ALL THE TOOLS IN

Talking Design Technology with Owen Clarke Design

For nearly three decades the design team of Merfyn Owen and Allen Clarke has been at the vanguard of high-performance sailboat design and among the earliest adopters of quickly evolving design software and computer-aided boatbuilding techniques.

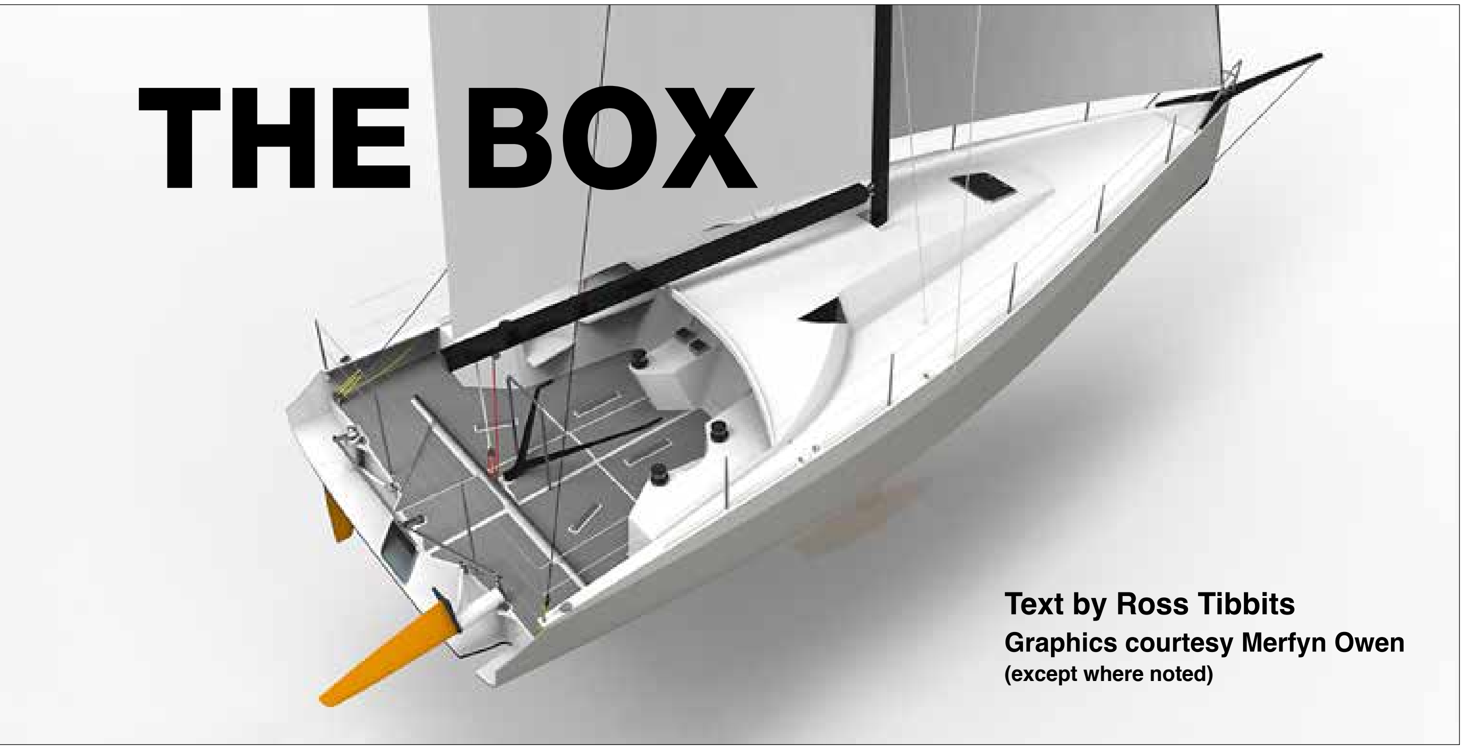
With offices in the United Kingdom and New Zealand, Owen Clarke Design (OCD) has earned a global reputation for creating the latest in high-tech high-performance racing and cruising yachts. The firm's sailboat designs span a spectrum from the compact ocean-racing 6.5m (21.3′) Mini Transats to 130′ (39.6m) superyachts. Its portfolio contains eight Vendee Globe IMOCA 60s (18.3m), including its latest, *Acciona*. Its IMOCA 60s have placed in successive Vendee Globes and the Barcelona World Race, and won the Transat and Route du Rhum singlehanded trans-atlantic races. In addition, OCD has designed more than a dozen competitive Class 40s (39′1″/11.9m). At the time of this writing, the company's latest creation, *Longbow*, a new Class 40, was launched at Carbon Ocean Yachts, in Bristol, Rhode Island, for an American customer. The office also specializes in component design, developing cutting-edge rudder systems and keels—canting, lifting, or a combination of the two—and consulting on reengineering and refits of sailboats.

