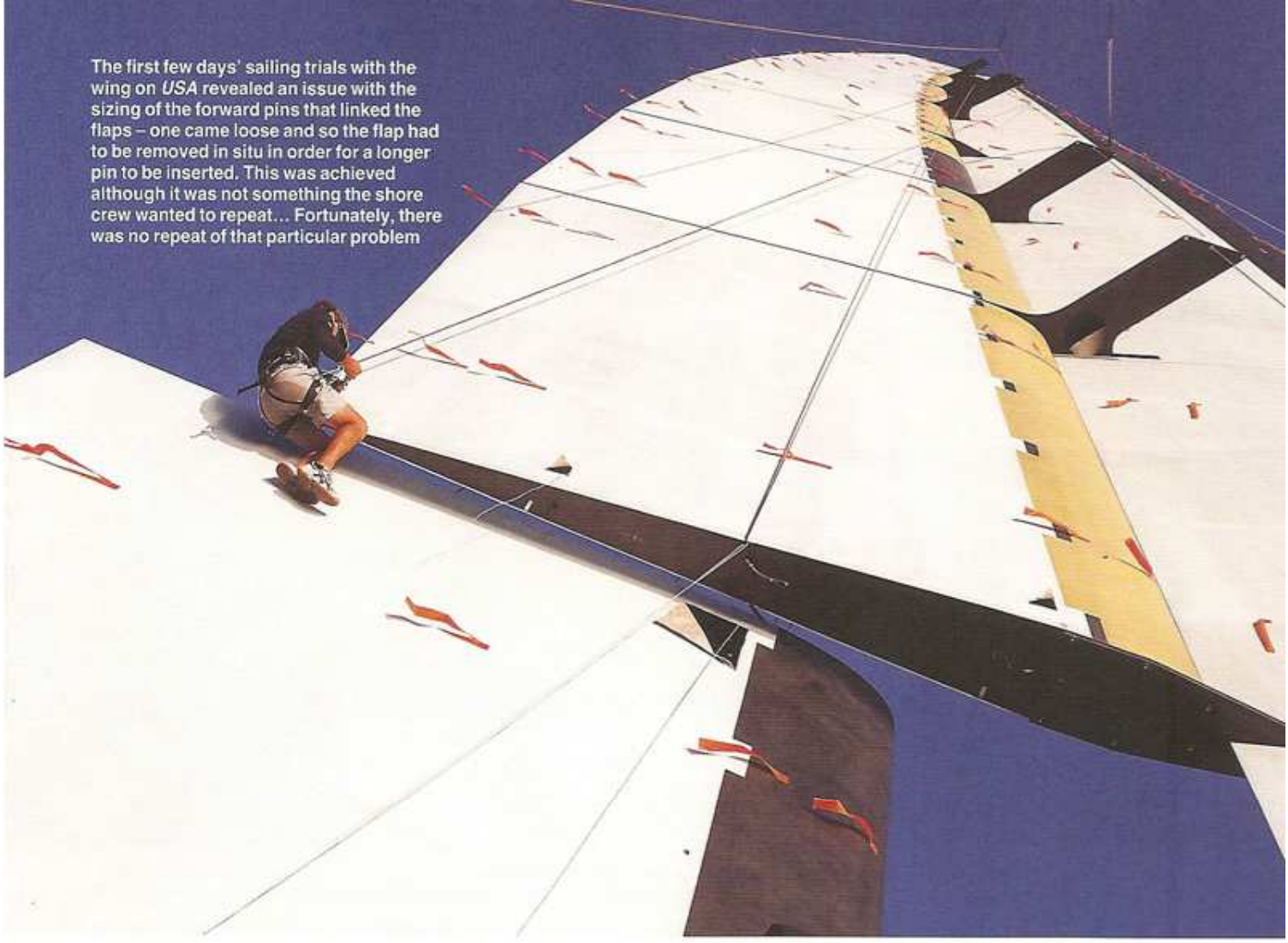


The first few days' sailing trials with the wing on *USA* revealed an issue with the sizing of the forward pins that linked the flaps – one came loose and so the flap had to be removed in situ in order for a longer pin to be inserted. This was achieved although it was not something the shore crew wanted to repeat... Fortunately, there was no repeat of that particular problem

ALL PICS GILLES MARTIN-RAGET

Silent heroes – Part II

In the previous issue BMW Oracle Racing build directors Tim Smyth and Mark Turner described the creation of their America's Cup-winning trimaran platform. That was the easy bit...

