effective in the U.S., from what I've seen. To have savings on your labor in China, your labor hours should remain under twice the total hours you would expect in the US. This may sound easy, but it is actually a challenge."

Also, Phil Harvey points out the issue of time zones: "You'd work through the day, and then most nights you're on the phone and computer, trying to speak to people in England and the States, so the workload is massive there. The hours are much better here in the U.S."

Johnstone believes that the economics of China work well for boats that can ship in a container or flat rack, or, he notes, "If a yacht is a 20,000-plus man-hour project in the U.S., China will look attractive on the labor savings. Larger cruising sailboats, trawlers, and power yachts can clearly be effective in China. With the growing Asian market, and some stunning Gunboat 60s delivered, we expect to continue the Gunboat 60 production in Xiamen." In the end, the market has played a big part in Gunboat's location literally on the opposite side of the world.

Johnstone says, "I felt we needed to be in Asia *and* America. The Atlantic basin is key for service in the sailing market, and this location [North Carolina] allows us to sea-trial and service year round."

Dan Bottjen, operations manager at the Wanchese plant, adds, "We also benefit from this area and its long tradition of custom-yacht construction. It's a good fit for us, because even though this is a sailboat, there is a high level of expectation for its fit and finish."

—Ginger Gardiner

Phil and Laura Harvey built the first two Gunboats in Cape Town, South Africa, and have been vital members of the Gunboat team in getting the 60 series production started in China, and now the 55 series production up to speed in North Carolina. Phil Harvey: "I'm not sure there's anything else in production being done like this. Because the bows are basically big tubes, it's quite a challenge to infuse these."

To add to the structural challenges, the boat has no forward crossbeam. Instead, a rigid structure of more than 100 plies of unidirectional carbon fiber is infused into the chines, from the engine bulkhead all the way forward, to resist outward loading. "This is a major innovation," says Johnstone. "We are the first performance cruising catamaran to do this, and it gets rid of the windage here. We wanted the bows to go into the waves with as little drag as possible."

Johnstone extols the Nigel Irens–designed shape, also used in the Gunboat 60: "It's unbelievable, providing true offshore sailing performance and high-end details. For example, one of the new Gunboat 60s has sailed 2,000 miles and experienced spray only twice, one of those being a stint through a 48-mph gale. This simple little chine Nigel designed in makes all the difference."

From looking at the six-piece hull tooling on the shop floor it's apparent that every last detail is included in the mold: gutters, hatches, wire chases, and through-hulls, as well as the daggerboard casings, thus eliminating the uncertainly and labor of alignment and secondary bonding.

Gunboat's precision tooling means that hull fairing like this is kept to a minimum, saving weight and labor.

"We do almost no cutting once the carbon fiber hull is built," says Johnstone. "This required a lot of thought and design work up front, but we've found every hour you spend in design takes out 10 to 100 production hours in the boat."

The six-piece tooling, which enables the boat to be built as one piece, was formed over 5-axis CNC-milled plugs produced by mouldCAM (Bristol, Rhode Island) and DLBA Robotics (Hampton, Virginia), reportedly to within 0.1mm accuracy. Johnstone concedes that this was expensive, but believes it should pay off in the long term. "We wanted confidence that when we pulled the parts off, the need for fairing would be minimal, and on the interiors, the furniture would drop right in," he says.

The tooling was infused with vinylester resin in a mix of balsa core and stop-print materials to minimize shrinking and deforming. The molds were post-cured while still on the plugs to ensure no further shrinkage or deformation during service. Johnstone is proud that walkways and stairways with rails are also built into the tooling, providing stable, safe access for workers loading laminates and prepping for infusion.

