The Soft Wing Sail

by David Tyler

The long quest for the "Holy Grail" - the perfect cruising sail.

The story really starts in about the mid '70s, when I fitted out a Sadler 25, *Lliutro*, from GRP mouldings. Financially, it was a stretch, as I was raising a family, paying a mortgage - you know how it is - and so the interior was of cheap lauan plywood, the mast was one of the early hybrid masts, and the first sail was sewn from reject sailcloth on an ancient black and gold Singer machine (£30 in a second-hand emporium in Fareham, if I remember rightly), in the local community hall.

In the early '70s, I'd had the good fortune to sail with Blondie Hasler aboard *Pilmer*, when I worked in the drawing office at M S Gibb, and drew some of the components for the Hasler self-steering gears. It was all so easy, sailing under junk rig, that I decided that when I finally built my own cruiser, she would have junk rig, or some variation of it. But even so, my dinghy racing experience had taught me the importance of having the right amount of camber, in the right place, and my designer's mind was thinking about how to add camber to the junk rig.

So I experimented. Always with the sail doubled around the mast, always with junk sheeting, but with a variety of battens, some stiff, some flexible. I remember that there was a competition in *Yachting Monthly* magazine, looking for innovations in the cruising yacht equipment scene, and I wrote about my rig. Blondie was one of the judges, and commented (if my memory is correct) that though my rig was an improvement, in that the mast was enclosed within the sail, there would be no worthwhile camber with stiff battens, whereas the junk rig gained some camber due to fanning and slightly flexible battens.

Later, I bought a second hand SwingWing sail from Sunbird Marine, recut it to suit *Lliutro* and made some articulating battens from Douglas Fir. These had a lashing connecting the wishbone section around the mast with the the straight stiff batten in the single, after part of the sail, and so there were constant chafe problems here. Nevertheless, I sailed *Lliutro* up and down the English Channel. The challenge was to get down to the Isles of Scilly, spend time there and sail back to the River Hamble within my three week summer holiday. The extra windward performance of the wing sail rig certainly helped, sailing west against the prevailing south-westerlies, and then sailing east, when the wind decided to be awkward and swing around to the east for the return passage.

In 1990, a life-changing event meant that I could afford a bigger boat. I bought GRP mouldings for Maurice Griffiths' Lone Gull II, and fitted out *Ivory Gull* as a junk-rigged schooner. A further life-changing event freed me from paid work and gave me the freedom to go long distance cruising, for which *Ivory Gull* wasn't ideal, so I sold her and got *Tystie* designed and built. *Tystie* sailed under two different designs of junk rig sails for the first three years, so since this article is about wing sails, we'll fast-forward over the years from 1990 to 2004.

In the summer of 2004, Fran Flutter and I cruised through all the Scandinavian countries in *Tystie*. We decided to go further afield, but at that time, I had doubts about the suitability of the one large junk sail for ocean passages. I decided to convert *Tystie* to ketch rig, as this was the easiest way to get a two-masted rig, simply adding a mizzen mast. However, I knew that if I made pure junk sails, I would find the performance to windward of the ketch rig to be less than acceptable.

The "Holy Grail" - a sail with the efficient planform and foil section of an aircraft wing, but which has the easy handling of a junk sail.

So, over the winter of 2004/5, I made wing sails, main and mizzen. I used Hayward's Sunwing sailcloth (sadly, no longer in production), hired Ravenglass village hall to serve as a sail loft, and made GRP battens in my garage.

This rig served well for 40,000 miles: around Iceland and the Azores, and back to the UK; down the Atlantic to

Early 2005 - the newly fitted ketch wing sail rig in Ravenglass Harbour. The mainmast in the original position, the mizzen mast added just forward of the companionway.

2008 - the bottom batten of the mainsail, in SE Alaska. Wishbone sides of 50 x 5mm pultruded GRP, hinge box of filament-wound GRP, luff former of moulded GRP, mast bearing of HDPE, after batten of 1 1/2" square pultruded GRP tube.

Capetown; back up and through the Panama Canal to Hawai'i and then Canada and Alaska; and down to Mexico and across the Pacific to reach New Zealand late in 2009.

But I was aware by then of these faults:

- I did not put in as much camber as I should have done.
- The luff did not have enough internal support, and did not keep its shape, especially when the sail was twisted, or the boat was pitching.
- The sail above the top batten never contributed much to windward performance, due to its poor shape.
- The battens were disinclined to articulate freely, due to the friction generated in their housings in the after ends of the wishbones (even though I had used HDPE linings), and also due to the compression generated by the planform of the head of the sail. To get reliable articulation when tacking, I had to put in limit stops in the top two wishbones, to 5° and 10° rather than the 15° of the lower battens, with a consequent reduction in drive in the head of the sail.
- The sail area needed to be increased; and with that increase added forward, to reduce weather helm.
- The square edges of the after battens were chafing the batten pockets.
- The battens were chafing though at the entrance to the hinge boxes.
- The HDPE mast bearings were cracking, due to UV degradation.