Mast world

We were called upon to build a third mast for the tri in late 2008. Early sailing with the first two masts had confirmed that more height was still needed, ideally with a bigger section in response to the light-air boat that Alinghi appeared to be building.

The builder of our first two masts could not process a mast that long or that big in their autoclave, so we decided to do it ourselves using out-of-autoclave processing only.

The tooling for a new 55m mast had been completed and we were ready to laminate when the call was made to extend it another 5m, such was the increasing confidence of those sailing the yacht. Fortunately, we were building the latest spar in two halves, so the simple addition of an extra 5m built into the parallel section of the tool took care of that.

For the third mast we also made use of M55J fibre, with a tensile modulus of 540Gpa. This fibre represents an order of magnitude higher than its predecessors in both stiffness... and price.

The price of carbon increases significantly with ultra high modulus. This comes in at about 10 times the price of standard modulus and approximately three times the price of high modulus. The benefit of this big step-up can be taken either through less weight for a given height or by means of less thickness in the chord (and hence less drag) for a given height while keeping similar stiffness. We took less chord thickness, much to the distress of those who had to crawl inside and do the internal bonding.

Mast 3 proved to be a significant improvement in light airs. By this time Alinghi had also done our set-up a big favour by allowing engines for the Match; the speed of the mast cant and the other hydraulics, along with the fact that we now had all these grinders to help us onshore, ▷

The starboard top half side panel of the main spar is offered up to the nose cone tool beneath it. The correct alignment of such long and slender components was a constant challenge and lasers were in use non-stop in the effort to ensure everything stayed in a straight line

was a big plus for the team as a whole.

Several months before Mast 3 was complete the idea of building a wingsail had also begun to gain traction... Alinghi's apparent light air optimisation had meant that we needed to do more to improve our efficiency in those conditions and a wingsail was one obvious way to do it.

For our part as builders it initially looked like the straw that might break our back. Time was short and we were very busy already. We were also exhausted from consistent 60-hour weeks, and having taken very little time off over the previous 18 months. We all struggled with imagining just how we would handle such a project. The most convincing arguments against the wing were in how we handled it – especially ashore – once we had built it.

That was still in the future, however, and there was time to think it through later. Meanwhile, we needed to concentrate on getting it designed and built.

A small team within the broader team was put together to concentrate on the wing programme. Recognising the risk of such a venture, the team were careful not to subtract effort from a known path, which was the Mast 3 soft sail rig, along with all the other improvements that were being made.

Some time later the breakage of Mast 3 was to cause us to put all our eggs into the one basket and concentrate on the wing; and perhaps that was just as well since the wing suited a configuration that could not easily be shared with a soft sail. For example, the lack of traveller load using the wingsail meant we could remove the mainsheet track altogether along with its 180 bolts for a significant weight saving. If we had still had the option of a soft sail rig then it is unlikely we would have made such a radical move.

The 'wingsail workshop', as the group became known, began to meet frequently online and in person during the first few months as we settled upon a path. It soon became apparent, however, that a large amount of design work was required before many of the structural solutions could even be contemplated.

The designers had quickly developed the concept of a large central spar on which to hang everything so the build could at least get started. With the main spar underway we settled in to the details. It soon became apparent there would be little time for detailed drawings, so we achieved that rare luxury of having structural design personnel come and live at the build site for the duration of the programme.

We had approximately six months to build our wing, and the sooner the better, in fact, as we were running out of time to trial it in the USA!

One of the biggest headaches was figuring out how to build and package the wing in such a way that we could fly it to Valencia and assemble it there if required; with hindsight I think the most important decision we took was to build it in demountable sections so that it then all fitted back together like a Lego part for the final assembly.

The wing's lightweight nose cone consisted of ultra light foam core with very light skins either side. We built the nose in a single 55m-long piece (the nose cone stopped a little short of full height) but with six overlapped joints on release to allow it to be shipped in parts and then reassembled. The nose cone resided in a stout tool carefully levelled and built to act as a strongback for the entire main spar.