Principals Merfyn Owen and Allen Clarke have spent years fine-tuning their business, developing strong relationships with clients and business partners, and building their reputation for designing some of the fastest sailing machines on the water. But when my conversation with them turned to the technical, I found they credit much of their success to the tools they use. Owen and Clarke make no secret of the fact that since their first projects together, in 1987, they have consistently adopted new design and manufacturing technologies, mostly computer-based, as soon as they develop. The ever-improving capacities for design manipulation and refinement; data acquisition, storage, and processing; computer numerical controlled (CNC) cutting of components and molds; and easy file-sharing worldwide have also allowed for efficient and effective outsourcing of design and construction in what has become a truly global market.

Let's take a look at some of the tools OCD has come to rely on over the decades.

Above—*Merfyn Owen, left, and Allen Clarke have been the principals at the center of a formidable team of sailing-yacht designers since 1987, turning out winners ranging from 6.5m (21.3') Mini Transats to superyachts and multiple IMOCA 60s (18.3m). Although both men play multiple roles in the partnership, Owen, the firm's senior naval architect, focuses primarily on managing raceboat projects and Clarke on aesthetics and production management.*

THE BOX



Text by Ross Tibbits
Graphics courtesy Merfyn Owen
(except where noted)

A computer rendering of the recently launched Open 40, Longbow, *highlights the latest in CAD rendering capabilities and Owen Clarke Design's (OCD) penchant for cutting-edge technology and design.*

The Early Years

"Merfyn Owen and I began working together when I was studying at the Southampton Institute (U.K.), and later when we designed and built *Fiery Cross*, a 35′ [10.7m] trimaran," says Clarke. "I'd been assisting Merf, who was beginning his career as a naval architect, in the evenings, manipulating hullforms and showing him how traditional lines plans were developed. Merf came at yacht design from a more engineering and mathematical approach, whereas I came at it from the more practical and aesthetic side. We both learned a lot from building and working on other people's boats, and with our different strengths in design, we just worked well together. When we started designing our boats more professionally and it began to take up all of our time, forming OCD in 2002 just seemed the natural fit for something that both of us had a passion for.

"In the early years before Owen Clarke Design became an LLP, I used to do a lot of drawing, both freehand on paper with pencils and using basic 2D CAD [computer aided design], to get information out to builders and providing clients information to study. Now, the paper drawing has almost disappeared, and even the 2D drafting is taking a backseat, whilst it is now faster and easier for clients and builders to understand something with a computer-generated 3D sketch/model before finalizing for production."

In contrast to Clarke's more traditional start, Owen admits that he's "never drawn a boat on paper. I've never drawn. Clarke can draw. But when I designed my very first boat, the *Fiery Cross*, I designed the hulls on the computer."

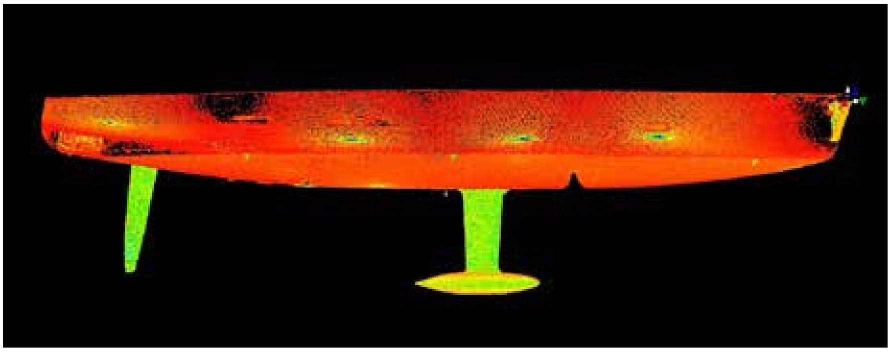
And those early roles have remained consistent in the Owen-Clarke partnership. "As well as being more involved in the day-to-day operation of the business, I still fulfill the role that I have always had, and that is being involved with the aesthetics and managing production of the output from the design office," says Clarke.

Owen, on the other hand, has taken on developing and managing the majority of OCD's racing boat projects. He's been the lead designer and design coordinator for six of the firm's eight Open 60s. Owen says, "I'm the company's senior naval architect, managing the business's research and development, and bring a strong engineering and technological bias to OCD's work."

Design Software and Laser-Scanning

Software impacts virtually every project. Although much of the company's long-term work involves building new boats, the majority of its day-to-day work involves modifying designs of existing boats. Often in those latter cases, there aren't blueprints or computer 3D drawings available for reference. Thus, a yacht must be reverse-engineered to generate the exacting measurements required for effective and accurate modification. The most efficient method is with laser-scanning technology. An example of the technique in action illustrates OCD's overall design process, including outsourcing to technical specialists.