The center part of the tool is securely bolted to the production floor, and the other components bolt to it. "It takes a couple of hours to take the tool apart and put it back together," says Johnstone, "but that sure beats weeks of assembling multiple hull parts." And he claims a further advantage from his high-quality tooling: "With the infused tools, porosity is so low that we are able to pull 6 to 8 millibars of vacuum on the whole hull. [Digital gauges from

Left—*The original plugs, milled by 5-axis routers at mouldCAM (Bristol, Rhode Island) and DLBA Robotics (Hampton, Virginia), are accurate to within 0.1mm.* ***Right***—*Those tight tolerances mean that bulkheads, shown here, and furniture modules drop in with minimal fitting.*

Three Gunboat 55s occupy different stages of the production line, from the raw carbon fiber hull at the back of the building to more complete iterations to the right. Everything to be installed at each station is placed next to that hull for efficiency.

Vacmobiles were chosen because of their accuracy.] In fact, the vacuum is so good, we can get down to 35% resin content by weight, which is aerospace prepreg level.

"We keep looking for ways to increase modularization," Johnstone continues, "to enable as much pre-assembly off the boat as possible. All wiring harnesses are built on a bench and brought to the boat, so there is no pulling wire as you would in a custom build. Of course, this means that the whole boat must be designed before you build it: interiors, systems, everything."

Operations manager Dan Bottjen adds: "We're reducing the lengths of wire to extremely short runs by using mini-panels controlled by a computer, so that the equipment can be turned on/off from a touch-pad via cabling. The touch-pads—one at the helm and one elsewhere as the owner specifies—can control all of the equipment. This reduces weight, provides better functionality for the user, and also makes production more efficient, but more of the systems and integration must be thought out and pre-planned."

Bottjen, an engineer who previously worked at Hatteras Yachts, describes how the furniture is also pre-assembled, arriving as one kit: "It was developed through the 2D and 3D computer design and planning, which enabled us to know exactly what our interior envelope is. I've never seen anyone do pre-design and preparation for installation to this level before."

All the Gunboat 55 hulls completed so far have been measured to confirm their accuracy. Furniture installation in hull #1 went as planned; any required trimming was measured and those data were sent back to the manufacturer to further refine the scribe on the next sets. Johnstone notes that accuracy of the interior fit is within 2mm (1/12″).

The Build

"A lot of what we have implemented here we have learned from our production in China," says Johnstone. "Getting everything there was a real challenge," Harvey adds. "You'd have to plan four to six months ahead and document and permit everything. It's much easier to build here in the U.S., and it has been much easier getting the production started than in China or South Africa."

Still, there was plenty of work to convert Gunboat's North Carolina facility. Harvey recalls, "There was a huge wall that separated the front from the back, supporting a mezzanine with lots of workshops at the top, so we had to dismantle all of that to get the production flow we wanted. This is a big catamaran, so we needed the space to form proper in-hull and out-of-hull production lines, starting at the back of the building and moving forward in stations to the front." The objective was neat and orderly production that is easily managed. "On the floor next to each hull is everything to be fitted in, so that the progress in what's been put in and what has not is evident immediately. The stations focus the work in stages, and minimize unproductive staff movements.

"Part of the challenge with actually putting raceboat technology into a production boat," says Harvey, "is that all of that detail has to be done cost-effectively and within a certain time frame." To that end, a PTFE-coated (polytetrafluoroethylene, i.e., Teflon) flat concrete table mold, large enough to accommodate a Gunboat 90 main bulkhead (38′/11.6m wide), is built into the shop to fabricate all the carbon fiber bulkheads and flooring for the 55.

In addition to the details in the primary hull and deck tooling, there are more than 100 composite parts to be installed inside once the hull is completed. But this is production

Built into the shop floor, a concrete table with a nonstick-coating accommodates the infusion of carbon fiber bulkheads, floors, and more than 100 miscellaneous composite parts for each boat.