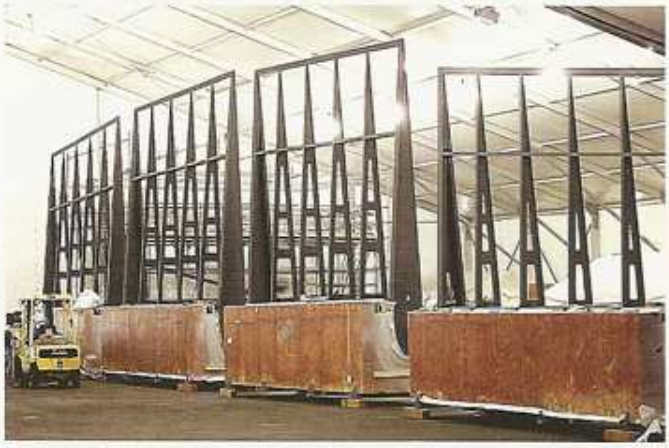
The 63m main spar was built with port and starboard side panels each built in two halves (top and bottom). The forward and aft panels were built separately on flat tables, to be joined together in situ. Essentially the two halves of the main spar were fully assembled into one piece and locked into their correct position on top of the nose cone in the same housing tool that projected upwards by an extra 50mm either side to receive it. These interfaces were treated for release and later disassembly.

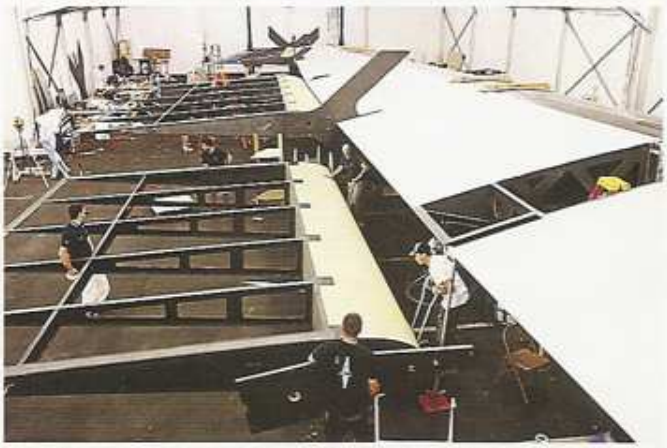
This concept took a while to get going, with well over 400m² of tooling to build. Meanwhile, the assembly meant wheeling these large spar sections back and forth between our two facilities in Anacortes – it was amazing that no one outside the team took a picture of 30 people merrily wheeling a wing section down the road on a lovely summer day in July.

The next stage was to split the spar in half and release it from the nose cone; these pieces then went into storage before being shipping to the assembly venue. The top and bottom halves were then wheeled off, one to each shop.

The frame fitting went quickly and soon we were into flipping the sections from side to side as we attached the various ▷

Launch day... The team started work at 2am to remove the wing from its tent in San Diego. Moving the wing on its two cradles outside to the stepping zone took over four hours due to the confined assembly quarters and the rough terrain that had to be dealt with. However, by 3pm that same day the wing was stepped and the yacht was out flying a hull and doing figure-of-eights in San Diego's inner harbour





***Left*: prior to skinning the sections a flap forest was raised in the tent in San Diego, transport issues requiring everything to be assembled in situ next to the yacht. The breathtaking precision and finish quality of even the largest components (*above*) – in six months, remember**

frames and their flanges to the main spar.

Meanwhile, it was still not decided what to cover the wing with. Fairly late on we decided to go with a polyester film used extensively in covering aircraft wings; however, this needed to be shrunk at 170°C to get the fullest extent of its shrinkage. The shrinkage would produce the tension which would minimise the deflection of the film.

A major consideration was the weight of the film, its ability to resist damage and its longevity. Even though it only needed to last a few months the sun can degrade many of these films in a very short time.

In the end we came up with a mechanism we called the 'faulty towers'. This consisted of several catalytic heaters stacked on top of each other, on a trolley, to a height of 6m. These could be carefully pushed on rails up and down along each side of the wing at a set distance to produce the desired temperature on the surface of the film.

