Catalyst

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As examples, the polar diagram p16 of *Catalyst 28* was re-created from a second generation photocopy, photos of shunting in the Champion article in *Catalyst 27* (pp 19-21) were screen grabs from a video supplied on DVD. The rest of the images in that article were scanned from photographs, and the text was OCRed (Optical Character Recognition software) or keyboarded.

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Features

Regulars

Cover photo*:*

Curly Mills sailing his Hobie trimaran in a Force 5. (See letters page 27)

Catalyst
Journal of the
Amateur Yacht Research Society

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Wingsails

AYRS members have been talking about these for almost 60 years now (AYRS Publication #9, October 1956), and it must be nearly 20 years more than that since the first rigid sails were made and used, but they are still not commonplace. Why?

Well, one answer has to be that wingsails are undoubtedly bulky things to move around. I can throw the sail of my 16ft (4.8m) boat into the back of my car with no problems. The wingsail I am building for it, although small in area, is going to need a special trailer to move it around. Not only is it too big to get it into the car, if I put it on the roof, it is too fragile to be out in the slipstream at the speeds I normally drive. So a box trailer it will have to be.

So why am I building a wingsail? Well, firstly is because I can. I am building a solid foam sail like the ones set out in Dave Culp's paper in this issue, and finding it surprisingly easy, though it's taking a lot of thinking time to sort out the details to fit it to my boat.

Secondly is that wingsails have undoubted performance advantages over soft sails. They may not produce more lift, but they certainly have less drag, and that means a better lift/drag ratio, which means they can sail closer to the apparent wind. As an inland sailor that is something I value. Being able to sail even just a few degrees higher means fewer tacks and much improved progress in the narrow rivers around here (Norfolk, UK).

Peter Worsley has been sailing these waters much longer than I. He's used both wingsails and windmills to get to windward. His wingsail boat is described in our second paper.

Wingsails are having a renaissance, probably due to the America's Cup boats and the television coverage they achieved. Many sailors now know what a wingsail is, and that, thanks to people like AYRS-member Tom Speer (one of the Oracle design team), they can achieve great things. However there is a perception that to make the best of them you need to spend millions on development. Part of the reason for these papers is to show that you don't need to spend millions but can have a wingsail on a normal sailing budget. When it's finished, my wingsail will have cost me, I estimate, around £200 – less than I would have to pay a sailmaker for a well-cut soft sail. If Dave and Peter and I can do it, then so can you, so let's bring on the wingsail revolution in small boats!

Simon

A Modest Proposal For a Modest Wingsail

Dave Culp

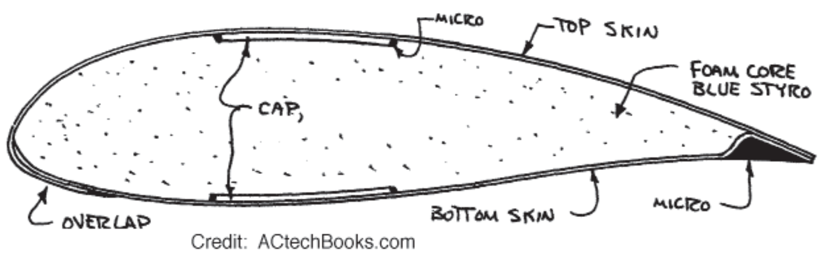


Figure1 - Rutan cut-foam wing section

There is a perception that wingsails need to be complicated, expensive and fragile. Often they are. Often they are designed to push the limits of performance, but just as a dinghy sail needn't be a tape-drive, carbon battened Mylar jewel, neither must a wingsail be of carbon fiber, Mylar nor even fiberglass. A perfectly functional, tough, wing can be built for less than $100 in materials and 20 hours of amateur labor.

The giant wingsails on classes like the America's Cup AC72 catamarans, AC45s and C-Class catamarans are marvels of engineering. They are built of hundreds of bits of expensive, ultra-strong kit, weigh nearly nothing and having sometimes dozens of control lines allowing them to be curved and twisted to perfectly optimal shapes—under expert hands of course! Their mission, their "design brief," is different to ours.

Let us consider a more modest brief. Our performance envelope will be optimized for simple easy construction, commensurate with the very close-windedness and super high lift abilities wings are known for. We will be satisfied, not to be the fastest wingsail ever built, but to be markedly higher performance than similar boats under conventional soft sails. Our wing will be 10 ft tall with a 4 ft root chord, tapering to 2.5 ft at the tip, its aspect ratio just over 3. It will be free-standing without stays and will carry no jib or spinnaker. It will be approximately 33 sq ft with a final weight under 20 lbs. Variations for building larger or smaller are at the end of the article. Ours will be more flexible than some, tougher than most, and will be suitable for small dinghies and multihulls, or large radio-control models. It will also be tough - sufficiently tough to take most capsizes and the occasional mishandling in its stride, both on- and off-water. It will be watertight even when broken, easily repairable, and downright cheap to build.

Construction Ideas

We will build in solid expanded polystyrene foam, reinforced with a bit of wood and perhaps some papier-mâché. We will skin with heat-shrink film, just like the Big Boys use. There will be no carbon fiber, no fiberglass and, unless the builder insists, no painting at all. We will build what's known as a two-element symmetric wing, capable of high-lift, low drag, attached flow on all courses. Two elements means the wing will be of two pieces, split and hinged vertically to create the finished wing. This means that, for building space and transport purposes, our wing pieces are approximately half as wide as the finished wing

The recent America's Cup has fueled a resurgence of interest in wingsailed boats. C-Cats and many speed-sailers have been winged since the 1970's; the aerodynamics and sophisticated control systems are well sorted; robust, effective — and complex. This is necessary for match or fleet racing, most especially in area-limited classes. It is perhaps time to explore the other end of the wingsail spectrum. Rather than scaling these sophisticated machines down to amateur size, we will investigate scaling up from model aircraft and model boat-building technologies and techniques.

Hot-wiring solid foam to create wing cores has a long history. Rutan's entire series of VeriEZ, LongEZ and Solitare homebuilts are all hotwire-cut foam. The technique yields sophisticated shapes quickly, easily and inexpensively. Using "The World's CHEAPEST foam cutter" (http://www.rcgroups.com/forums/showthread.php?t=191128) a single person can cut up to 3ft x 4ft wing sections alone, with a single template, in a few minutes. Once prepared and set up, the entire wing can be cut in an afternoon, including test pieces, errors and all.

Sailing forces and strength of materials.

No wingsail on a monohull dinghy (Laser, Sunfish, Optimist, etc.) can generate a maximum overturning moment greater than the hull-plus-sailor's maximum righting moment otherwise the boat capsizes! If we take that to be on the order of 480 ft-lbs (65 kg-m) (80 lb hull heeled at 30 degrees; hull form shifts center of buoyancy ~1 ft to leeward, plus 160 lb sailor, sited 2.5 ft upwind of center of buoyancy), then a 10 ft (3 m) tall, 33 sq ft (3 sqm) wing, with its center of effort located some 6 ft (1.8 m) above that same center of buoyancy, will cause the dinghy to capsize when it produces about 80 lbs (36 kg) of sideforce. If this is all the force we can handle, and is actually distributed throughout the wing, we can understand how a wood + foam + plastic film might suffice.