I had been studying aerodynamics for a while, by then, and had decided that a foil section based on Wortmann FX77w153, modified in the way that Tom Speer has described for designing a wingmast/sail combination, would generate more power.

I decided to make new aluminium alloy battens based on this section, with the kind cooperation and assistance of Paul Thompson, in Auckland, NZ. You can read the full story at:

http://www.junkrigassociation.org/technical_articles

- "*Tystie's* Rig Update, Dec 2009 to Jan 2010".

It became clear over the following year that although the performance had improved, and the handling was reasonably good, I was going to have longevity problems with the aluminium battens. It seems that fully heat treated aluminium alloy is hard to find in New Zealand and Australia. The straight tubular after battens bent, and had to be replaced by tubes of larger diameter; and the channel section bridges in way of the mast were pulling their fastenings out of the curved side tubes. Nevertheless, *Tystie* made a crossing of the "psychotic" Tasman Sea, sailed around the south coast of Tasmania to the wild west coast, crossed the Tasman Sea again, and sailed down the South Island of New Zealand as far as windy Dunedin with this rig, so it can't have been all that bad.

Early 2010 - the battens are now of aluminium alloy, the mainsail is larger, and the the heads of the sails have been altered.

Call me an obsessive-compulsive rig builder if you like. On 24th February 2012, I wrote in the Technical Forum:

"It's like this:

My wingsails are now more than 50,000 miles old. They are still sound, but somewhat stretched, chafed and patched. How much life do they have left?

*Wingsails seem to have turned out to be an evolutionary cul-de-sac. Except for Bertrand Fercot, nobody else is following me down that track. It's getting kinda lonely, in a minority of one. Only if a major manufacturer sets it up for series production will that situation change. Isn't going to happen, in my sailing lifetime. **

And anyway, I feel like a change. I'm never content to leave things as they are. I'm always wondering what would have happened had I taken the other fork in the road, and whether I can improve on what I've done already. Once a designer, always a designer.

So what do I do?

I've tried my utmost to design a ketch rig JR with high-peaked yards, fanned planform and cambered panels, and I can't do it; at least not so as to fit on Tystie's masts where they are, with the centre of area far enough forward.

I've tried to design a ketch rig with a "split-rig" main, to get the centre of area further forward, and I still can't do it; at least, not without looking brutal and futuristic, and I want to get back to having a beautiful rig. Wingsails seldom look beautiful, no matter how well they might drive a boat.

I actually liked sailing with the big red fanned sail I had before the wingsails. It performed well when the wind blew, and the fanning came into play, but less well in lighter winds, because I hadn't put enough camber in the lower panels. Also, the very high-peaked yard didn't make deep reefing very satisfactory.

In Fantail's new rig, I feel I've got things balanced better. Not so much fanning at the top, more camber at the bottom, less positive stagger to the battens, and less yard length and lower yard angle, to make deep reefing more satisfactory. When sailing in company with Fantail, over the holiday period, I found that it was very difficult to catch her, in light airs; and she always looked good, whether at close quarters or at a distance. I think I've finally "got it right", as far as a single sail rig goes.

So, I want one like Fantail's got, and like Footprints is going to get. David Thatcher and I will be making two sails, one of 53 sq m, and one of 59 sq m, but otherwise to the same pattern".

* It's happening in my sailing lifetime - Beneteau are engaged in a two year programme to bring a wingsail to market.

