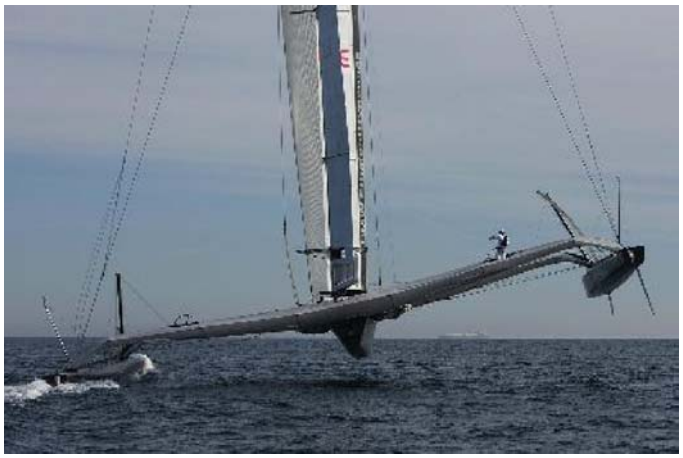
Wingsail Cup Winner

BY JOHN BURNHAM

The America's Cup finally emerged from two years in New York State courts with two extreme 90-foot multihulls contesting the 33rd America's Cup Match. Halfway through the first leg of the first race, the one with a wingsail bigger than a Boeing 747 wing was making it look easy, but from an engineer's perspective, the challenge of building, hoisting, and optimising that wingsail was anything but. Photos by Gilles Martin Raget/BMW ORACLE Racing.



The 33rd America's Cup took place in Valencia, Spain, last February with a sleek catamaran, the 90-foot long, 80-foot wide *Alinghi 5*, sailing to defend the Cup for Société Nautique de Genève. Lined up against her was *USA*, a trimaran that was 90 feet long and 90 feet wide, sailing for the Golden Gate Yacht Club of San Francisco. In racing sailor's terms, the challenger did a "horizon job" on the defender, winning the best-of-three series easily, 2-0.

By the time the first race took place on 12th February, many pundits had picked the challenger to win, but according to one of the men who engineered the boat's wingsail and then kept it flying even as its designers made it 7.5 meters taller, the result was not a foregone conclusion. This is an amazing story of innovation, a race against the clock to build something never done on this scale before – and to do it just in time for the Cup Match. Only thing was, in the final months and weeks, the race's location and starting date were up in the air, too, due to the legal proceedings.

The effort by the challenger, BMW ORACLE Racing, to design, build, and compete in a machine such as *USA* required a large team of sailors, designers, builders, even scientists, and each had a key role to play and a unique perspective. For one insider's view, we sat down a few weeks after the racing with Scott Ferguson, who designs high-tech masts from his office in Jamestown, Rhode Island, and Scott replayed the events of the previous year in fast forward. This included how he shifted from BMW ORACLE mast designer to wingsail engineer and an evolving role as "onboard designer" to keep an eye on the loads and tuning and to help the sailors become more comfortable with the wingsail setup during practise sessions.

For those who didn't follow the prologue to the 33rd America's Cup, the timing, location and many of the conditions for the event were essentially mandated by court decision, since the challenger and defender couldn't agree between themselves. Given that the wingsail was raised experimentally for the first time in November, only three months before the eventual Match, the dominance of *USA*, winning each of the two 40-mile races on the Mediterranean by several minutes, is that much more remarkable.