Left—*To kit laminates, crew first cut the fabric for a composite part, then spray-tack laminate stacks together, and in some cases store the stack on curved tables to prevent the wrinkling of inner layers that occurs when flat laminate stacks are applied to a curved mold.*
Below left—*Crew fit core material to the dry laminates of a bulkhead section on the flat infusion table.*
Below—*The table can accommodate multiple infusions simultaneously. The team members that build these parts are paced so that when a new hull comes out of the hull mold, they are ready with a full set of flat panels to put into it.*

building, so they go in quickly. Johnstone: "When the hull comes out of the mold, all of the bulkheads have been made and are ready to go in. That is the first station, followed by systems installation, interiors, and then paint and finish. So, we're pulling hull #3 out today, and we will start laying up hull #4 tomorrow. Every 30 to 40 days, we will infuse a new hull."

Workers are kitting materials constantly, so when the next hull comes along, the dry laminate stack is ready to be laid in. The outer and inner skins are each three layers of woven carbon fabric. Workers cut each layer and then join them with spray-tack adhesive from Zyvax.

"We only lay down material once, which saves time," says Harvey. "In the past, we would have laid three separate layers, but now we lay down one pre-made skin, and then we're ready to start the core."

Johnstone says, "We also store the pre-made skins on curved tables to prevent wrinkling of the inner layers [when stored flat], which helps us to maintain fiber alignment in the finished laminate."

The process for laying in the dry stack is also unlike other methods. The six pieces of the tooling include the inside bow molds (1) and (2), the center forward bridge deck (3), the aft bridge deck and aft inside molds, all forming one piece (4), and finally the two outside hull molds (5) and (6). Harvey: "We start by joining the two inside bow molds to the center forward bridge deck. This is then joined to the main center mold (4), which is bolted to the factory floor. We then vacuum-test the tooling joints for any leaks before proceeding with the dry stack." He says the complex geometry of the boat hull would make it difficult to load the laminates with the molds fully assembled, but having them only partially assembled makes it easy. The outer hull molds, for instance, are fully accessible for their entire length in this configuration. Next, the team brings in the outside molds and completes final assembly of the tooling, followed by interleaving the outer and then inner skin plies, with the foam core butt-jointed along the length. The very forward sections of the bows are molded separately, so there are openings forward during the hull layup and infusion that can duct cool air. The "crash bows" and their bulkheads are installed when assembly of the boat is almost complete.

The six pieces of the hull tooling are spread out on the shop floor prior to loading with laminates. Due to the complex geometry of the part, the molds are only partially assembled as the kitted laminates are laid in place; then the outer sections are bolted on, the laminates are interleaved, and the foam core butted. Before infusion the entire unit is vacuum-tested for at least a full day to reveal any leaks, and eliminate any moisture in the dry stack.

Harvey points out that no gelcoat or primer is sprayed into the mold, as the hulls will be painted. A semi-permanent Zyvax mold release is wiped on every time the mold is cycled. "We could go six pulls on one layer," says Harvey, "but the system is also a mold cleaner, so applying it once every time we start up just helps us maintain the mold."

Infusion Refined

Harvey says every new Gunboat series has required developing its own proprietary system of infusion based on its particular size, design, and features. "With every infusion we do, we take a step forward." For the North Carolina production line, Gunboat developed an infusion setup that reduced the number of feed lines, which significantly reduced wasted resin, from 30% down to a single digit. That efficiency started with the company's experience in China, where Gunboat had worked with consultant Peter Kjosen to develop a parallel infusion system.

Johnstone: "He had helped Oracle with wing components for the last *America*'s Cup campaign and had a wealth of carbon fiber infusion experience, including building 130′ [39.6m] yachts in Turkey."