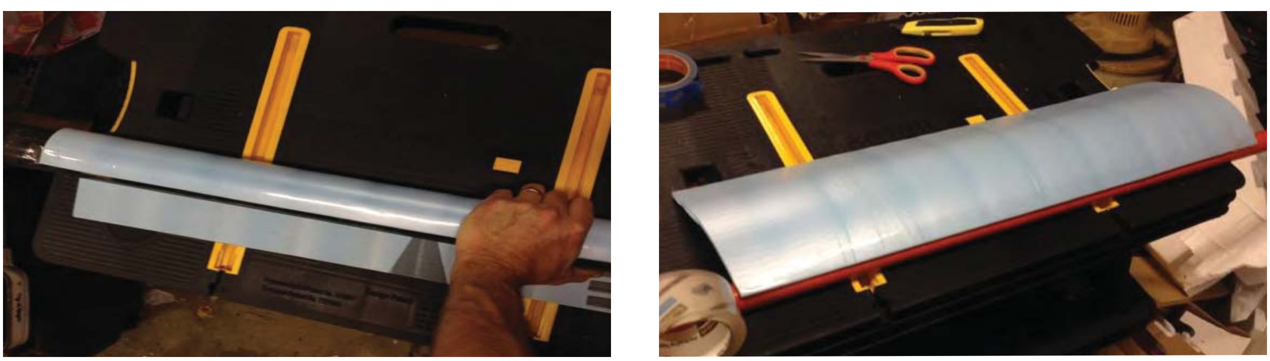
One can envision "distributed throughout the wing" in this way. Visualize the wing off the boat, mounted in a horizontal, not vertical, mast step, without staying. Now, envision placing a dozen, 6.5 lb sand bags spaced along the wing, from root to tip. This is our max design load then, not including safety margin, and equals about 2 lbs/sq ft. This is quite modest, on a par with fabric-winged hang gliders and 1/5 to 1/10 that of small sport aircraft.

Moving to a multihull platform, consider a Hobie Bravo. This boat is 12 ft long, weighs 195 lbs empty, and has 3.5 ft spacing between centers of buoyancy of its two hulls. At max righting moment we will see 195 lbs of hull, centered 1.75 ft to windward of CB, plus the 160 lb crew whose CG is sited 4 ft to windward of CB (sitting to windward, not trapezing). We now see just under 1000 ft-lbs of righting moment, requiring a wind force of 132 lbs, 7.5 ft above the CB. This is our design load for a multihull - our sand bags now need to be 11 lbs apiece to simulate max design load.

"Conventional" aircraft and sailing wing engineers often ignore, in a structural sense, the support structure for the wing skin. Thus the ribs or foam are considered "ride-alongs," and sufficient support for all aerodynamic loads are provided by wing spar(s), sparcaps and/or glass fiber or carbon fiber skins or partial skins. (See Fig 1). Spars and sparcaps form essentially "I" beam structures, or, if with multiple spars, box structures that are engineered to withstand not only constant aerodynamic loads equal to the aircraft's mass, but also safety factors on the order of 5-10 times that load. It is also the job of the sparcaps and/or skin to resist torsional loads—twisting.

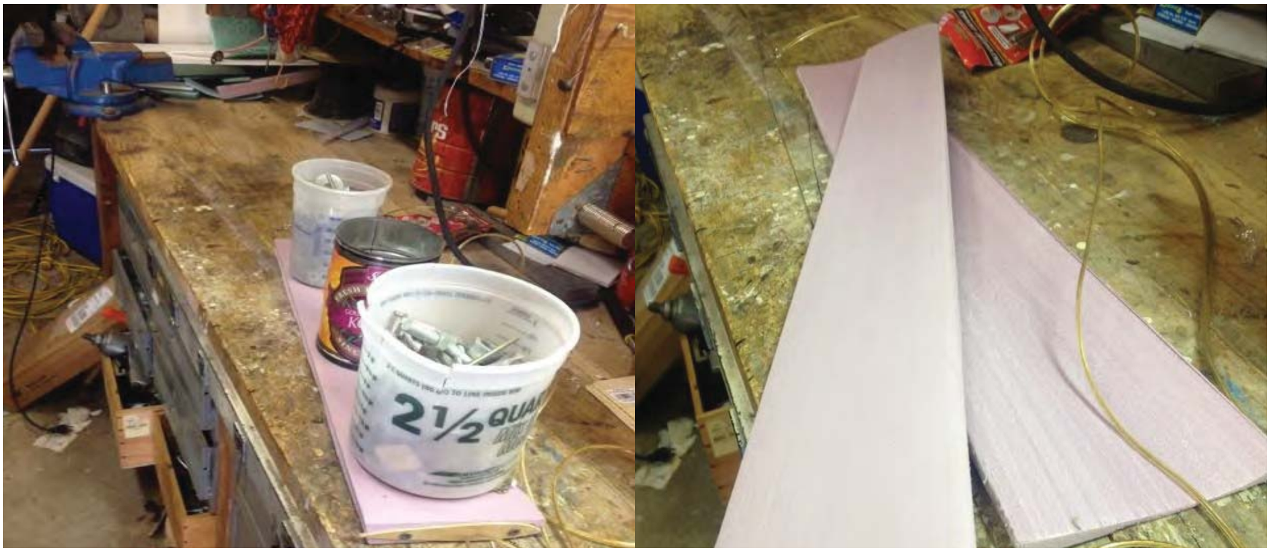
Model-makers ignore this in small models and take up to 100% of their support solely from the foam to a surprisingly large scale. Only when model wing half-spans increase above about 24 inches (4 ft wingspan) do modelers begin to consider letting in wood, glass or carbon shapes as partial spars, and not until half-spans exceed about 4 ft (1.2 m) will they move to full thickness spars and plywood, balsa or fiberglass skins to serve as sparcaps. "Foamie" aircraft are built to absurdly large sizes. Third-scale, even half-scale R/C aircraft have been built and flown with actual wing areas up to 80 sq ft. Even the smallest of these use design loads on the order of 4-10 lbs/sq ft to account for high-G maneuvering.

Basic structure of "built-up" foam wing. Note that is ready to fly in photo 3; the foam comes with surface film, and I've used packing tape on leading and trailing edges for finish. Other brands of foam do not have the perforations.