One of OCD's close associates is Marcus Evans, who specializes in laser scanning, point cloud processing, and CAD modeling for SLC Associates (Southampton, U.K.). Evans has worked on many OCD projects over the years and provides firsthand knowledge of scanning technology and its specific role in naval design.



The OCD design office relies on Marcus Evans of SLC Associates (Southampton, U.K.) to create the 3D renderings similar to this one of the 24m (78'8") Wally 80 Tango G*,* ***left****, which can then be developed into a point cloud for further computer modeling. These renderings require Evans to shoot multiple scans of the hull using a laser scanner that can be seen atop the yellow tripod,* ***bottom left.***

"The scanners have precise angular measurement capability, similar to theodolites *[precision instruments for measuring angles in the horizontal and vertical planes—Ed.]* manufactured by companies such as Leica and Trimble," says Evans. "To create x,y,z coordinates, this vertical and angular measurement is combined with distance measurement by the laser. Laser accuracy is normally the limitation and is, for example, usually quoted by the manufacturers at ±2% at a given distance of the object to the scanner. Normally when we do boats, we are quite close to the surface, and the final result will be more than accurate enough for most purposes."

To create a complete yacht scan, for instance, multiple scans are performed and then "registered" or linked together to create what is called a point cloud, allowing designers to view the yacht "virtually" from all angles as it floats on their computer screen.

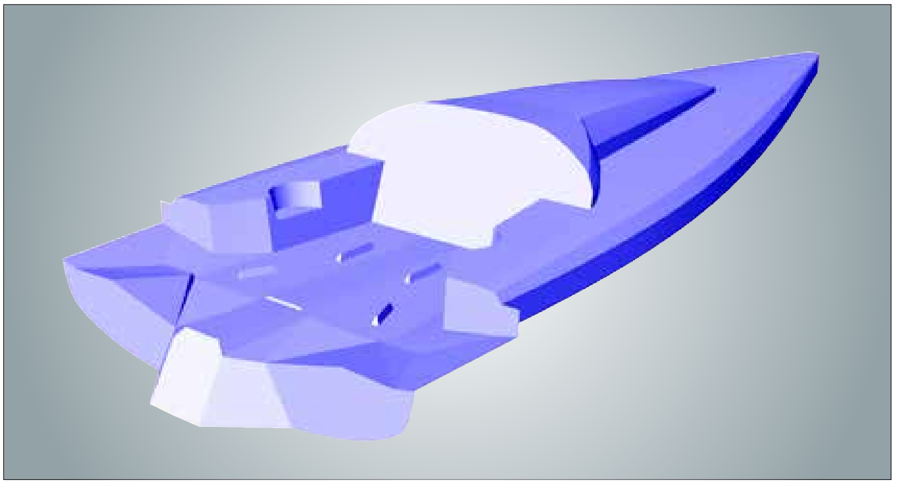
Putting some perspective on the time needed to scan a yacht, Evans estimates that "a 60′ [18.3m] yacht hull will probably need eight to 10 scans at, say, five minutes per scan, plus setup time." This completes the job in about two hours. "On the other hand," he says, "I recently scanned a 28′ [8.5m] military RIB [rigid inflatable boat] with the flotation collar off, and I needed 18 scans of the hull in order to be sure to get the chine features and other detailing. For this latter project, I also needed quite high resolution, so each scan was taking around eight to 10 minutes. Normally the scanner will also be taking photographs, which allows the scan points to be colored. This can be helpful during data processing." Ultimately, this results in a scan cloud with upward of 20–30 million data points.

"It's great if I'm working with people like Merf, because he understands what I can and can't deliver," says Evans. "Our work together with Allen Clarke on the classic yacht *Misty* [discussed later in this article] was a case in point. You wouldn't necessarily want to build a replica from my surface model without a fair bit of tweaking, but it was good enough to do the hydrostatics and get a provisional velocity prediction program [VPP]."

Often, contractors like Evans ultimately create what's called an initial graphics exchange specification (IGES) file, which allows for the free exchange of digital information among a variety of CAD systems. This is ideal for designers like Owen when they need to share 3D files with several people. Also, "it's an important factor, because as designers we take the information from the scanning company in IGES format, and then we import that into Maxsurf; that's a hull-modeling program," says Owen. Maxsurf provides naval architects and large shipbuilders alike with a wide range of software tools for each phase of the vessel's design, analysis, and construction.

The number of scans required for proper modeling varies dramatically depending on a hull's complexity. This relatively small 28' (8.5m) RIB hull required 18 scans to incorporate the more complex chine features.