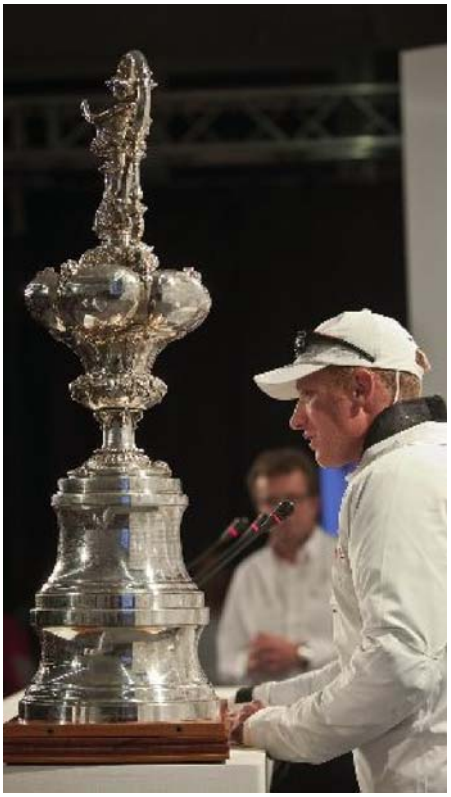
"You've got to understand," Scott told me, "that until the first race, we'd never sailed the wingsail all the way around an America's Cup course."

December 2007: Building commences in Anacortes, Washington, on a 90-foot trimaran for a race in an unknown location and date, possibly as early as July 2008 (but subsequently delayed repeatedly by legal proceedings).

September 2008: Long-time wingsail designer Dave Hubbard is recruited to join the team and contribute his experience with smaller versions, including Stars & Stripes, the successful 1988 Cup defender.

December 2008: *USA* had been launched five months earlier and test sailed both in Anacortes and San Diego with two "conventional" carbon-fibre masts, the second one reaching an impressive 55.5 metres (182 feet) above the water.

January 2009: Starting to build "M3", a third mast, to try to improve light-wind performance. This mast will be more foil-shaped, longer fore-and-aft, and 5 metres taller. At the same time, design chief Mike Drummond introduces the wing-sail concept to the team with an 18-foot A-Class cat, a singlehanded racing design rigged, in this case, with a wing sail. ▶

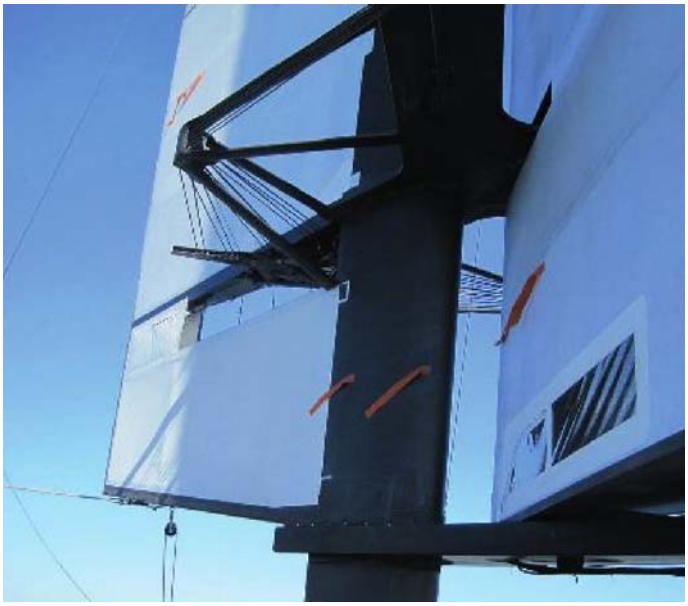


OPPOSITE
To remain closer to vertical, for efficiency, the wingsail could be tilted to windward. Notice James Spithill, alone in one of his steering stations on the aft crossbeam.

ABOVE
The *BMW Oracle* trimaran extends its lead, sailing upwind against the *Alinghi 5* catamaran; downwind it was even faster.

LEFT
Skipper James Spithill speaks to the press after winning the prized trophy.

April, 2009: In addition to building M3, the design team meets in Valencia and gets the green light to build a wingsail, too, because of its potential to provide even more power in lighter winds. The team meets next in Anacortes and finalizes a list of materials needed, including carbon fibre, Kevlar, and Nomex core to carry the loads and fibre-reinforced aircraft-grade film spread across the structure to capture the power of the wind. The "mast" designed to support this assemblage is essentially a carbon box structure that rotates on a hinge made of titanium, bronze, and stainless steel. It mounts on a pedestal maststep and can be tipped forward, aft, and sideways. It has an aerodynamic fairing in front (the "nose"), a primary wing element behind it, and eight adjustable flaps, aft of the main element. Lines from the flaps lead around individual control arms, then down to a master-control system about 10 feet above the deck. How much will all of this weigh? The team calculates it will be similar to a conventional mast, rigging, and sails.