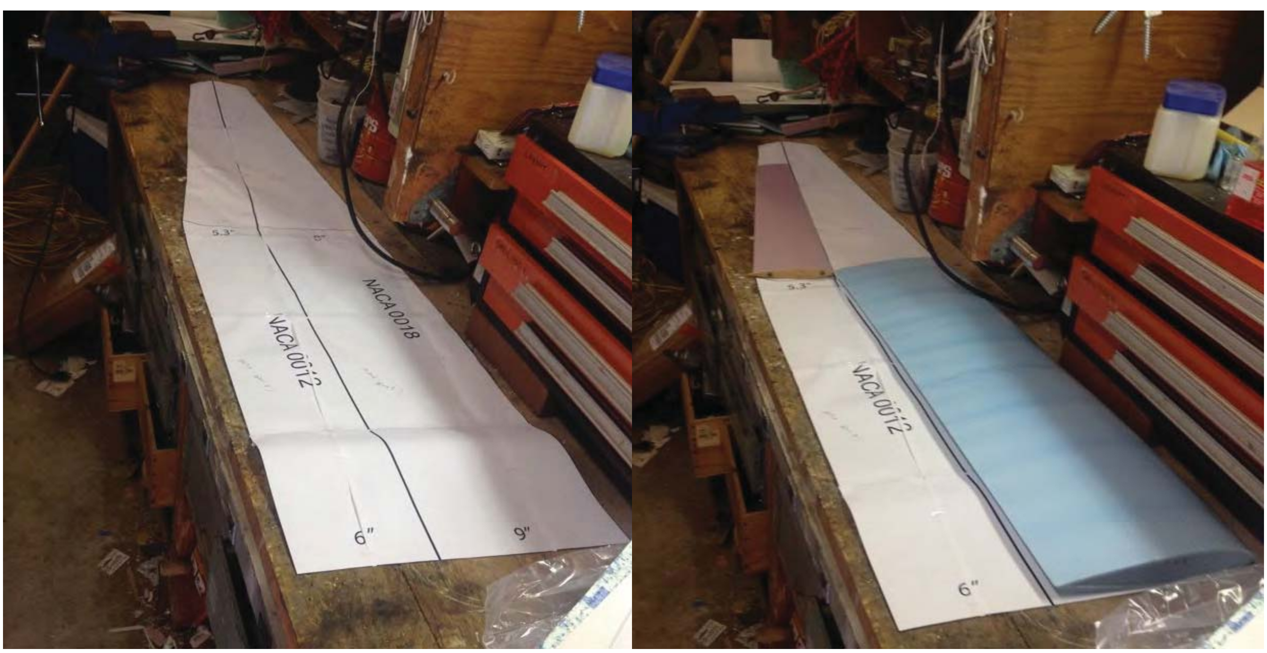


"Cold forming" curve into foam with factory film, and the resultant permanent bend

Sections showing reinforcement for stub mast; this is the forward element of a 2-element wing, thus the apparently too far aft location of the mast. Then wing ready to assemble, then fully assembled. This element should have had 1 more rib—these are only needed to define the airfoil, not for strength. This element is about 9" x 30"



Here I'm hot-wiring one of the thinner elements (too thin for built-up process). The entire hot-wire setup, except for transformer, is fully visible here—it's so minimal you can hardly spot it.



Here's the complete wing template. It's 60" by 15" chord at the boom; about 5 sq ft. The two completed elements are shown (yes, one needs a rebuild!)

I think a wing just double this size is easily achievable with strictly hot-wire cutting (more fool-proof than the built-up method), plus addition of ridiculously cheap mounting and reinforcing materials. That wing would be 10' X 2.5'; about 25 sq ft. Could disassemble into either three pieces; largest being 10' by 1.5' or into 4 pieces, 5' by 18". 30 sq ft is enough to power a very small dinghy or a pretty large R/C model — perhaps 8' LOA.

I would like to take it a step farther; to 20' by 5', about 100 sq ft. At this size, though, the foam requires significant reinforcing, including (probably) a laid-up spar, thin plywood or fiberglass planking and a serious method of transport. Perhaps a bridge too far? Perhaps more like 16' by 4' at ~60 sq ft.

My goal here is cheap and fearless construction, and a sufficiently tough structure to handle most knockdowns/capsizes.

Construction Overview

We are going to build our wing 10 ft tall by 4 ft (1.2 m) root chord. It will consist of 2 elements, a 60% chord main element using a symmetric NACA 0020 airfoil and a 40% chord flap using a symmetric NACA 0012 airfoil. These proportions were recommended by AYRS member Tom Speer, and the expected aerodynamics are available here: http://www.tspeer.com/RigidRigs/40flap/S902fa20.htm. Tom uses a custom airfoil slightly different to the NACA 0020, but the latter is easily available online at any scale for full size printing at AirFoilTools•com Perhaps we can persuade Tom to explain to us the advantages of his custom foil and to upload its coordinates to AirFoilTools so we can scale and plot it as easily as the hundreds of other airfoils there.

Our main element will have a root chord of 28.8 inches (730 mm) and a max thickness of 5.76 inches (146 mm). Our flap will have a root chord of 19.2 inches (485 mm) and a max thickness of 2.3 inches (60 mm). Both elements will be slightly tapered, for aesthetics, aerodynamics and ease of hotwiring their solid foam construction.

We will cut a total of six foam pieces for the entire wing, three approximately 40 inches by 30 inches (1015 by 760 mm) and three approximately 40 inches by 19 inches (1015 by 485 mm), then assemble them into the two 10 ft finished elements (variations for disassembly of the wing into 2, 4, or 6 pieces are possible, with a small weight penalty).

We will use a full-length mast to carry all sailing loads. Our mast will need to be about 12 ft in length and can be the original mast from the boat if suitable. This greatly simplifies the engineering and the build. We will address using shorter "stub" masts and internal wing spars at the end of this article. The wing will be 90% foam with 1 inch plywood laminated boom plus three ½ inch plywood sectional reinforcements, to transfer bending loads to the mast and to provide gudgeons for flap attachment. We will use heat shrink plastic, applied directly onto the foam, for skins. There will be no built-in spar, no sparcaps, and no stringers. There will be no torsion box, though we will demonstrate a simple method to add papier-mâché stiffening for pennies. The main element is quite thick so offers sufficient resistance to twist, but the flap will need some stiffening.

There are variations to add strength to this wing at very low cost, with slightly more labor, and that will allow larger wings and/or stiffer multihulled boats. See later in this article.

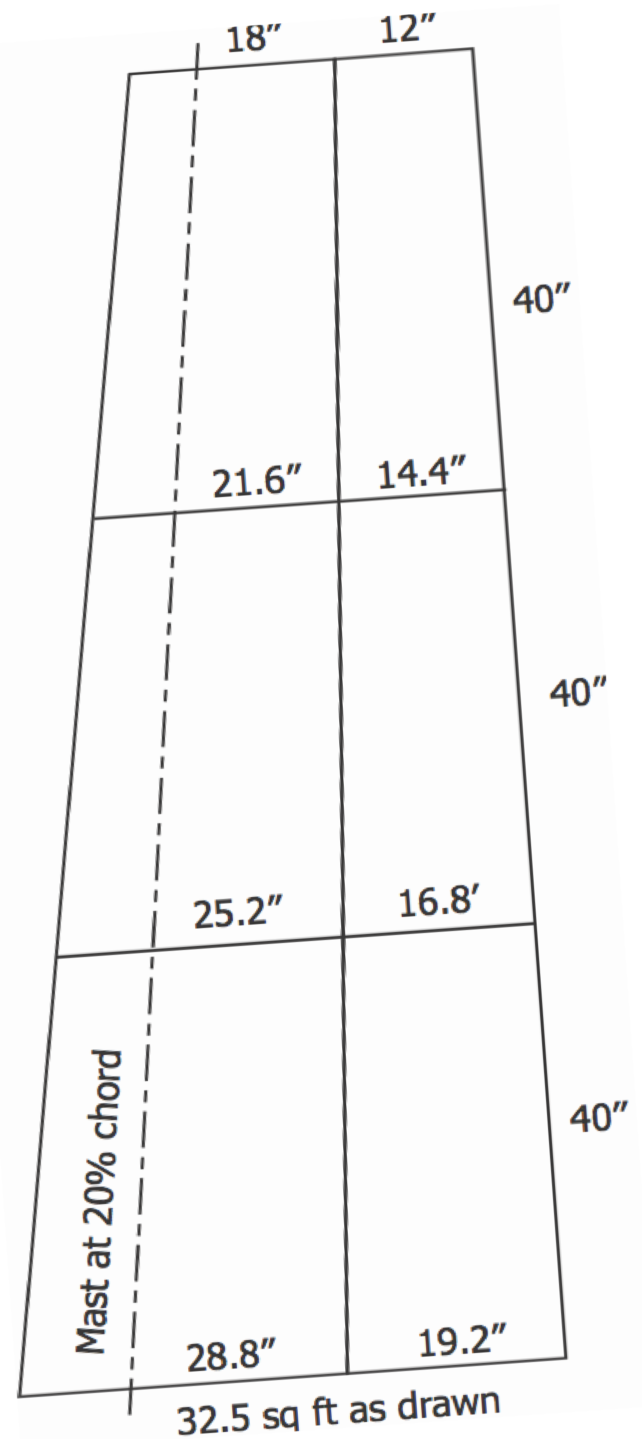


Figure 2 - Outline drawing of wingsail

Construction Details.