COURTESY MARCUS EVANS (ALL)



***Left—**Longbow's complex deck design is displayed here via an initial graphics exchange specification (IGES) file, which is easily imported into Solidworks software to create sophisticated, detailed models of composite parts. The beginning of Longbow's transformation from computer model to physical yacht is seen **below.** This inverted deck mold was milled by a computer-numerical-controlled (CNC) router to tolerances of a few millimeters.*

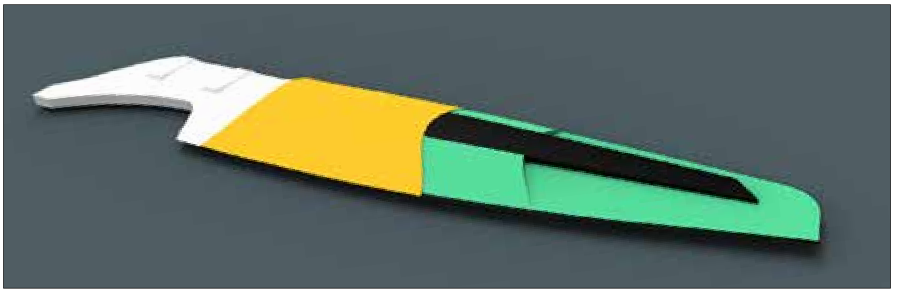
"We use Maxsurf software for pretty much anything with which we have to run stability numbers, velocity force prediction, or anything having to do with naval architecture," says Owen. "Basically, it allows us to load a virtual 3D boat up with a certain displacement and a certain center of gravity and be able to incline it in order to find stability values and other hydrostatic values. It's our standard software that's been upgraded, and added to, over time, and we've been using it for 25 years or so."

After the boat model has been run through Maxsurf to determine all necessary variables, it is transferred back into IGES and used in-house. For instance, OCD will take the file and import it into Solidworks. "Solidworks defines solid objects, unlike Maxsurf, which is basically a way to work with 2D and 3D solid surfaces," says Owen.

Owen uses a common pencil to explain a Solidworks application. "A pencil is made up of an external wood housing, and a piece of graphite runs through the middle of it. You can actually create that in Solidworks, taking an external surface file, filling in the gaps, and developing a solid model of that pencil. You ascribe the different parts of that model with different densities, one for wood, another for the graphite, and then there are the rubber and metal parts as well. What is remarkable about Solidworks is that you can apply densities to the materials, and you can actually work out where the center of gravity for that pencil is. Furthermore, you can slice it, cut it, or take a horizontal section and produce a 2D drawing of a particular section. Thus we've created a solid model of the item and sliced it up for analysis."

Taking this example a step further, Owen creates Solidworks models for designing rudders, among other marine-based gear and appendages. In the case of a rudder, the basic elements include the carbon rudderstock and the blade. But, as Owen says, "the blade has to fit precisely onto the carbon stock." Traditionally a builder creates the carbon stock by layering carbon and making it a certain thickness. This isn't as precise as building a mold for the stock. "We, the naval architects, produce the outside surface in Solidworks, and then we ascribe the outside surface a thickness, say 1.3mm [0.05″], and from there we go ahead and ascribe the stock dimensions based on our engineering, and we can produce a mold for the stock. This mold for the stock then fits perfectly into the mold for the blade. So there is no estimating on the builder's floor." The digital model is then sent to a CNC shop. "The shop makes the molds for the blade and the stock, lays them up, and they are 100% absolutely sure that when they join the two objects together, they are going to fit precisely." This is remarkably more

Solidworks allows OCD to design rudders with specific materials for the rudderstock and blade. Appropriate thicknesses and material properties are attributed to the model as well. The model can be used by CNC shops virtually anywhere in the world to build molds for a rudder that will fit perfectly with the other components of the design project.



efficient, Owen says, than having "a guy in the corner of a workshop laying up sections of the material, checking the sections, and so forth to make sure that everything fits just right."

By using Solidworks in conjunction with IGES files created from a laser scan, "the rudder system is engineered to fit perfectly into a boat at precisely the right angle at precisely the right position. It's an amazing tool. It's very cost effective," says Owen.

Solidworks also works with finite element analysis (FEA) tools that can apply various loads (stresses and strains) to the modeled components for analysis.