"Winny's System," developed by Thiha Wing, adjust the 9 port and 9 starboard aft-flap control lines so they can be trimmed together or independently.

July, 2009: M3 is stepped in San Diego, only it's grown by 5 metres with the addition of an extra piece in its mid-section and now stands 60.5 metres above the deck. Soon, M3 proves that the larger sails it flies can lift the trimaran's centre hull out of the water sooner than the shorter M2. Meanwhile, the pieces of the wingsail are under construction.

October, 2009: The wingsail is almost ready and arrives in several parts in San Diego for assembly. The wingsail has a smaller but more efficient sail area and theoretically will be able to fly two of the three hulls even sooner than M3.

November 3, 2009: M3 breaks. The team is faced with the question of whether M4 can be built in time for a Match that may take place on February 8th (but may not, given that several conditions for the racing are still being debated in court and between the teams). Scott says, "If we hadn't broken the rig, we'd have had to answer the question of which is faster. Instead, the wing became our focus."

November 10, 2009: The wingsail assembly is complete and fitted to the trimaran – the ball joint doesn't quite fit at first and needs a few thousandths of an inch trimmed off. The wingsail is levered up and stands 60.5 metres (almost 200 feet) above the water. *USA* goes sailing, gingerly. Scott is aboard, as he is most days now until the Cup starts: "We thought we'd go really slow," he says, but soon Skipper James Spithill has the boat doing figure eights at 20 knots around the narrow harbor and asks, "Can we just fly the centre hull?" "Now's as good a time as any," Scott replies. The hull flies.

November 12, 2009: Even though wingsails operate best without headsails because their shape can be made the fullest and most powerful, testing with headsails begins to ensure that even more power can be generated in light winds. (With a headsail redirecting airflow in front of it, the wing must be trimmed much flatter and generates less power, but the net effect in some conditions is to generate greater power.)

November 13, 2009: The pins that secure the aft flap elements and allow them to rotate are held in place by gravity; on this day, one jumps out of position, causing damage as it goes. Brad Webb goes aloft to inspect. Damage isn't severe, and, with the wing unloaded, Brad is able to tear away some of the film, pull on the pin, and pop it back in place! All the pins will soon be replaced with longer pins.

November 16, 2009: The bottom of the first of the aft-flap elements breaks off where the traveler line attaches. Instead of rebuilding or replacing a ripped sail, this is a matter of rebuilding and reinforcing a piece of structure and reapplying the polyester film.

December 9, 2009: After less than a month of testing, the wingsail is disassembled for transport. The main element has a brief "flying" episode and elements are damaged as the structure is moved to the ship that will take boat and sail to Spain.

January 18, 2010: Still wanting more power, Mike Drummond had wanted to build an extra element to extend the wingsail by