Hot wire-cutting devices and procedures are well covered elsewhere. The simplest and least expensive is here: http://www.rcgroups.com/forums/showthread.php?t=191128. A complete reading of the several dozen messages contained in this link form a useful primer on simplified foam cutting. The device consists of nothing more than your workbench, 20-30 ft of stainless steel fishing leader wire and any one of dozens of simple variable voltage power supplies. These run the gamut from a borrowed 12 volt battery charger with an ordinary home lighting dimmer switch in its primary, to laboratory-grade Variac units. The thread author uses a near-antique model train transformer, widely available on eBay for $10-15. All that's wanted is about 3-4 amps at 10-18 volts - a total of ~35-50 watts. Some builders use mains AC with nothing more than a dimmer switch to control temperature, but this is extremely dangerous, and not recommended!

The stainless fishing leader will be your hot wire - Nichrome wire is expensive and simply not necessary. The leader should be ~.018 inches - .026 inches diameter, or between 60-120 lb breaking test and will be available in lengths of 30 ft for under 10 US dollars at Amazon and elsewhere. Very complete instructions for building and cutting with this tool are in the RCGroups link above. Please note that, while this cutter can be used by a single person to cut highly accurate foam wings, it will only cut tapered wings. Straight sections require two templates, not one, and a second helper to guide the wire. Gloves are a good idea all round, but the wire will only become hot between the alligator clips energizing it - even very long reaches to get out mild tapers will remain cool away from the actual workspace. Spend time sanding the template edges perfectly smooth. If the wire catches or chatters, it will leave gouges and ridges in the foam.

Wing templates from AirFoilTools.com (link below) can be printed full size. Try this with the smallest template first in order to calibrate your printer. For most, "100%" will yield an off-size template, so print one and assemble it with tape, measure the chord and compare it to what was expected. Now reprint using the appropriate percentage and check again. It should be perfect, and this ratio will be appropriate for printing your other templates.

Each wing and flap segment will need one template only, thus 6 templates total. We will leave these templates "built into" the wing to create hard points for bearings, flap attachment, counterweight, etc. They can be five-ply 1/5 inch (5 mm) hardwood plywood for all but the root, which will get a 2nd layer of ½ inch (12 mm) later and will become the boom. We will also need a plywood template for the wing element's tip. Not needed for wire cutting, this will become the actual tip of the wing. Please note in Fig2 that we have indicated cutouts for the mast in each template. The slit allowing the hot wire to enter this chamber will be glued back together in the template and the foam later.

Bearings need a bit of thought. It is assumed that the aluminum or wood mast can be designed to rotate in its step if that is simplest, or the stub may be fixed and the wing rotate around it. We will have four bearing points built into the wing, one at each template, so it will be well supported. Bearings can be as simple as smoothed oversized cutouts in the plywood templates, varnished or epoxy coated inside the cutout to create the actual bearing surface, or inserted Delrin or Teflon bushings. Minimum friction and good tolerance of mast flex can be had by buying or machining such bushings as shown here. Whatever you choose, these will be encased in the wing permanently.

Foam "blanks" will be built up from widely available expanded polystyrene (XPS) foam - the cheapest and lightest kind. This is typically sold in 0.75, 1.0, 1.5 inches or 2 inches thickness, and in either 2 ft x 4 ft or 4 ft x 8 ft sheets. This insulation is often sheathed with clear plastic, foil or kraft paper. Remove this before assembly and cutting. The main wing element will have a max thickness just under 6 inches, the flap just over 2¼ inches. Building the blocks thicker than needed will make the wire cutting easier: 6.0 inches and 2.5 inches should be sufficient. It is fine to cut the foam to final shape and size in profile, before gluing up. See Fig 1 for one efficient layout of varying width foam pieces. This minimizes waste and assists with wire guiding.

Assemble the foam blocks with contact cement as this does not impede the hot wire. Polyurethane glue, white glue and epoxy all leave a hard line that the hot wire cannot cut. It is also difficult to get solvent-based, even water-based glues to harden inside foam buildups as the foam is both air and watertight. I recommend spray contact cement such as 3M Super77, but make a trial piece first to be sure your choice does not attack the foam. A full coat is not necessary, though more than a "mist" on both surfaces is needed. Careful alignment of the foam pieces is important as there is no repositioning once the cement contacts. Easiest is to lay both pieces glue side up, spray both and wait for them to dry, then lay thin strips of bare wood every 6 inches or so across one block. Turn the other block over and place it carefully on these strips. When aligned, extract the strips one at time to bring the foam surfaces into contact. As soon as they have contacted you can continue on with the next piece of foam.

Templates can also be contact cemented to the foam. Be sure the foam surface is flat and smooth. It is a good idea to drill the template and screw into the foam with three to six long dry-wall screws, 3 inches (75 mm) is about right. Be careful to keep these away from the hot wire's path.

Hotwiring foam is not at all difficult and very well covered in the discussion thread listed above. Mildly tapered cores, like we are building today, require a wire pivot point up to 20-30 ft distant from the actual cutting table. The discussion thread offers a simple trial-and-fit method for finding this point, but at larger sizes either of these calculators work better: http://tailwindgliders.com/files/Foam Cutter Calc.xls (second worksheet, not the first, which is associated with a completely different cutter) and also: http://www.rcgroups.com/forums/showatt.php?attachmentid=4691434.

Once we have cut all tapered sections and sanded any grooves or ridges with 100-grit sandpaper we can stack them to assemble the wing elements. This can be permanent, gluing each foam block+template to its neighbor, or if you've decided to build a knock-down wing, each needs a second template fabricated and glued/screwed to the foam so that each foam section has two plywood ends. Arrange at minimum two, 1 inch holes and pins in each to align them during assembly and carry torsional loads. Do not rely on the mast cutout through the foam for alignment, as these are oversize to assure the mast won't bind.

A note about putty fillers and foam: filling dings and dents is easy, but be mindful that the filler will almost always be harder than the parent foam, so sanding can be frustrating. Make every attempt to avoid fillers altogether if possible, and especially over large areas. Best filler is ultra-lightweight "spackle" designed for patching holes in ordinary walls. You'll know it's the right container when you pick it up; it feels empty! This filler is nearly as soft as foam, so is easiest to finish, but be aware that it is not waterproof. The finish sanded putty needs to be sealed against water. Water based polyurethane varnish (WBPU) or thinned Titebond III (not I or II!) work well for this.

Twist and torsional stiffness

We'll discuss optional papier-mâché sparcaps and torsion boxes later under "Variations". In the meantime, our flap element needs help. It is relatively thin and will be significantly loaded, as it is farther from the mast than the main element. With this element only actuated by the boom at one end, there's a significant issue with twist. A very much stiffer element may be had by covering it with paper and glue, or paper and WBPU. Papier-mâché is much stronger than one might think. Thin brown kraft paper, as used for paint masking, has a tensile strength of 5000 psi, twice that of balsa. It's also double the density of balsa, nevertheless a bit of planking or sparcap in papier-mâché can be half the thickness of balsa, yielding the same strength and weight for a few pennies.