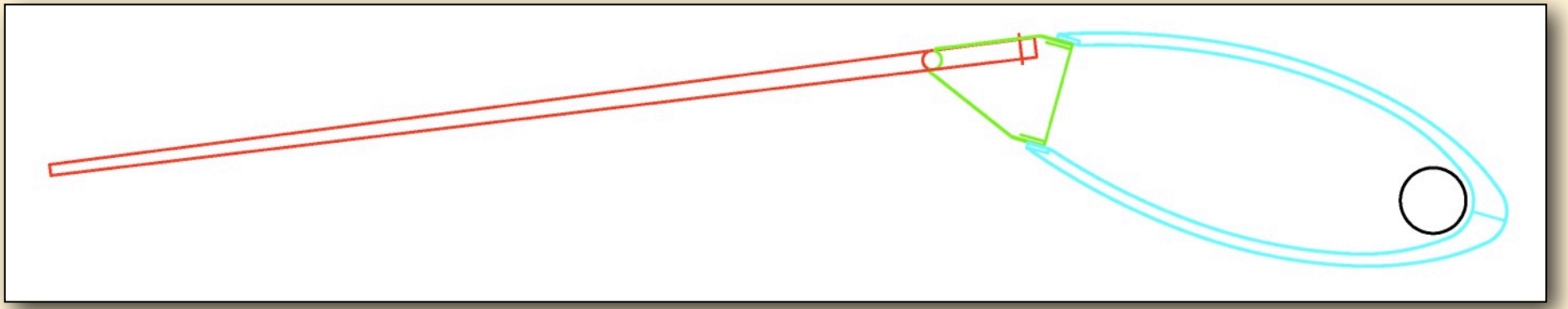
So, David Thatcher and I cooperated on building "fantail" sails for *Footprints* and *Tystie*. Fast-forward again over the period between July 2012 and December 2013, as I sailed *Tystie* from New Zealand, to Tahiti, Hawai'i, Alaska and finally Victoria, British Columbia. This demonstrated that this type of sail was indeed capable of ocean passages, but it was a big, heavy sail, and I found it hard work to handle at times.

I hankered after a wing sail rig again. It was even easier to handle than pure junk rig, and the performance was better.

Enter Darren Bos, in Coquitlam, Vancouver and John Robertson, on Saturna Island; both with two masted boats in need of new sails, both very interested in wing sails, both with good home workshops. Here was my chance to go back to a wing sail rig. Obsessive-compulsive rig builder again.

I'd made a carbon fibre yard, battens and boom for the fantail sail. It wasn't easy, and I made a lot of mistakes, but carbon fibre seemed to me to be the best way of getting spars light enough for me to handle, in a rig big enough to power *Tystie*. Having learned something about the use of carbon fibre, in the fantail rig, I determined to try to make the wing sail spars from it.

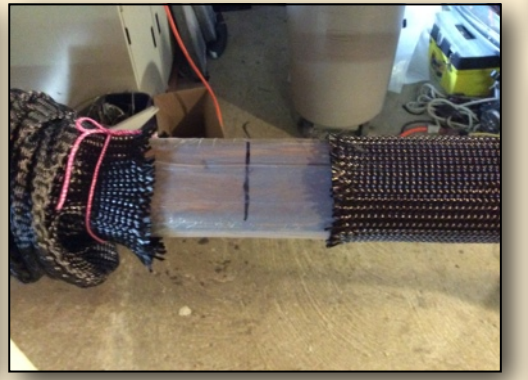
So Darren and I set to work in March 2014. I intended to go back to the ketch rig, and we started to develop ways of making components for the mainsail first.



The basic configuration of the batten assembly: a straight after batten (red), a hinge box (green) and a nose (cyan). The batten rotates within the hinge box, and the hinge box is bolted to the nose, permitting vertical articulation, and also permitting assembly of the nose around the mast (black).

Making the straight after battens was relatively easy. I made a wooden mandrel that was parallel sided at 40mm, vertically, but tapered from 40mm to 60mm horizontally, to make it easier to draw out, and to provide extra strength and stiffness in way of the pivot at the forward end. The edges were rounded off. The layup for most of the battens was two layers of 3" nominal diameter, 12K biaxial carbon braided sleeve. A small amount of unidirectional sleeve was also available, and I used it for the inner layer on three of the battens, making for a stronger layup.

The mandrel is coated with Vaseline, and a strip of thin plastic film is wrapped around it.

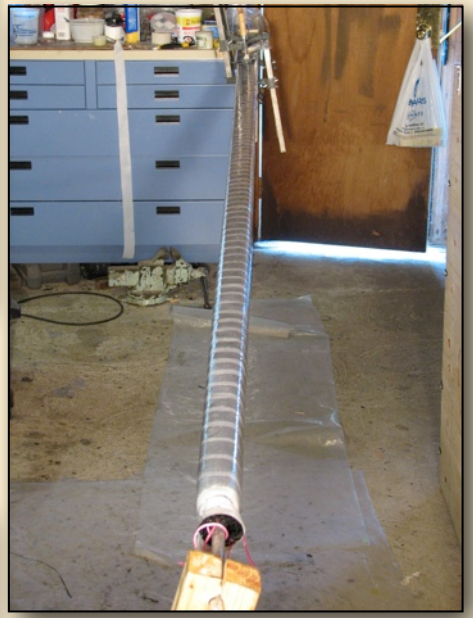


That layer is bunched up and tied back at the large end of the mandrel, and a second layer is added.