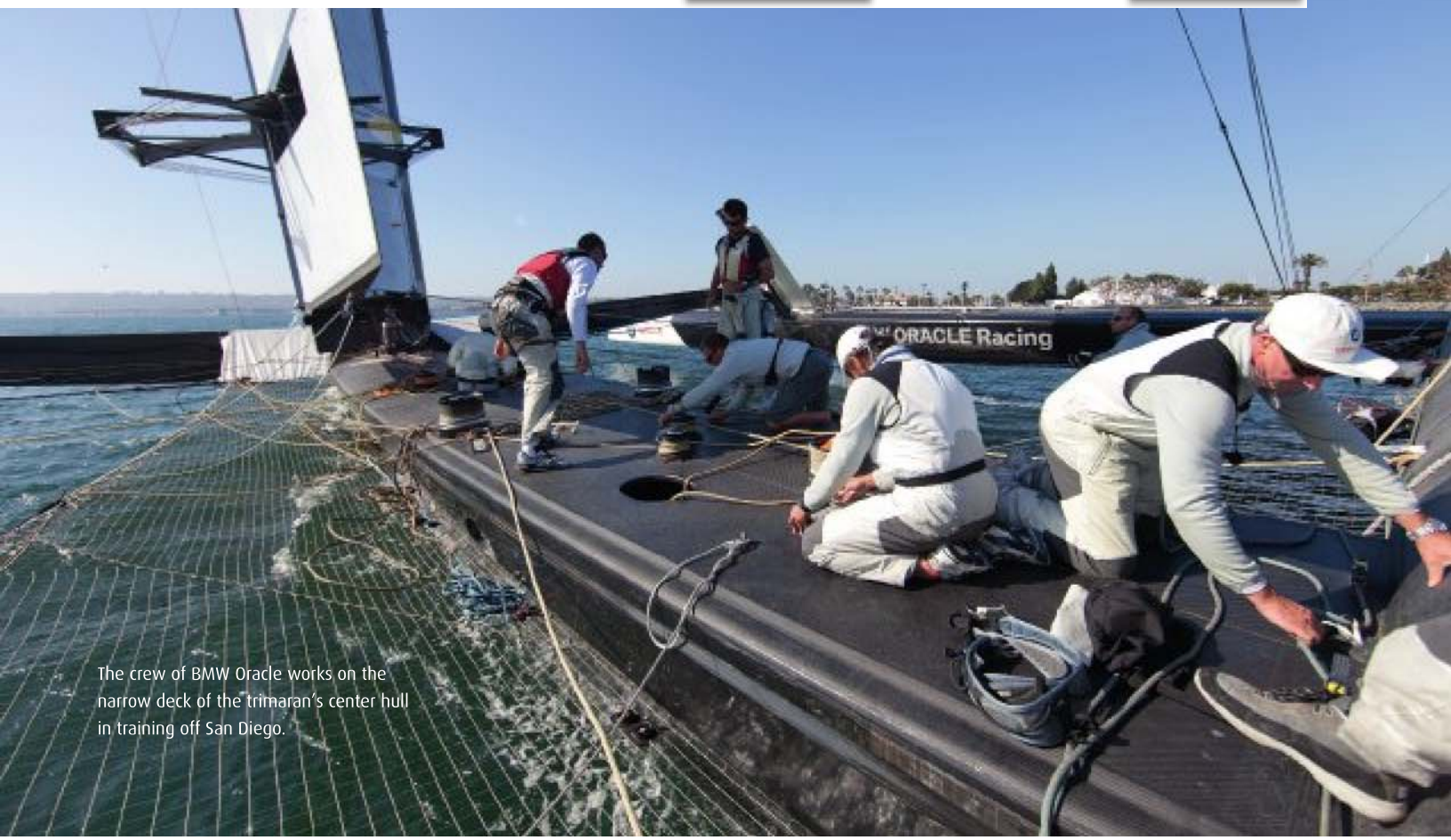
PHOTO THIS PAGE BY SCOTT FERGUSON

diate frames
ach flap support
and maintain

is a
e of
Nomex

Traveler line attaches to control overall mast rotation

Wingsail mounts on a pedestal maststep with hinged joint



The crew of BMW Oracle works on the narrow deck of the trimaran's center hull in training off San Diego.

Mike Drummond:
From Winged Keels to Wingsails

A veteran of every Cup since 1987 – including winning with Team New Zealand in 1995 and 2000, and with Alinghi in 2007 – sailor and structural engineer Mike Drummond was BMW ORACLE's design director. Following are excerpts from an interview with John Burnham:

When did the trimaran design start?
When the original challenge was lodged in July 2007, but nobody expected anything to come of it. It wasn't until late December that we realized Alinghi wasn't negotiating, and we turned toward multihulls.

What were the main reasons to build a wingsail?
First, it promised performance better in two respects—more power and less drag. Next, the controllability of the wingsail would allow us to set it quite accurately compared with the stretch of a sail and bend of a mast. Third, the sheet loads would be a lot less, and at the time we thought we'd have to use manual winches.