Harvey says the system in China employed a number of parallel feed lines, and they infused to each line

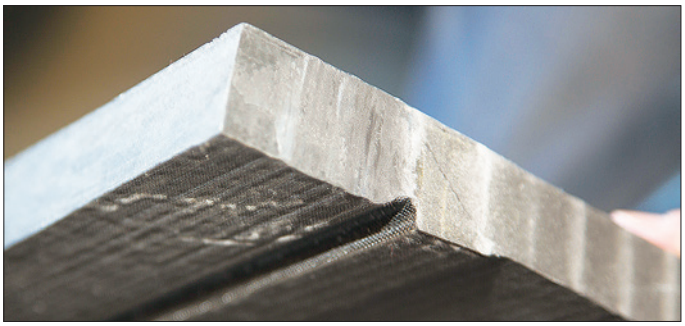
Gunboat develops a new infusion system for every new model. In North Carolina the system designed by consultants Peter Kjosen, a veteran of the company's China production facility, and Philip Steggall of bravolab, Jamestown, Rhode Island, divided the complex hull up into multiple parallel sections shot in carefully choreographed sequence. The result dramatically reduces resin waste and the number of feed lines.

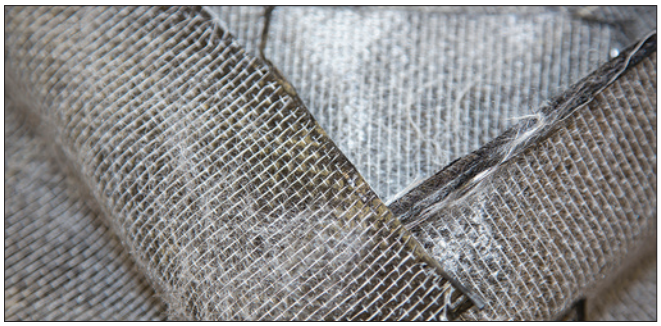
at a time, sequentially: "The only problem is that each line needs its own infusion tube bringing the resin, so from the back of the boat to the front there is a huge amount of resin waste." After calculating those numbers, the team wanted to reduce that waste as much as possible in the 55. In addition, they would be infusing the complex hull in one shot, and carbon fiber is notoriously hard to infuse.

Another complication was the more than 100 plies of unidirectionals in the chines that must be completely wetted out. Harvey: "That big uni-band, 1.5″ thick [38mm] or so, hasn't really been done before as part of a whole-hull shoot."

To help with the 55, Gunboat brought in Kjosen from China as well as Philip Steggall (bravolab, Jamestown, Rhode Island), previously vice-president of technical development for Vectorply (Phenix City, Alabama). Steggall had been working on how to infuse really thick carbon unidirectional laminates. He had found a report by ATK Aerospace Structures (Clearfield, Utah) in which they described applying a nylon monofilament mesh called Spunfab to achieve less than 2% voids in an infused carbon fiber rocket part and that also increased impact resistance. He suggested placing Spunfab between the layers of unidirectional carbon fiber in the 55 laminate to achieve the flow needed.

"Before we commit to an infusion system for production, we pre-test it," says Harvey. "For the 55, we used a





Left—*A 100-ply band of unidirectional carbon fiber runs the length of both hulls, providing remarkable stiffness that allows elimination of the standard forward crossbeam. Infusing the band was successful after Steggall suggested applying a light nylon filament mesh called Spunfab* ***(right)*** *between the unidirectional laminates to improve resin flow.*

Left—*A separately molded section will cover the narrow opening in the forward-most part of the bow; the gap is helpful during layup in the tight area and can duct cool air during infusion.* ***Right—****Infusion of the Gunboat 55 has been improved by employing metering and mixing equipment and by reducing the number of multiple-line feed stations from four to three or even two.*

4′ x 8′ [1.2m x 2.4m] glass table and packed it with the same laminate stack and breaks that we would have in the boat." The glass panel test showed that the nylon mesh facilitated resin flow through every layer, and also prevented asymmetry in the flow front from the inner to the outer skin.