Outsourcing

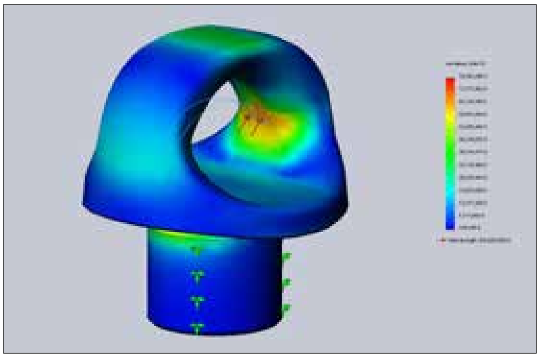
Drawing and design offices can be much smaller today because these processes have been made much more efficient. "We don't all have to be in the same place," says Owen. "We can work with lots of other designers and engineers from around the world within the same day, and we don't have to wait long periods of time for paper files to be mailed around. Now with the IGES files and Solidworks and the cost of CNC machining coming down, you don't have to be beholden to a single manufacturer in the next state or the same country to build a part for you. You can manufacture a part with confidence, within fractions of a millimeter, and know 100% that when it shows up at the shipyard it is going to fit."

Outsourcing also provides remarkable flexibility for designers. Owen says, "If your cost of man-hours is expensive (unlike places such as China, where they are very inexpensive), then CNC starts to make a lot of sense. Or, say you are a small workshop and you don't have the room to manufacture the mold, you get somebody else to manufacture the mold. There are other reasons to outsource, too. Perhaps you're too busy, and to get the next project rolling, you need to get a mold started before you can physically accommodate the project in your shop. So, have it made elsewhere. That might mean the difference between getting the job and not getting the job."

There are other potential opportunities to save money. If a boatyard has a local supplier of carbon posts, OCD can look at the engineering specifications of that post and design around it if the specs are appropriate. Using local parts (say, in New Zealand) and engineering the rest of the materials out of its offices in England can also save money. Or, OCD will have a custom supplier make the posts to OCD's specifications for a good price and have the materials shipped to the yard where installation takes place.

For example, OCD designed a titanium screw-in deck eye, performed FEA, and modeled it using Solidworks. They sent the file to New Zealand, where the hardware was machined. Then it was shipped to Germany to be fitted. This flexible design model holds true for many of OCD's projects, where outsourcing components to various machine shops around the world makes its work easier.

Over the years, OCD's relationships with CNC shops have also gone global, spanning to New Zealand, where the company built some of its Open 60s, as well as to suppliers in



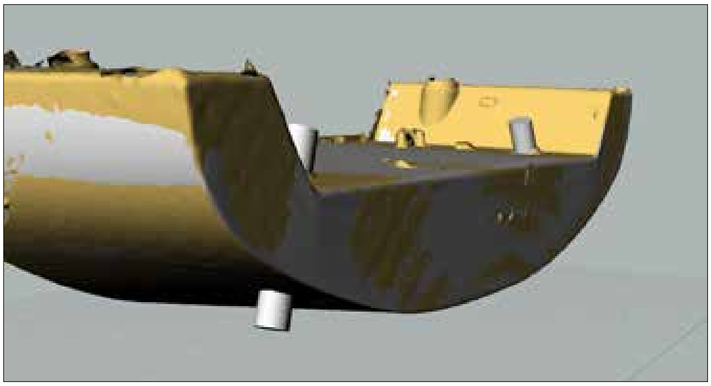
An example of the power of outsourcing enabled by advanced design software: A titanium sheet lead is designed in Solidworks at OCD ***(above),*** *the file is sent to New Zealand for machining, and the final product is installed on a boat in Germany* ***(right).***

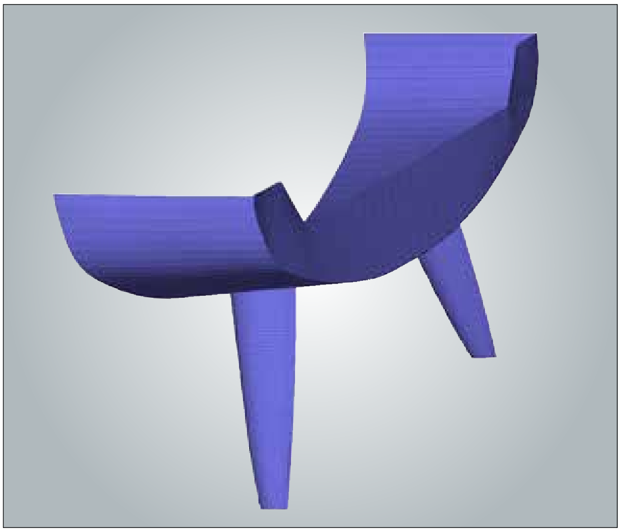
the United States and Europe. In Canada, where OCD had one of its 60-footers built a few years ago, the local engineering shop had no experience building marine parts (only parts for the oil industry). But given component specifications, it was able to build the required parts, and OCD eventually hired the shop to build the keel with the shop's CNC machinery.

Refits

Outsourcing also plays an important role when OCD refits yachts—a significant portion of its annual work. Naturally it varies year to year, but over the last 12 months or so, OCD has overhauled four major systems for boats between 50′ and 115′ (12.2m and 35.1m) in length. These projects speak to the success of building various components at different locations and assembling them on the boat, without having to move the boat significant distances.