A layer of carbon braid is "pushed"on, so that it expands.

The inner layer is tied at the small end, and thoroughly wetted out.

The outer layer is untied, smoothed out over the inner layer and tied at the small end. There should be an excess of resin in the inner layer, which then appears on the surface of the outer layer, indicating that the inner layer has been fully wetted out.



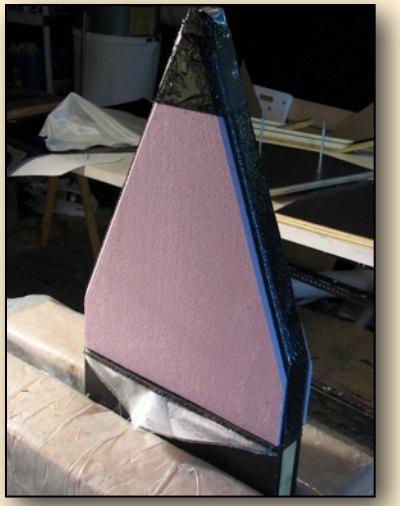
Having wetted out the outer layer with a slight excess of resin, the two layers of carbon braid are "milked" firmly, with gloved hands, from the small end towards the large end. The surface should feel uniformly wet and slippery.

Finally, the batten is tightly bound with strips of peelply, compacting the layup and causing the excess resin to seep out evenly over the entire surface.

When cured, the peelply is stripped off and the mandrel is pulled out using a chain hoist, or a 4WD vehicle.

For the hinge boxes, I returned to the compression moulding technique that I had used for the original GRP components.

The inner mould - the central piece of wood, clad with Formica; the outer pieces of 6mm HDPE. A one-piece, parallel-sided mould could not be drawn out, but the central section, if well greased, can be drawn out, and then the outer pieces can be broken away from the moulding.

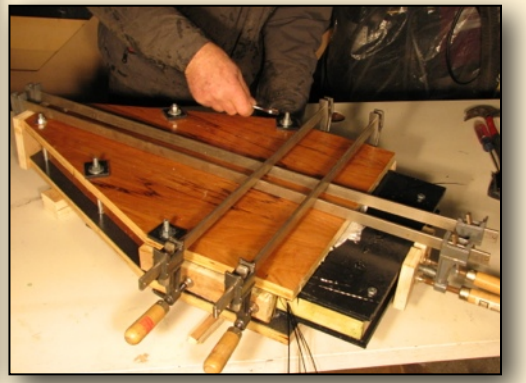


Halfway through the layup. Two layers of glass cloth, followed by two layers of carbon cloth are laid up on the inner mould. Then 6mm polystyrene foam core (pink) and 6mm HDPE sheet bearing block (black).

Completing the layup. Two more layers of carbon, followed by two more layers of glass.

The outer mould - faces of 18mm plywood clad with Formica; side strips similarly made, with their edges built up so as to form a chamfer on the finished moulding.

The completed layup on the inner mould is laid on one face of the outer mould, which is then assembled around it. The longitudinal clamps are tightened first, followed by the lateral clamps, followed by the vertical bolts.



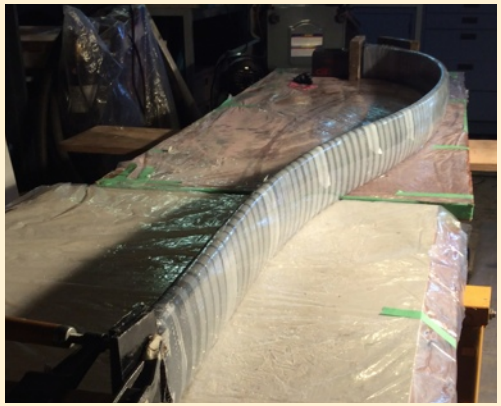
The completed hinge box, trimmed and with the semicircular recess for the batten pivot block, cut by holesaw. One coat of polyurethane paint ,to protect the sail from the carbon, and the epoxy from the UV.

For the noses, after an abortive attempt to make closed compression moulds, we settled on a core of extruded polystyrene foam, 38mm square in section and rounded off, with one layer of 3" nominal diameter, 12K biaxial carbon braided sleeve.

Hot wire cutting the foam cores. A template has been made from Formica, and is pinned onto the sheet of foam. The hot wire is 20 swg stainless steel rigging wire under tension, and is supplied with a low voltage by the controller in the foreground.

The two sides of the foam core have been glued together, and a recess cut for a plywood block for bolting to the sail. The braided sleeve is being pushed onto the foam core.

Wetting out the braided sleeve.