Complete instructions are in this video: http://www.youtube.com/watch?v=IDGgj7UehVI After the paper covering is completed and sanded, you will go on to paint it (optional) and cover it with heat-shrink film, just like the main element. Covering with papier-mâché - even a single layer of kraft paper - will be much stiffer than covering only in plastic film, but it will also be more brittle and less resilient to scuffs and dents. The video shows complete coverage of the foam; consider leaving a few inches at the leading and trailing edges covered only in plastic not paper. These will then take the worst of any mishandling.

Connecting flap to main element.

At zero degrees deflection the wing elements want to be immediately nose-to-tail, there is no spacing between them. The hinge line, however, will be forward of the main element's trailing edge, at about 90% chord. This causes the slot between elements to progressively open as wing deflection increases.

Connection will be a simple pin, bolt or clevis in holes bored through the centerlines of the templates. The main element is simple; a ¼ to ½ inch hole is bored through each template at 90% of chord. The template is not very wide here, therefore gluing or screwing a piece of 1/8 inch aluminum bar stock, through which the hole is bored will suffice. This is done before the template is attached to the foam core. The flap element needs a bit more, as the hinge point is outside the template altogether, forward of its leading edge. Again, though, a piece of aluminum bar stock with the appropriate hole bored through it, glued/screwed to the template extending ahead of the leading edge is perfect. There will need to

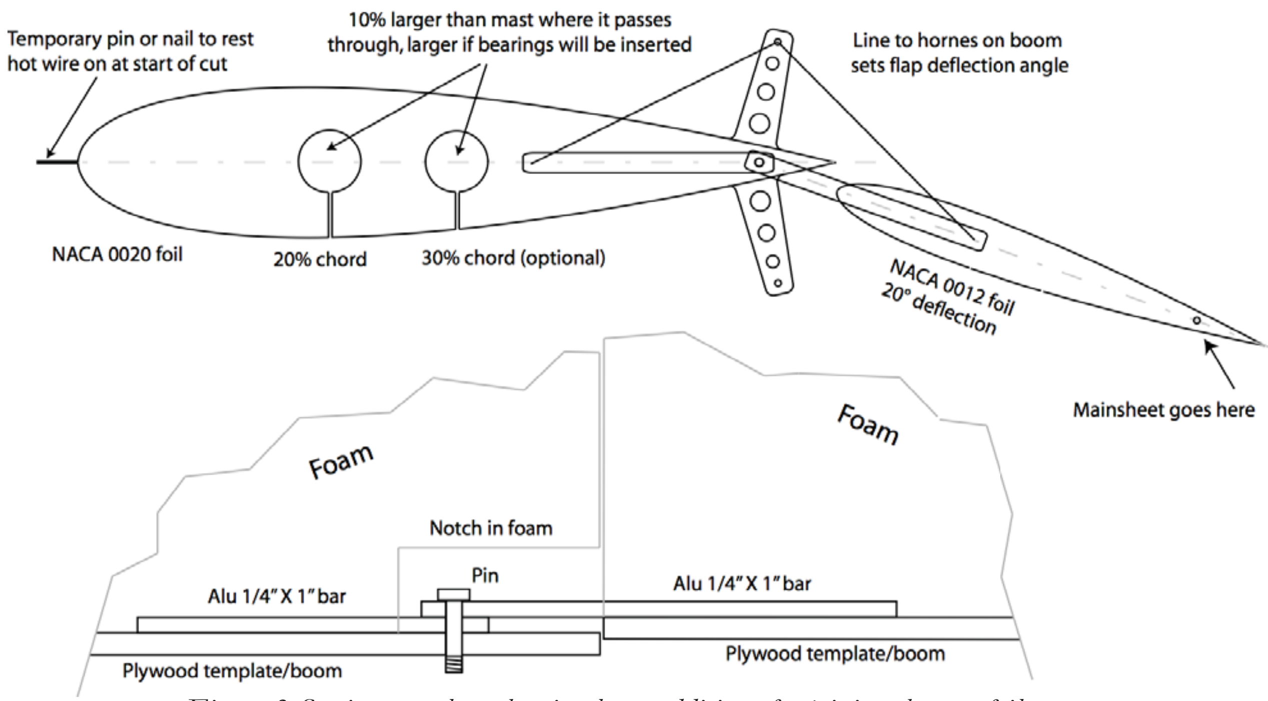


Figure 3 Section template showing later additions for joining the two foil parts.

be permanent cutouts or notches in the foam to accommodate inserting and removing the hinge pins; these should be kept as small as practical, using short pins and simple keepers. The notches should be cut before covering the wing with heat shrink, then trimmed as necessary. If the film comes away from the foam when trimming the notches, judicious use of contact cement and/or tape will keep it in place.

There will be four sets of pins/gudgeons, one at each plywood "hardpoint" of the wing. For transportation, the wing can be transported assembled, in suitable brackets on a trailer or atop a vehicle, or it can be disassembled, making it much smaller. It will not be possible to fold the assembled wing beyond about 120-130 degrees without removing the pins.

Now is the best opportunity to paint your wing, if you plan to. An experimental wing looks fine finished only with clear heat shrink plastic. All of your work will show, it will be lightest and you'll have no compunction against opening the wing back up for future repairs or alterations. However, if paint is wanted, this is the easiest time to do it -- before the shiny heat shrink covering goes on. Any type of paint is acceptable on the raw foam; "rattle can" spray, brushed on ex-house paint, almost anything is fine so long as it doesn't attack the foam. It does not matter if the paint is gloss or flat—the plastic film will make it uniformly smooth and high-gloss.

Once the wing elements are stacked and assembled it's time for heat shrink covering. The shrink film can be purchased in simple kits for making shrink film "storm" windows. Kits are available at DIY stores, Home Depot or Amazon. These kits will include rather thin film, typically 60 or 70 "gauge," equivalent to 60-70 thousandths of an inch, before shrinking. Ideal will be 100-200 gauge, but minimum quantities of these thicknesses are sufficient for dozens of wings, though not expensive.

The easiest way to shrink-film a wing is to create a "bag" of the film, insert the wing and then shrink the bag until it's tight. Seams can be done with a simple soldering iron as sealing tool and a very smooth working surface. Window glass is best, but melamine or Formica or "whiteboard" will work (think kitchen table). Wood surfaces, even MDF particleboard or the like, aren't suitable. The seam will be uneven and weak.

Cut out a sufficiently large piece or pieces of the film and tape it together temporarily, then take it to your smooth sealing surface and run your soldering iron around 3 sides. (Use a straight edge if you can, you'll know your seams are "right" when the offcuts are left stuck to the seaming surface and the seams cannot be pulled apart. Practice first on scrap.) Insert the wing and seal the fourth side. The fit can be quite loose - even 3-4 inches oversize all round. The film can shrink as much as 50% dimensionally so is very tolerant of fit.

Usually a full-sized hand-held hair dryer is sufficient to shrink the film. Do it in stages so that all the film is more or less evenly shrunk, before finishing and shrinking every wrinkle out. Try to arrange the seam to fall neatly on the leading or trailing edge as the film shrinks. Finish both with clear packing tape at the end for durability—and to cover this seam. This tape should adhere aggressively to the film but if it does not, mask then spray a light coat of Super77 or equivalent contact cement on the film first.

Your film will not be glued to the foam. This is acceptable as the film bag is complete and the seams are strong. It facilitates future disassembly for repair or modification; you'll just cut the entire shrink covering away and re-bag later. Glued-on film will damage the foam when removed. Localized repairs can be done with simple packing tape and/or spray contact cement.