"One recent project of note involved an IRC 52′ [15.8m] racing yacht," says Owen. "The customer approached OCD, asking us to evaluate an issue with the boat's performance and provide a solution. In this case, our





Many yachts requiring retrofitting do not have architectural designs available. ***Above—****The laser scans provide remarkably precise measurements for the designers to work with.* ***Right—****OCD's redesign (in Maxsurf) of the same aft sections with new twin rudders.*

recommendation was to revert to a single rudder, or new rudders, further forward and inboard. The client opted for the latter. I worked in Maxsurf to determine where the rudders should be. One of the problems was that the distance from the waterline to the root of the rudder was too great. So when the boat came upright, the rudder was ventilating [it sucked in air], and the boat would spin out, losing control. But by moving the rudders forward and inboard, you start losing the advantage of having twin rudders. So it was somewhat a Hobson's choice.

"This type of work, reviewing existing designs from other offices on and off the water, has been a feature of the kind of consultancy we've undertaken on numerous cruising and racing yachts of all sizes since twin-rudder boats entered mainstream yachting. Foil/appendage design and consultancy for owners of existing boats and shipyards has also become a steady income stream for the company in recent years. Not surprising, with over 30 of our own high-Froude-number twin-rudder designs on the water ourselves, we've built a name and reputation for diagnosing and providing support where required, and by no means does this always mean building a new foil or foils.

"We studied the 52's early transom scan, which includes the deck because the rudder bearings go through it," continues Owen. It contrasts significantly with the new scan. "The reason we have to do this is that a picture paints a thousand words. We had no drawings, and we have to find where the position of the bottom and top bearings are in order to be able to engineer the [rudder] stock. So we have to be able to place the rudder in space between the deck and hull. And as you move the rudder forward and inward, the distances are always changing between the components and the deck/hull. We need an accurate representation of what that rudder is going to look like so that we can engineer it and produce a 3D model in order that the yard can build it."

In *this* case, the rudders are being made in the U.K.

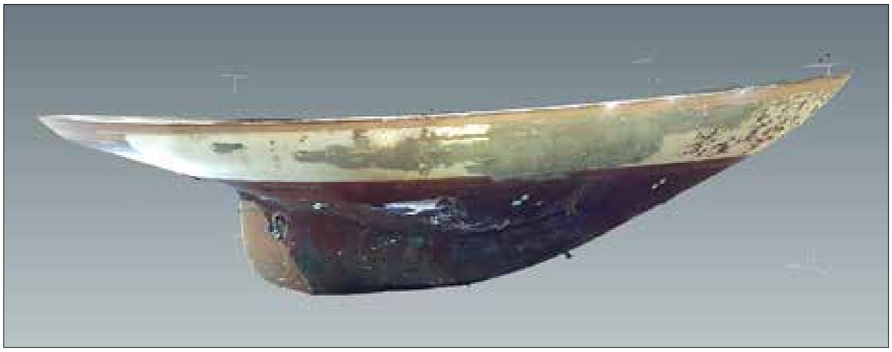
Rerigging *Misty*

Not all of OCD's projects involve carbon fiber hulls, composites, futuristic yacht designs, or even outsourcing. Case in point is the classic 50′ *Misty*, a beautifully restored wooden yacht. The owner wanted to race her in an upcoming summer regatta in the Solent. Over the years *Misty*'s rig configuration had changed, but the client wanted to ensure that she had the correct rig and sail plan for this particular race.

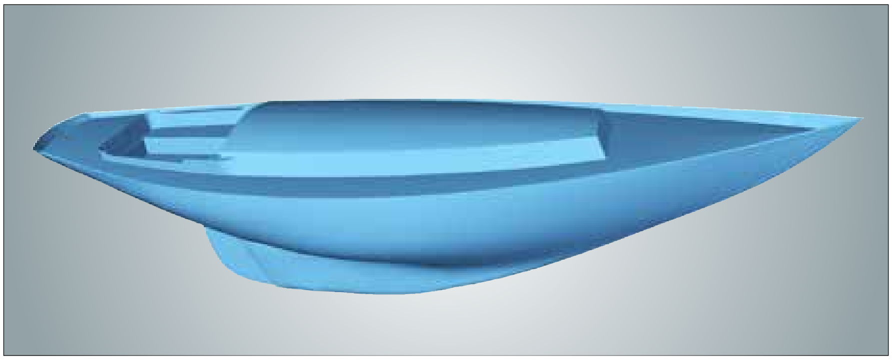
As luck would have it, years earlier OCD had purchased a library of data detailing the Solent's summer months for a different project, providing real wind speeds over a 10-year cycle. But weather data were only one piece of the puzzle. As is common with older yachts, there were no physical architectural drawings, so *Misty* was laser scanned and the data imported into an IGES file.