Potential negatives?
Mostly logistics of building and handling the wingsail. You can imagine bad things happening, but we just took the view that we'd figure out a way to make it work. Some people were skeptical that the wing would deliver better performance, and there was concern how it would handle in strong winds. Our answer was that we would use the shorter masts with reefs if a strong wind venue were selected. But we anticipated that Alinghi would choose an extreme light-air venue. If they were flying a hull and we were not, the difference could be 1 to 2 knots.

When did you decide to make the wingsail even taller?
When they announced Ras al-Khamaih as the venue ([later overturned in court], we found the wind might often be 5 knots or less. At that point, it was September, and we said to the designers, "Can we have some more, please?"


Design director Mike Drummond (at left) with builders Tim Smyth and Mark Turner.

Describe the first time you put up the wingsail?
It required the effort of every person on the team to push the wing out of the shed and put it on the boat. It was a bloody big piece of wing and quite light. If there's any wind, it's going to want to move, so it's a bit heart in mouth. We got it on the boat, out to the mooring, up, under tow and sailing in 12 hours—it was almost to the minute that we flew the center hull.

The boat made winning look easy...
We had to collectively imagine what could be done. We had a situation where there were no rules, and the rules we thought there were, got removed. We were only limited by our imaginations. Dave Hubbard had designed smaller wings, but everybody had to imagine how to design, build, assemble and handle one this size.

You've gone from wing keels to wingsails. What's your encore?
I haven't thought about the next one. Maybe we'll put the boats on hydrofoils. I have a question for you: What kind of boat should be raced in the next America's Cup?

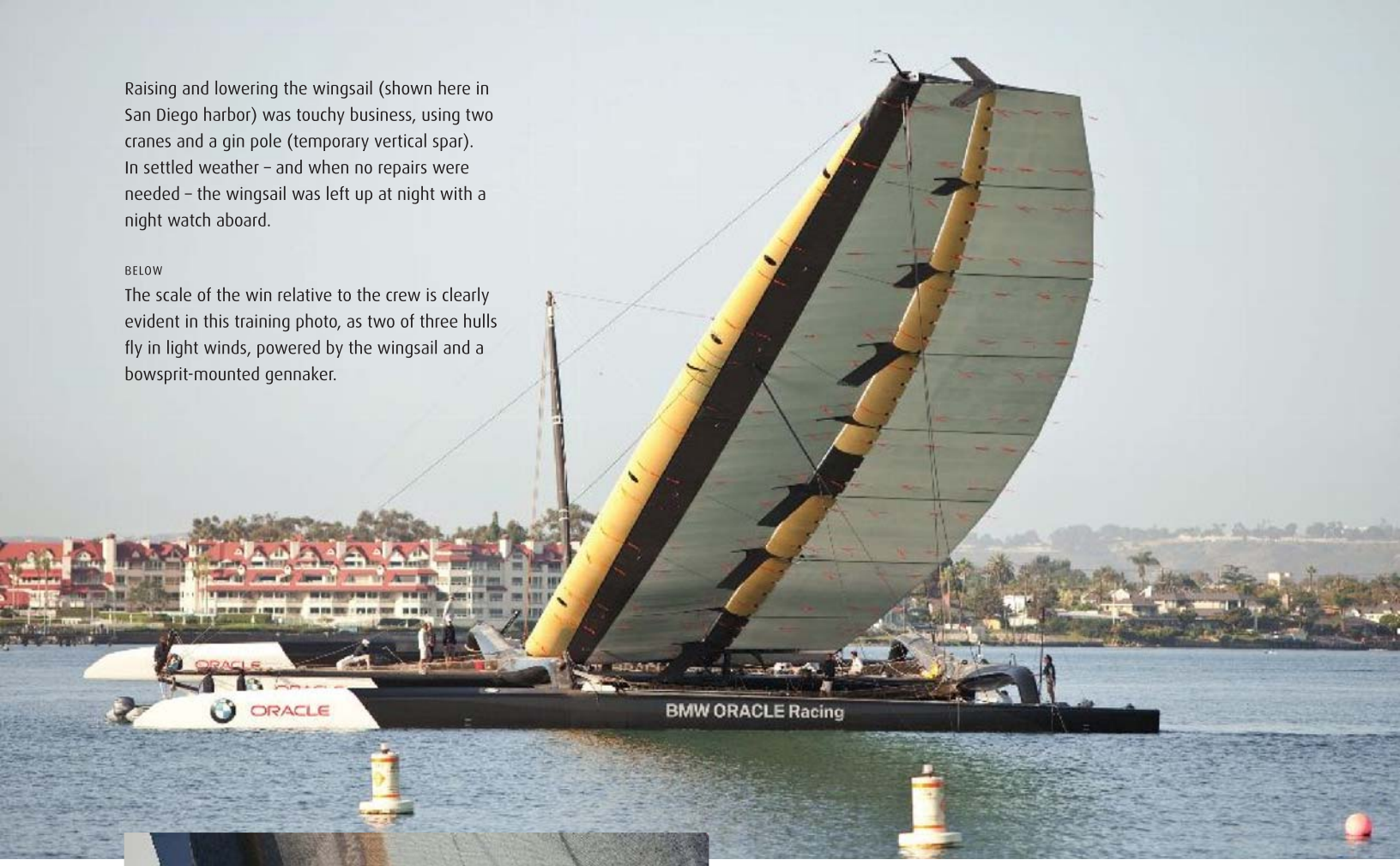
Sixty-foot wingsailed catamarans racing on San Francisco Bay. There'd be more excitement in the races – and for those watching. What do you think?
My view, which doesn't represent our team necessarily, is exactly with you. About 60 feet, so they'd be more manageable. Even a small team without grand multihull experience can probably do a pretty good boat, and there's probably going to be more passing. The version 5 [America's Cup Class monohulls] give the illusion of close racing, but it's really difficult for the port tack guy to get around the starboard tack guy. Not in multihulls. When you go upwind, you just duck, and then the starboard tacker's in trouble.