Harvey: "Before, with the parallel shoot, we'd have a feed line and then a flow media on the surface of the inner skin. We'd shoot up to a certain level, and then we'd have to slow it down so that both sides of the core could catch up to each other before we opened the next line." He notes that the flow front on the inner surface would typically overshoot the outer layer on the other side of the core. "If it shoots fast enough, especially where you have a joint in the core, you could potentially close an area off and have a big dry patch."

For additional security, they scanned the monolithic chine areas with ultrasonic testing equipment to ensure they were getting a good

laminate. "We actually scanned the whole hull of the first boat to give us confidence in what we are doing," says Harvey.

The resulting setup is a unique infusion system layout, refined over several iterations. Harvey: "Instead of branching up and doing the whole hull in one shoot, we break it into parallel sections." Because they are shooting both hulls simultaneously, it is critical to maintain communication to ensure everyone is on track and all sections are aligned. "I take pictures every half-hour to monitor how fast each zone is going, so I'll know where we are and can start talking to our infusion lead about opening up the next zone," he says. "It takes about an hour to infuse the first section of the hull, and then we let the resin flow completely through to the next section."

After shooting the hulls, the team opens the flow to the bridge deck section. The last area is the radiused front of the bridge deck, with the full hull infusion taking a little over four hours. Harvey says, "It's very controlled. We have gotten it down to a fine art, but we have reduced the different zones significantly from what we used in China, making it much simpler and easier to manage the resin flow, and we always have people double-checking each other, because you can always miss something." Those checks start before the resin even starts to flow.

The pre-infusion check of vacuum integrity starts with vacuum lines only, which are split up the same as the resin feed lines, and not simply fed into the whole boat. Next, resin feed lines are added one at a time, with the vacuum checked after each one to ensure that no faulty valves risk damaging the part. "Before we ever infuse, we leave the vacuum bag on for at least one full day," says Harvey. "That's plenty of time for any problem areas or leaks to show themselves." It also eliminates any moisture in the dry stack, which would create porosity in the laminate. "When we first pull vacuum in the bag, the pressure will lower to about 25 millibars, and then it just stops. Remember, this is a huge part. So we just wait, give it at least an hour or two, and then it comes right down to between 6 and 8 millibars. If we don't get down to this level, we don't shoot."

At the end of infusion, there is another vacuum hold. "Once the whole boat is wet out, we shut down the resin feed lines and open up every vacuum line once again just to make sure we pull out any excess resin," Harvey says. "We leave it like this for 24 hours at least and maybe up to two days in the winter." These vacuum holds are partly due to the slow-cure resin they employ. Harvey explains, "I don't like to heat. I'm not in a hurry to get the resin to kick off, and I don't need to reduce the viscosity, because PRO-SET has customized the resin to meet the flow and open time we need."

Gunboat relies on infrared liquid-propane-gas heaters in the factory to maintain temperature during the winter months at roughly 50–60°F (10–15.6°C). Harvey notes that if it got really cold, the team might wait a

day or two before starting a hull infusion. "But the relatively mild winters are one of the benefits of this location, so that would be rare," he says.

The facility has two large-capacity mobile vacuum pumps for infusion. Harvey: "We bought Decker pumps direct from the importer and set them up on mobile carts that we built in-house. Each pump is capable of running the complete infusion for redundancy, and we have a standby generator in case of a power failure during infusion." Everything is tested before each hull infusion, and a monitoring crew remains on duty for the duration of the cure cycle.

Metering and mixing equipment from Rook Metering/Michael Engineering (Mount Pleasant, Michigan) saves on labor by delivering metered and mixed resin into a large drum, where correct percentages can be quickly double-checked before delivery into feed lines. A single machine provides more capacity than is needed to keep pace with the infusion.

"We keep a log of how much resin we're using as we proceed," Harvey says, "so that we know exactly where we are throughout the shoot, how much we have to go, etc." Production started off using four feed "stations" with multiple lines attached, but is now down to three, and may be further reduced to two.

Why Wanchese?