If you cannot get sufficient heat to shrink in a decent period of time, try two hair dryers, with a helper. Last, consider a heat gun (industrial sized is best - these are no hotter but do include stronger fans), but be very careful not to overheat the film. Film will fail above about 300 degrees F and heat guns can easily exceed that. Once all the film is on and shrunk, stand back and admire your work. The wing will be beautiful.

We are nearly finished. Angle of deflection is typically set at the boom via a horn with a simple short line and cam cleat [Fig 3]. This limits the maximum deflection. The sheet is then taken to the end of the boom. In this way, the wing self-tacks internally without adjustment. It is possible, sometimes desirable, to auto-control deflection of the wing to match apparent wind direction (see Peter Worsley's system) This is simply accomplished via control rods taken to horns on main element and flap, as is done with radio control.

The boom can be easily built up of the same ½ inch (12mm) plywood as the templates, increasing thickness as appropriate. For maximum flexibility of future mounts and controls, consider extending the aluminum gudgeon doubler the entire length of the bottom-most template, facilitating bolting on various boom configurations. It is possible to configure the boom to be one template higher up the wing (in our case, 40 inches above the root of the wing). This will introduce a bit more complication, but will allow the root of the wing to sweep closer to the deck if your hull allows. It also reduces the twist on this rather flexible wing.

The leading edge of the main element needs a horizontal socket worked in either 40 inches or 80 inches above the root. Wing sails behave much better when mass-balanced; auto-actuated control systems require it. This can be a simple fiberglass, aluminum or papier-mâché tube with a chunk of lead on its end, socketed into a slightly larger tube inserted into the leading edge of the main wing element alongside one of the hardpoints, either 40 inches or 80 inches from the root. The physics of mass balancing suggest that higher off the deck is better than lower, even though this moves the wing CG upwards. As well, a smaller weight on a longer tube is better than a larger weight on a shorter tube.

Aerodynamic balance

We are often told that wingsails should be pivoted at their center of lift; about 25% of chord. If pivoted here, minimal force is needed to control the wing—perfect for R/C or other automatic control. However, if handheld, this leaves no "feel" to the sheet, no feedback as to how hard the wing is pulling—and also no self wind-vaning if the sheet is released. You would need to mechanically push the boom back to center.

If pivoted from the leading edge, as a fabric sail is at the mast, the wing will have maximum "feel" but will require nearly as much force to sheet as a soft sail and will increase twisting loads on the wing. For this wing we've specified the mast/pivot location at 20% of chord. Enough to make the sheet loads small, but not so much as to deaden the wing's feel altogether. It is perfectly acceptable to arrange your templates to hot wire two or even three locations for the mast pivot, and to experiment. Be mindful of how much you weaken templates and foam, and be aware that whatever bearing scheme you choose, you will need 2 or 3 times as many, enveloped within the wing.

Looking at weights, the above wing will contain 5.5 cubic ft of expanded polystyrene foam at 1.6 lbs/ft^3 = 8.7 lbs. ¼ inch plywood for the 4 enveloped templates will equal about 2.25 sq ft. At 30 lbs/ft^3 = 1.4 lbs. Aluminum gudgeons plus full length boom alu backing plate, 1/8 x 1 bar stock, we have 94 linear inches = 1.2 lbs. Heat shrink plastic film will be about 92 sq ft at .001 inches thick before shrinking = 0.50 lbs. @ 65 lbs/ft^3. Adding a 25% contingency factor (fillers, boom, pins and glue) = 14.75 lbs (6.66 kg) all-up. Add a fiberglass windsurf mast 12 ft long (or a 12 ft, 1.5 inches X .062 inches wall 6061 Alu tubing) = 4 lbs (1.9 kg). Final all-up weight of the wingsail = 18.75 lbs (about 8.5 kg).

Reinforcement

It is possible to strengthen our wing with simple changes and additions. The mast carries all of the aerodynamic forces in our little wing. In a larger wing, or the small one with a shorter mast, we would need to add a wing spar. When enveloped within solid foam, which maintains the spar in column, it is possible to use "ribbon" spars. Outside of R/C modeling, these are most commonly seen in surfboards. The foam blank is sliced in two and a piece of ordinary wood, quite thin and as wide as the core is thick, is glued into the juncture as the core is glued back together. Multiple ribbon spars may be contemplated, spaced anywhere from an inch to perhaps 25% of the chord apart.

Slicing the chord to make room for these is easily accomplished with the hot wire cutter, even before the wing is assembled (be sure to label all the bits carefully!) The ribbon spar needs a cutout at the lower portions, making room for the stub mast and its bearings. Some will build ribbon spars of either fiberglass or carbon sheet (which are sometimes designated FR4 or G10 respectively). These plates can be had in thicknesses from .015 up to 0.25 inches (3.8 to 6 mm) or even thicker. See for instance: http://www.acpsales.com/OnlineStore.php Be mindful that ribbon spars need to be unbroken if possible, Therefore, the decision to use them needs be made early, as the enveloped templates need to be cut apart and reassembled around them as the wing is built. Generally, a ribbon spar is sufficiently thin that no allowance needs be made for it when cutting the foam. Cut it with your hot wire, glue the spar in and glue the second piece on neatly - the chord of your wing will have increased by the thickness of the ribbon spar, but the air won't care.

The simplest sparcaps are of papier-mâché. Link 4 shows covering model foam wings with kraft paper and either thinned PVC glue (Titebond III brand is waterproof when dry) or water based polyurethane varnish (WBPU). The water is necessary in order to cause the paper to shrink as it dries, both removing construction wrinkles and also pre-tensioning the skin/sparcap, greatly increasing its stiffness. It is not necessary to cover the entire wing with paper; the resultant is wonderfully inexpensive and stiff, but it is a bit brittle compared to heat shrink film over foam. Using 2-5 layers only on the thickest 50% of the wing chord will yield similar stiffness, while maintaining the tough and resilient foam/shrink film near both leading and trailing edges.

Sparcaps can also be "planked" with 3mm plywood, right over the foam. In this case, a 3mm deep cutout in the hotwire template—thus the foam—is wanted. After assembly of the hotwired sections, the precut layer of plywood is laid into the cutout, again with contact cement. If there are two ribbon spars let into the wing, these plywood caps can span both, yielding a complete torsion box (consider epoxy for the wood-to-wood join; the contact cement will hold these joints in register while the epoxy sets). This is not only hugely strong in bending (due to the two spars) but also in torsion where it is unbelievably stiff. Purists may consider removing much of the foam within this torsion box, though we are treading on diminishing returns here!

Strongest, of course, is a full fiber-glassing of the foam wing core. This is the Rutan recommended method for building their VeryEZ and LongEZ aircraft, with wing loadings of 15-20 lbs/sq ft. Fiberglassing wings is beyond this treatise. Though not technically difficult, it entails much higher materials cost, much more labor (sanding!) and yields a heavier, yet more fragile, wing in the end.

Scaling

This wing may have identical scantlings if built at half-scale, as for a model boat. It can also be stretched to 12 ft (3.6m) span, again probably without alteration - though 48 inches is a long "reach" for hot wire cutting. If it's a first effort, consider slowing the cutting speed to avoid the wire lagging behind in the foam.

The design ought to stand scaling up as well, to perhaps 150% (18 ft tall, 6 ft root chord) but will benefit by some of the reinforcements mentioned. The basic method is perhaps effective for wings as large as 100 sq ft, but not larger.