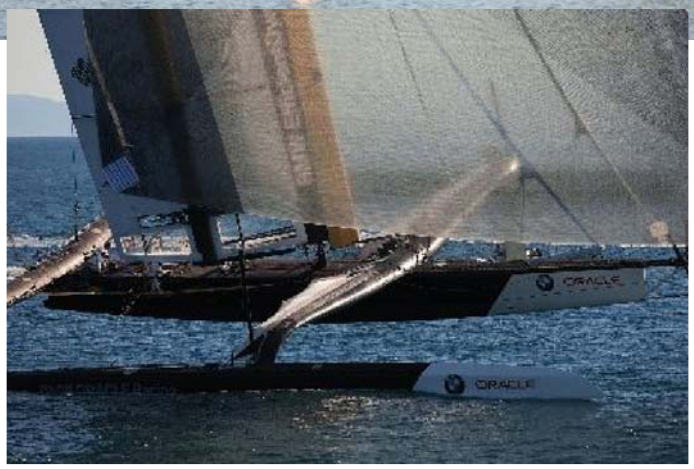
I think of myself as a traditionalist; multihulls have been around a lot longer than monohulls. If there'd been a Tahitian empire instead of British, we'd have been racing multihulls from the beginning.

Raising and lowering the wingsail (shown here in San Diego harbor) was touchy business, using two cranes and a gin pole (temporary vertical spar). In settled weather – and when no repairs were needed – the wingsail was left up at night with a night watch aboard.

BELOW

The scale of the win relative to the crew is clearly evident in this training photo, as two of three hulls fly in light winds, powered by the wingsail and a bowsprit-mounted gennaker.