The IGES file was then imported into the Maxsurf stability program, which defines the boat's weight and center of gravity. For *Misty*, Owen had to subject the boat to an inclining test to get her stability rating, finding her center of gravity in the process. This resulted in developing a stability curve, and from that, "data such as length of waterline at different angles of heel, wetted surface area at different angles of heel, waterline beam at different angles of heel, and what it's like to trim the boat while sailing," says Owen. "It gives us, among other things, the righting-moment curve, and we can input those numbers into a wind VPP file."

Clay Oliver is the senior naval architect at Land Rover Ben Ainslie Racing, the team currently representing England in the lead-up to the 2017 *America*'s Cup. He has worked for years with OCD on a variety of designs, primarily the Class 40s and IMOCA 60s. "One of the tools we use is WinDesign," Oliver says. "It's a velocity performance prediction program I wrote and is used by hundreds of yacht designers around the world for traditional and advanced yacht design and performance analysis. The version I am using here is called WinCup, and it can predict the performance of a foiling wing-sailed



COURTESY MARCUS EVANS (BOTH)



Top—A laser scan was made of the classic 50' (15.2m) yacht Misty*. It yielded a 3D hull model of the boat* ***(above),*** *which allowed the design office to virtually test a variety of aerodynamic and hydrodynamic conditions using a variety of sail plans for optimal performance in a specific geographical location.*

multihull using either traditional aero- and hydro-dynamics or force models from computational fluid dynamics. This approach and technology are used on a wide number of projects I've been involved in over the years with OCD.

"The rules and conceptual brainstorming are combined to generate various geometries and candidate configurations," Oliver continues. "This can be a systematic series, where one or several parameters are varied in an orderly way, or maybe just five different ideas to investigate the design space. Often, these candidates are put directly into a VPP like WinDesign, and the result is a set of speeds, heels, sail trims, etc., for a range of wind speeds and wind headings."

Once Oliver had modeled the hull and its appendages, OCD designed different sail plans and rigs for *Misty*. "The VPP allows a virtual wind to blow on the virtual model, creating thrust, drag, and lift, among other affects driving the boat forward. The VPP can then analyze the hull's drag at various wind speeds, working out what sail force is needed to create enough drive to overtake the boat's physical drag. Ultimately, this information is synthesized into a chart listing *Misty*'s polars."

Different sail plans can also be run through the VPP to optimize the boat's performance on a specific course. "Running a windward-leeward and an Olympic-triangle course at various wind speeds in correspondence to weather models and the time of day closest to an expected race, can be incredibly insightful," says Owen. "The models tell exactly how long it would theoretically take to run the course, and the best combination of sail plans and appendages can be determined."

Once the numbers were processed, an application was sent to the Royal Ocean Racing Club to determine *Misty*'s time correction factor, or handicap rating. With this number in hand, other boats can be added to the simulation and tested against the rating by racing each other virtually.

"We ran the boat in its original configuration, and we ran the boat in different masthead configurations that we developed, and made comparisons about elapsed time and corrected time, and then chose the optimum rig for the boat," says Owen. After that, it seems that only the driver could be blamed for any less-than-stellar finishes.