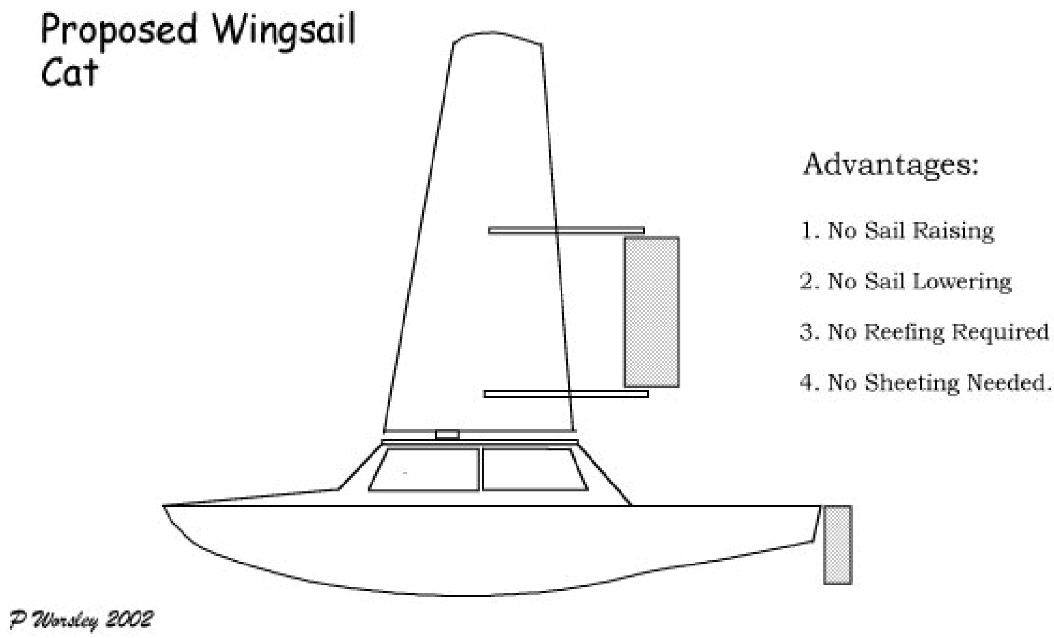
Useful links:

1. Foam cutting of aerofoils: www.rcgroups.com/forums/showthread.php?t=191128
2. Airfoil shapes and coordinates - www.airfoiltools.com This not only has the coordinated for a large number of foils, but also can generate printer ready template files.
3. Calculators for locating wire ends: http://tailwindgliders.com/files/Foam Cutter Calc.xls (second worksheet, not the first, which is associated with a completely different cutter) and also: http://www.rcgroups.com/forums/showatt.php?attachmentid=4691434.
4. Video instructions for adding paper reingoorcements: http://www.youtube.com/watch?v=IDGgj7UehVI

Wingsail Experiments

Bringing sailing from an "adventure sport" to a practical means of power for water transport

Peter Worsley



Since the invention of aircraft, a similarity has been noticed between the operation of sails on boats and the function of wings of aircraft. Sails on boats provide thrust in a horizontal direction derived from moving air, and wings on aircraft provide "lift" in a vertical direction to support a plane in the air, also from moving air (relative to the plane).

In order to fly, wings had to have a certain degree of efficiency, and some experimenters have realised now that aircraft-type wings could be used on a boat and would be more efficient than sails.

Having tested wings on boats in place of sails ("wingsails") designers noticed another feature used on aircraft that would be useful to use in conjunction with wingsails, that you could control the angle of attack to the wind of the wingsail with another smaller wing mounted behind or in front of it (a "tail").

There are many examples of tails used to control the direction of bodies in a fluid, such as arrows, darts, bombs, torpedoes, submarines, and of course the rudder on the boat serves the same function, in that case in water instead of air.

Aircraft use them to adjust, to a precise degree, the lift or (angle of attack) of their wings, in that case the pivot point is the centre of gravity of the aircraft.

The Self-Trimming wingsail "sailset"

When fitted as a way of propelling a boat, the wingsail and tail combination (also known as a "sailset") can adjust to maintain maximum thrust during every small change of wind direction, in this way relieving the sailor of continually manually adjusting for every slight wind direction variation, using a tail can of course do a better and more precise job than any human can do. Such a wingsail/tail combination is referred to as a self-trimming wingsail.

As in the diagram below, the a pivot point for the whole wing and tail assembly is arranged at or near the wing's centre of pressure, and the tail, which is mounted some distance behind this point, exerts a stabilising force to keep the wing at the correct angle. The whole assembly, or "sailset" then follows the wind direction at all times in a similar way to a weathervane, and the angle the tail makes to the wing centreline determines the angle of attack of the wing, causing the wing to exert lift from either side, according to whether the wind comes from the right of the boat or the left, and whether it is required for the boat to go forwards or in reverse.

If the tail is aligned perfectly with the centreline of the wing, the sailset will provide no thrust to the left or the right and is in a "neutral" position. This can be used when the boat is moored or at anchor. Since the profile of the wing and the tail are made to an aerofoil low drag section, the neutral position the rig creates less drag even than a boat with bare poles (no sails raised). Therefore when moored, it is not necessary to lower the wingsail as you would have to do with a conventional flexible cloth sail. This is the most frequently asked question: how about reefing or lowering? It is not necessary to do either of these operations, and the rig will just weathercock about and take care of itself without any danger. When you want to move off in either direction, all that is required is to alter the angle of the tail, and the rig will find the wind and set the thrust of the wing pushing in the required direction.

Non self-trimming wingsails

Some wingsails have been made that are not self-trimming, that is, the helmsman has to adjust the angle of attack of the rigid sail to the wind manually. This is the most popular option lately, since the the America Cup boats have brought wingsails more to attention. There are some disadvantages, here because the system does not look after itself, has to be adjusted manually, cannot be left up and is more difficult to adjust correctly, since a sail is very forgiving in adjustment, but with a wing the angle of attack needs to be more exact to maintain efficiency, quite apart from the fact that with such a tailless system the sailor cannot hope to keep pace with the changes in direction of the wind which occur all the time.

It seems strange that whilst accepting aircraft principles with respect to a wing, many have not even considered that in order for a wing to work best it requires governing by a tail, as in a plane. They have accepted half the technology, but not noticed that wings on planes require tails to make them work properly.

After all, you don't see the pilot of a plane pulling a rope to adjust the aircraft's wing!

Advantages

A self-trimming wingsail sailing system gives the following advantages over a traditional cloth sailing setup.

- No sail raising.
- No sail lowering.
- No reefing required.
- No sheeting required.
- Reverse is as easy as forward - and as fast.
- Sailing in comfort from inside the cabin, there is no need to get cold and wet on deck.

In fact, the only ropes required on a self-trimming wingsail boat are those required for mooring.

The advantage of using a rigid wing is that it can be pivoted vertically on or near its centre of pressure and therefore requires very little force to change its angle of attack. (Such a system is very difficult to arrange on a conventional non rigid cloth sail).

Since the wingsail is balanced and needs only a small force to change its angle, it lends itself to control by a tail vane.

The tail vane follows the wind instantly and in this way takes away the need for manual adjustment of the wing and is in this way self-trimming.

In its simplest form, the wing is of symmetrical section which allows it to develop lift on either side according to whether the boat is on a left or right tack.

Peter Worsley sailing on Barton Broad (photo: F Ball)

Manually controlled tail.