The yard is made in a similar fashion, but the foam core is of 3 layers of foam, hand worked to an elliptical cross section, there are two layers of 6" nominal diameter 12K braided sleeve and the halves were made separately and bonded together afterwards.

The braided sleeve has been firmly "milked" from the centre towards the ends, to tighten it down onto the foam. A HDPE disc has been inserted into a recess in the foam, to bear the bolt which attaches it to the hinge box, and the braid is tied off tightly. The nose is then bound tightly with strips of peelply. The nose is pinned onto a board on which the required outline has been drawn, to keep it in shape while it cures.

Around the area of the luff, the peelply strips must be narrow.

A stack of battens, hinge boxes and noses, awaiting finishing.

By the time I had made a set of noses and hinges for the mainsail, I was exhausted. I couldn't face starting again on a set of smaller noses and hinges for a mizzen sail. So I revised my plan to go back to a ketch rig, and made the battens longer than they would have been for a ketch mainsail, so as to make them suitable for a single sail rig. Make no mistake - it's a big undertaking to make any kind of rig that is as big as this, as complex as this. Many a time and oft, I wished that I could wind the clock back to a time just before I ordered the materials.

Having finished moulding the carbon fibre components, I moved from Coquitlam over to Saturna Island, where John Robertson kindly allowed me the use of his workshop to complete the finishing. However, the main reason for the change of venue was that John could arrange for the use of the island's community hall, which was perfect for sailmaking.

I needn't say much about the sail. It is made from Mustang, or Top Gun 9 as it is now called. The cloths are laid from leech to luff, along the port side, and then back halfway along the starboard side, where there are buckles at each batten position, and zips in between. The yard is in pockets, as are the battens. There is a cloth sailcatcher, which is essential on a sail with such a short yard, as otherwise, the yard would catch under the topping lifts at every hoist.

The overall weight of the rig must be less than that of the fantail rig, as I only need a 2:1 halyard and 30:1 winch to hoist it, as against the 3:1 halyard I needed previously. The lifts are of 3/16" Amsteel, and since the fall of the halyard is within the sail, there is very little parasitic drag.

Finally, at the end of June, the rig was complete and ready to test. This was just in time, as I was due to attend an OCC 60th anniversary meet at Bamfield, on the west coast of Vancouver Island, arranged to coincide with the Bamfield *Music by the Sea* festival. Did I say I was exhausted? I was doubly exhausted by this time, and more than ready for a summer holiday. After those events, I spent a week or two going a little further up the coast, sailing around Barkley Sound and Clayoquot Sound, enjoying the much improved handling and performance of my new rig, before returning through the Juan de Fuca Strait.

And that's where things started to go badly wrong.

On summer afternoons, in Juan de Fuca Strait, the wind gets up to near gale force from the west. I was running in, having to gybe from time to time, and take in more and more reefs. The secondary point of articulation between the nose and the hinge has turned out to be a very bad idea. When reefing on a run, the forward end of the nose stays up, due to friction against the mast, while the batten comes down. There is thus an angle between nose and batten, which causes the noses to tilt over, which generates a wringing load on the nose. As well, this joint acts virtually as a pin joint, placing further demands on the stiffness and strength of the nose. I broke three noses, and also their hinges, in a kind of chain reaction. I limped back to Saturna, via Victoria, and patched them up. I got this completed just as I needed to clear out of Canada, my six months visitor immigration allowance being about to expire.

The sail filled the entire floor of the community hall on Saturna Island.

Luckily, in Puget Sound in summer, there is next to no wind, and I motored and sailed gently south to Eagle Harbor, to meet up with Garth Wilcox, who is also interested in this rig. I got as far south as Gig Harbor, where I'd heard that I might get a berth while I flew back to the UK. I headed back north up the Colvos Pass, and - again the wind freshened in the showery conditions, again I took two reefs while running, and again the upper noses broke.

It's clear that the design of the nose and hinge area is not satisfactory. The hinge box needs to be rigidly attached to the nose, as was the case with my original GRP battens. The secondary point of articulation might have eased one problem, but has generated another in its place. Try as I might, I cannot devise a way of adapting the components that I've already made. I have to make new noses with the hinge box as an integral part of them. I haven't time to do that this year, so it must wait until early next year.

I subtitled this article "The long quest for the Holy Grail" with good reason. I know it's there. I get glimpses of it from time to time. I now have a rig which satisfies me, in terms of performance, handling, helm balance - but not yet strength and longevity. I know the Holy Grail is there, and one day I'll find it. But for the moment it remains just out of reach below the horizon. Maybe by issue 67, next February, I'll have some better news for you.