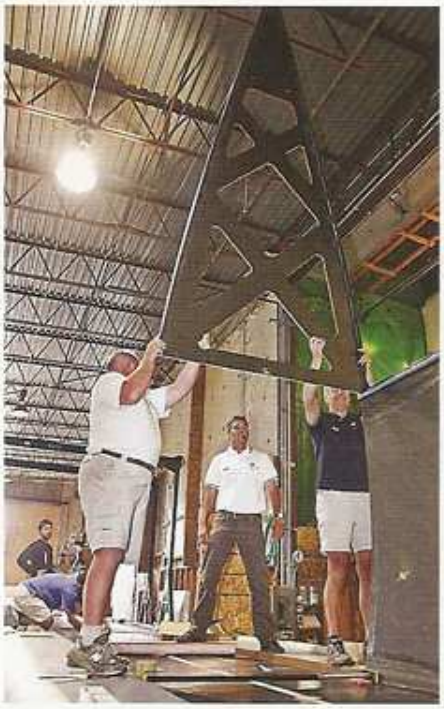
Having built, covered and painted the two halves of the main element, all that remained was to get them to San Diego where they were destined to meet up with the eight sections of the movable second element. But first we needed to build cradles that fitted the truck beds and served to anchor them for movement at 60 miles per hour on the freeway. The wing is like a big, fragile egg and any way that we chose to rest it on itself was not ideal.

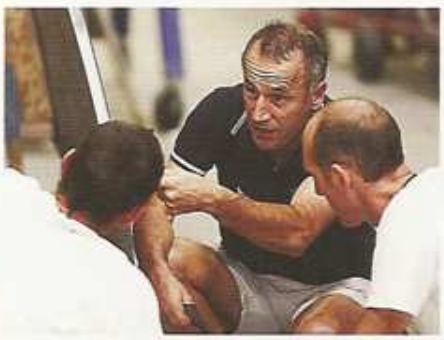
The second movable element consisted of eight separate flaps. We only assembled these flaps in San Diego because, at 7.5m x 7.5m each, they were virtually impossible to transport by road. It took approximately three and a half weeks to fully assemble the wing and all its components once everything had arrived in San Diego.

Then, halfway through this process Mast 3 came down, prompting major and urgent soul searching while we tried to work out if we could build a replacement in time.

Core Builders are very fortunate to have very skilled boatbuilders on call who have worked with them during previous America's Cup challenges. Dave Hurley and Chris Mellow are two of the people who were able to come and join our team at key times when the going got tough. Alongside people like Manu Armenanzas, Ben Hanley, John Holstrom, Jan Kinberg and Andrew Walker, they provided the extra skill and firepower to get us through these projects... and these frequent crises.

In the end we did decide to take on a fourth mast to replace Mast 3. So at the same time as we were completing the wingsail in San Diego, back in Anacortes we were busy adapting mast tooling and





***Clockwise from above*: Chris Mellow, Tim Smyth and Tim Collen reviewing a detail on one set of half main spar sides. The sides are held on trolleys in preparation for the 2km march through the back streets of Anacortes; the flap assembly station; Mark Turner and Tim Smyth hold up a main element intermediate frame to show Russell Coutts the scale of what they are going to be in for... The tip of this frame was approximately 7m above the floor; two sides of one half of the main spar are prepared for the delicate delivery across Anacortes to the team's second workshop**

getting the people and materials together to expedite its construction. Christmas was forgotten and two shifts were organised and put in place to make it happen.

But it was not to be. We were on track with Mast 4 when the call came from San Diego – the wingsail had been damaged quite seriously during the loading process.

The pressure to now get everything to Valencia by ship had meant that we simply did not have the time to wait for ideal loading conditions. The wind came up while the wing was being craned on and gave it a couple of good jerks – this had obviously caused some damage but we could not make a full inspection until we got to Valencia. It was clear from what we could see, however, that we were talking another big push to rectify the problem.

Thus came about the 'Core Builders invasion force', 26 people getting set to fly to Valencia and effect repairs the moment that the wing appeared in Spain four weeks later. In the meantime, we got busy building a series of replacement parts that we could see were needed, along with several key parts that could not be rebuilt overnight were more damage to occur in Spain.

All this meant that Mast 4 had to be stopped; there were by now simply not enough resources. Plus we had finally run out of time. As we said earlier, all our eggs were firmly in one basket and we needed to make sure there were no more breakages. Or if there were, we had to ensure we had the firepower and spares to fix them immediately in Valencia.

All that remained, once we had repaired our wing, was to keep it in one piece out on the boat and safe when ashore and on the ground – and at all points in between.

But that's another story... ❑