"I was fully intending to set up the plant in Rhode Island," says Johnstone, "but after looking at a dozen potential locations, we couldn't find the right facility at the price we needed. I asked the state for help, but they said all they could do was give a low-interest loan that was actually three percentage points above the commercial rate, and they demanded a personal guarantee."

So he started looking elsewhere, thinking maybe northern Florida, but then he talked to Peter Truslow at Edgewater Boats, who said if *he* was starting a new facility from scratch, he'd go to North Carolina. So, Johnstone sent a note to the North Carolina Economic Development website and within a few hours, Mike Bradley, director of North Carolina Boating Industry Services, responded with a four-page road map showing specific facilities to visit. "He had done his homework," says Johnstone, "and narrowed down a list of 23 possible sites to four or five in Beaufort [Jarrett Bay Boatworks], Wilmington, and Wanchese."

Johnstone says the Wanchese area intrigued him, because less than a decade ago there were 2,500 skilled boatbuilders there, though that had shrunk to a scant 180 employed in boat construction after the economic meltdown. "There is plenty of access to distributors here, and unemployment is 18% in the area, so from a supply-chain and labor standpoint it looked good. Bradley gave me the average labor rates, household income figures, and everything I needed to make the necessary decisions, draft a business plan, and project initial cash flow," Johnstone recalls.

Bradley: "I've been doing this for

Left—*The Gunboat shop crew in North Carolina draws heavily on a depth of local knowledge and skills in boatbuilding, an industry that employed upward of 2,500 in the Wanchese area before the recession.* ***Right—****The catamarans require detailed fiber work to meet the ambitious strength and weight goals. Shop crews review each drawing with a foreman first, and have the drawings nearby for reference after work begins.*

over 20 years, and I understand the supply-chain issues and how to network with boating-related services and products in the region. I have no allegiance to any county or area, but can focus on what best meets the company's needs. Once I'm contacted, I have a big matrix that I try to fill with as many answers as possible and help them identify what will work for them."

Johnstone had contacted the State of Virginia as well, and while they were responsive, it just wasn't as attractive for business.

Training was another key part of the North Carolina response, says Johnstone: "Bradley had outlined some of the grants available, but then the SBTDC [Small Business Technology Development Center] assigned Tim Ivey as our economic developer. Tim came and ran through all of the North Carolina programs, including training that would be paid for and conducted by the local community college, The College of

One of the incentives that North Carolina offered Gunboat was a series of grants for on-the-job training of boatbuilders eager to work in the high-performance composites shop, where skills in working with carbon fiber and resin infusion are required, and efficiency matters.

the Albemarle, which is just a few miles down the road." The program would also help with on-the-floor training in exchange for Gunboat covering the hourly wage while the workers were being trained. And there were additional government grants based on the number of employees.

As Gunboat started developing the infusion system and defining the necessary training, Johnstone asked Tim Ivey and training coordinator Shannon Kinser if it was possible to hire Philip Steggall as a carbon fiber infusion expert. The answer: "You tell us who you want to use." So Steggall did three one-week training sessions and helped develop Gunboat's in-house infusion course, which every new hire now takes.

Help from the state didn't stop there. "They also provided an employment services agency to do all of our employment screening, and guaranteed the results," says Johnstone. "We could trial the employees for 90 days and let go of personnel without any penalty if they did not work out. They basically acted as our human resources department for the first three to four months, which was a huge help."

This helpful attitude is one of the things Johnstone says convinced him that he'd found the right home for Gunboat. "This is the right market, the right location, and the workforce is tremendous, with second- and third-generation boatbuilders who understand high quality, the details of construction, and reliability."

Johnstone sees opportunities here, including possible new production models and service and repair: "Northeastern North Carolina is such a perfect fit for Gunboat and for where we want to go in the future." PBB

About the Author: *Ginger Gardiner is a technical writer for* High Performance *and* Composites Technology *magazines, and a frequent contributor to* Professional BoatBuilder.