8 metres. The Wingsail Workshop team gave him 7.5 metres (the same dimension as all the other elements), and with the new piece added, the wingsail is now 68 metres above the deck (223 feet). With other repairs completed, the wingsail is raised for the first time in Spain, three weeks before the Cup is to start. The extra element is essentially unsupported by the primary shroud system; Scott spends much of the day looking up. "On the first bear-away," he says, I was totally focused on that top element, thinking what the worst was that could happen. If it had let go, it wouldn't have just flown away; it has a control line through it, so it could've swung down and caused damage below." Scott's fears are quickly put to rest, and the sailing team begins race training.

January 19, 2010: A control arm breaks after a gennaker (foresail) is hoisted and the halyard lock doesn't catch; as the furled sail falls, it hits one of the arms. Another night in the shed.

January 20, 2010: Coal dust from a nearby industrial part of the Valencia port interrupts the raising and lowering one of the curved foils in the outboard amas (also called "floats"), costing the team half a day. Small repairs are regularly needed to the wingsail, so it's lowered every night – a time-consuming process.

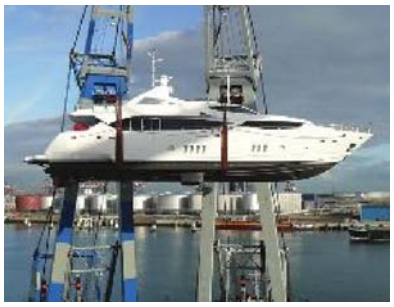
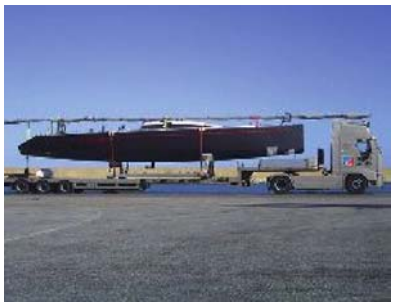
January 23, 2010: "A great day of sailing," Scott says, describing their first sail in strong winds, a prelude to some stormy winter weather on the Med. "It was a real confidence builder." But water gets into the onboard computer that controls the motor that powers the winches which trim, among other things, the wingsail's traveler. Sailing home without winches proves difficult, and then the unthinkable happens; a line breaks while lowering the wingsail and the trailing edge crashes down on the sea wall.

January 28, 2010: Repairs complete, the wingsail flies again. But today the main control arm breaks (probably due to damage when dropped).

February 4, 2010: Part of the frame in the fourth aft-element flap

G L O B A L M A R I N E L O G I S T I C S

Your leader in boat transportation...
with a truly global alliance


B Y R O A D , S E A & A I R

Providing the complete boat transport solution

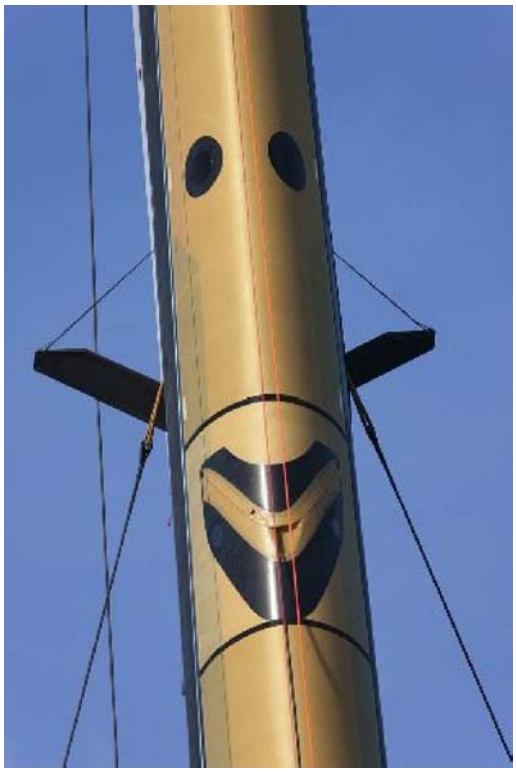
Peters & May Germany GmbH
Berliner Tor Center, Beim Strohhause 31, 20097 Hamburg.
T. +49 (0)40 236 08 890
F. +49 (0)40 236 08 893
E. germany@petersandmay.com