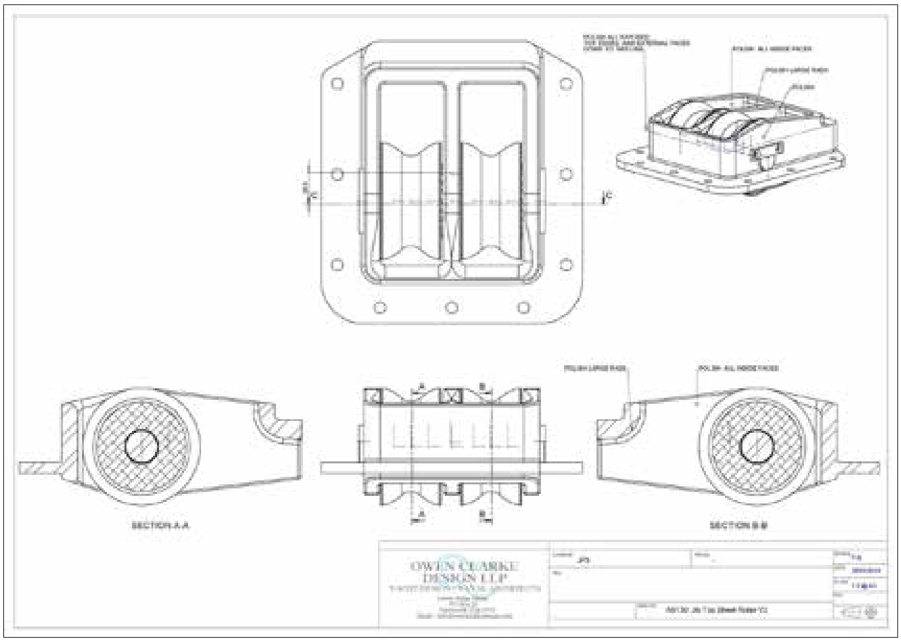
Diminishing Time Frames

Designs like *Misty*'s evolved over a number of years. Various aspects of her rig and sail plan had been changed to find the perfect combination. Owen: "It turned out that she was close to her optimum performance when we got her. But it took decades to get there. Today, that time frame is reduced to a few dozen hours. Not that we are perfect, but our starting point was very close to spot-on."

A remarkable benefit of VPP is that it produces a wealth of information about OCD's earlier-generation boats. "For instance," says Owen, "when an individual recently bought one of our older Open 60s, he came to us and we worked together to show him how to sail her. Specifically, when to hoist particular sails; when to raise and lower the daggerboard and by what increments; when to cant the keel; when to add ballast; and how to manage sail crossovers. Everyone takes this for granted nowadays. This information can be [disseminated] very quickly to the sailor, where[as] it used to take months to develop similar information via trial and error."

Something Gained, Something Lost

Owen laments, "The number of drawings and time spent drafting have increased, with a corresponding spiral in design costs, because clients' and yards' expectations are much higher than 20 years ago. Fortunately, some of those hours spent are reflected in a more efficient construction, so build costs are lower. Now that we've got all this ability to produce CAD drawings, 3D images, and can measure everything down to the millimeter, they want the Cadillac for everything, be it the smallest or the largest boat. There's an overwhelming reliance on technology that is replacing old-fashioned boatbuilding and common sense. One of our designers, Tim, at

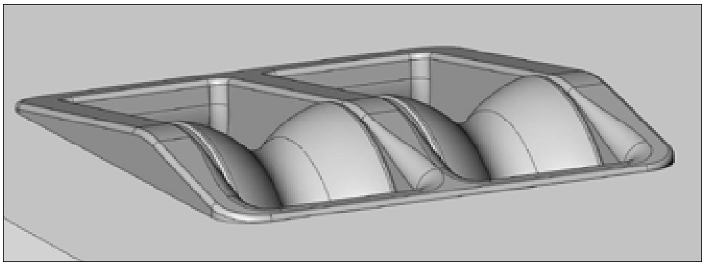


Two-dimensional computer drawings provide today's designers with the most precise specifications when designing components like this spinnaker sheet sheave. Traditional hand drawings are becoming a lost art.

our New Zealand office used to work as a project manager at Marten Yachts, and there was a cruising boat they were working on. A builder comes in to the office one day and asks for a printout of the full-sized cabin door. Tim takes a piece of paper, roughly sketches a door with some specs, and declares, 'Here's your bloody door!' It's pervasive, but common sense is lost. The basic knowledge of the traditional boat builder is slowly but surely waning, and individual builders are, in a sense, getting lazy because of technology." This has contributed to the loss of individuals with traditional boatbuilding skills.

Designers now spend a great deal of time developing models based on very tight specifications. "There are times when you want and need that tolerance, but there are other times when it becomes ridiculous and simply increases costs when it isn't necessary," says Owen.

"Once upon a time, a yard would mock parts up, and they would look through drawings well ahead of time and contribute to the design process. Now, the expectation is that when the drawing turns up, often they just go directly from that drawing. Less so before; a builder would get a drawing,



Above—A 3D model of the spinnaker sheet sheave gives a better understanding of what it will look like when installed. *Right*—The finished product in service.

look at it, and the designer and he would have a conversation about that drawing and how best to build it. So the designs you sent out were not the final drawings. The first drawings were for information and feedback. Now, we find that many builders don't want that. They just want to receive a drawing and build it, where actually we like to work with the builder, because we don't think we have all the best ideas. We like them to come back to us and make other suggestions. CAD has almost killed this interaction."

Today, designers such as OCD, who define the vanguard of yacht design, have achieved much-deserved professional accolades and created some stunning boats. Their accomplishments are largely the result of hard work, application of numerous technological advances, and creative thinking. No longer are designers tethered to a single geographical location to create and build their yachts. They can work from any location, employ individuals worldwide at competitive prices, and be fully confident in the quality of their products. Perhaps their greatest challenge is in not letting technology overwhelm their knowledge of the traditions of boatbuilding or their own common sense.

About the Author: *Ross Tibbits, a lifelong sailor from San Francisco, California, has been writing about sailing and many of its colorful characters for more than 12 years. His writing career grew out of an interest in technology and his endeavor to understand new developments in yacht design.*