peters &may

petersandmay.com
00 49 4023 608 890
germany@petersandmay.com

UNITED KINGDOM • CARIBBEAN • AUSTRALIA • NEW ZEALAND • USA • SOUTH AFRICA • FRANCE • SE ASIA
NE ASIA • SPAIN • GERMANY • TURKEY • UAE • PLUS A COMPREHENSIVE NETWORK OF AGENTS WORLDWIDE

is discovered broken, likely due to the drop, twelve days earlier. Mike Drummond tells the Wingsail Workshop team to come up with a "go sailing today" fix, simulating what they might have to do if this were a race day. After 20 minutes, they have a solution and cut pre-fabricated carbon plates to bolt into place to support the damaged structure. James Spithill later calls this a "defining moment of the campaign," because it gave the crew critical practice time handling the gennakers. "I could've been swayed either way," he said later, "because I didn't want to further damage the wing. It was a really good call by Mike."



February 8, 2010: First day of the America's Cup Match! The boats go to the starting area, but racing is called off for lack of wind. These boats need very little wind to race, but on this day a steady area of breeze can't be found for a course that must go 20 miles upwind and then 20 miles back down.

February 10, 2010: Racing is again cancelled, this time because it's too windy and rough.

February 12, 2010: Racing begins in a breeze under 10 knots. *USA* enters the starting area flying two hulls (at a speed in the "high 20s," the skipper says) and engages quickly with *Alinghi 5*, which is penalised for a right-of-way infringement. Manoeuvring for position, however, *USA* stalls and *Alinghi* starts well ahead. By the time the boats have sailed ten miles, however, the trimaran has sailed right past the catamaran and doesn't look back.

February 14, 2010: Race 2 starts in late afternoon, and *Alinghi* draws another penalty, this time for being inside the starting area when the sequence begins. *Alinghi* holds the early lead again and gains in a windshift. Gradually, however, *USA* closes and just before the first mark of the 39-mile triangle course, the trimaran takes the lead. On the second leg, *USA* shifts into overdrive and makes a massive gain. Scott is following close behind in the team's tender, and *USA* is going so fast he worries that a furled sailed could get loose (in what amounts to 35 knots of apparent wind aboard the boat) and break a control arm during a sail change, but the crew handles the sails perfectly. The BMW ORACLE Racing team wins and the celebration begins.

"It's an engineer's job to worry," Scott said in our interview. "We are always thinking, what did we miss?" Throughout the event, he followed behind, knowing "it's never over 'til it's over," even after it became clear that *USA* was exceptionally fast under its new wingsail, flying two hulls upwind at speeds over 20 knots, in winds less than ten.

Normally, Scott told me, when installing a mast on a big new racing boat, such as one of the Volvo Ocean Race 70-footer's masts he is currently designing, you have six months to tune the rig perfectly. Mike Drummond had predicted that the wingsail could be ready after five weeks in the boat, and that's almost exactly how it turned out.

A few days after our interview, Scott sent me an e-mail saying, "Although there were many challenges along the way, I had good confidence in all that we did, and a lot of pride that we delivered many engineering solutions against a very challenging time schedule. We also pushed to make things light and just to the limit of where they needed to be, knowing there would be some teething problems that could be solved with a bit of time. In this case it was "Just in Time Engineering," as we made it through the races when it counted."

Thanks for the insider's view, Scott. And congratulations to the whole BMW ORACLE team on making this 223-foot wingsail really fly.

The team at BMW ORACLE Racing known as the WingSail Workshop included Tim Smyth (builder), Scott Ferguson, Steven Robert, Hervé Devaux, Dave Hubbard, Andrew Gaynor, Christoph Erbelding, Dimitri Despierres, Thiha Win, Eduardo Sanchez, and Mike Drummond. When he is not working on masts (and wingsails), Scott Ferguson is usually racing his Laser; he is the current Laser Masters world champion. ■

John Burnham is the editor of YachtWorld.com Magazine, has covered several America's Cup matches, and is past chairman of the America's Cup Hall of Fame Selection Committee.