A wingsail/tail combination, as described above, freely pivoting through 360 degrees, automatically finds the wind direction and keeps the wing working at the correct angle.

Although the operator does not have to adjust for wind direction all the time as you would with a normal sail, there still has to be control of the tailvane for forward neutral and reverse.

Typically, a lever is provided for control with a neutral position in the centre for no power, and left and right positions to drive the boat when the wind is from the left or the right.

There is nothing else needed for control, no ropes or anything else. Reversing is as easy as going forward.

However, you do have to change the setting for changing tack, so need some awareness of the direction of the wind.

Automatically controlled tail.

A more recent development is an automatic self-tacking device, which makes self-trimming wing sail control completely automatic and controlled with only one lever.

This is the most simple to use system yet devised.

This has been achieved before in a complicated way with electrical sensors, computer control and servos, but my own patented system is entirely mechanical and much more simple to build and operate. To see a video of how it works go to http://vimeo.com/79511782

The operating lever is the same as a throttle on a power boat. Go, neutral, reverse. That's all! You don't need any knowledge of the wind direction.

The only difference between a boat with this system and a power boat is that the wind is your engine and your speed will depend upon its strength.

If the wind threatens to be too much you can reduce power with your lever towards the neutral position accordingly, this is equivalent to reefing a normal sail.

Answers to some objections often made to wingsails by conventional sailors.

Q: Why use a tail or trimming surface to control a wingsail?

A: A tail relieves the helmsman of the duty of adjusting the sails to get the best angle to drive the boat. The wind is invisible, and with conventional sails the best adjustment can only be judged by indirect means such as the speed of the boat and the "feel" of the boat etc.

Luckily, conventional cloth sails can tolerate inaccuracies in adjustment quite well, and still drive the boat. At best, the adjustment of the angle of attack of conventional sails is only approximate, due not only to the adjusting system, but also from the small strength and direction changes which occur in the wind all the time.

To get the best from a wing, adjustment has to be more precise, and this is best provided by a secondary trimming surface, - the tail.

You only have to observe a self-trimming wingsail in action to see how it automatically adjusts all the time to the wind. These adjustments could never be achieved by a manual sheeting system.

Q: When I pull in my sails on my conventional yacht it takes a lot of strength, how can a tailvane develop similar strength?

A: The answer is that your conventional sails are not "balanced" and you are pulling against the full power of the sail. Conventional cloth sails pivot on their leading edge (luff) and it is very difficult to arrange for them to pivot at any other point.

With a self-trimming wingsail the pivot point is arranged to be about a third of the way back from the leading edge, and therefore most of the lift developed behind the pivot is counterbalanced by the lift produced in front of the pivot - therefore allowing adjustment with minimum power.

It's like the difference between trying to lift a person on a seesaw with no-one on the other end, compared with lifting them when the opposite seat is occupied.

(The lack of "balanced" adjustment on conventional sails leads to many complications such as winches and block and tackle purchases, resulting in yards of rope on the cockpit floor, and dangerous accidental gybes where the boom comes crashing over from one side of the boat to the other, (sometimes resulting in head injury). These kind of inconveniences have always been regarded as part and parcel of sailing and "part of the adventure".

However, they are really unnecessary, and they are all avoided on a self-trimming wingsail system.)

Q: In their simplest form, these wingsails have symmetrical aerofoil sections, aren't these inferior to asymmetric sections?

A: They are only inferior in the respect that they stall at a lower angle. Most aircraft-type wings will lose lift if presented at an angle of more than about 15 degrees to the wind. With a symmetrical section the stalling angle is lower, usually about 10 degrees.

Evidence that symmetrical sections produce nearly as much lift as asymmetric sections can be seen in the fact that many aerobatic aircraft use symmetrical sections and still perform spectacularly! Various schemes have been used to make a boat's wingsail adjustable so that the wing can present an asymmetric section on either tack.

Such ideas are trailing-edge flaps or even pivoting the entire wing horizontally about its centreline. Although these ideas can be useful they are by no means essential.

Q: Can a wingsail be lowered in a gale? Does it need to be lowered? Surely, the drag is more than bare poles?

A: A self-trimming wingsail in "neutral" – that is with its tail at zero degrees – (not angling the main wing to lift in either direction), presents a perfect streamlined section to the airflow and has much lower drag than a circular section of the same thickness, and since it is constantly aligning itself to have the least-resistance to the wind is therefore better than "bare poles".

All experimenters so far have found that in "neutral" there is no problem in any strength of wind. The Walker Wingsail, which is the most prominent design of wingsail so far, has survived many Atlantic hurricanes without damage.

So the consensus seems to be that there are no conditions where they would have to be lowered.

Self-trimming wingsails and electric in combination

Recently, for the first time, a solar powered boat crossed the Atlantic. This boat used photovoltaic cells on its roof to charge batteries, which in turn, drove electric motors with propellers underwater to push it along. The achievement was hailed as a triumph of low-carbon sustainable transport. Whilst this was an interesting technical first, it was by no means the first time craft had crossed the Atlantic without the use of fossil fuels. Atlantic crossings have been going on for hundreds of years using windpower, (which also originates from the sun).

The problem with sailing, is that it has always been there, and so has been taken for granted, and largely ignored in recent times as a inexhaustible source of marine power.

Consider this scenario. Our solar powered boat is struggling to get into port, batteries low, overcast conditions and getting dark, a strong wind is blowing, but the boat cannot use the powerful wind because it has no sails or means to convert the wind into forward motion. Eventually, the crew have to be rescued as the craft is in danger of being blown onto the rocky shore. Surely, if sustainable non-fossil fuel motion is the aim it is clearly a serious omission to fail to equip a boat with a means of using the wind!

The probability is that designers feel that the traditional methods of using sails, which still predominate, and the inherent awkwardness of handling them and adjusting them make their use to impractical for normal transport use.

Of course, this works in the other direction also. A sailing boat is becalmed on a beautiful sunny day and is going nowhere in the doldrums. The sun is beating down, but our boat cannot make any progress because it has no means of converting the abundant sun's energy into power to drive itself along. Supplies are getting low, eventually the crew have to be rescued.

Clearly, an effective eco-boat needs to use all available sources of natural power to be a success.

We could call such a boat a "hybrid" craft, since it uses both solar and windpower.

At the present time, there are hardly any examples of boats that use both windpower to sail and solar power to motor. Windpower and electric power do not integrate very well together, their methods of operation are very different.

The following example compares using electric power with using conventional sails for windpower.

To power up your boat with electric power, you need only to move a lever a few inches and the power comes in and pushes you along.

To drive your boat using the wind, it is a little more complicated, an example would be as follows.:

1. Assess wind strength, decide what sails to use, or how much to reef.
2. Connect up necessary sails.
3. Hoist sails (usually more than 1) secure them.
4. Adjust sails for best result.
5. Monitor course and wind at all time to get best sailing result.
6. If your intended direction is more less than 45 degrees towards the wind, tack as necessary.

That is at least 6 separate and quite often awkward steps.

Compare this with the simplicity of only moving your power lever on your sail/electric system!

To integrate electric power with sailpower, clearly a more user-friendly sailing system would be an advantage!

A self-trimming wingsail would be much more suitable for use with electric solar power than the traditional cloth sailing system.

Perhaps an ideal system would be one where a speed-sensitive switch was employed which, when the speed of the boat drops below a certain value, the electric power was automatically switched on.

With this system, if there was sufficient wind from a convenient direction the boat would sail happily along using the self-trimming wingsail only.

If however, due to headwind, or the need to tack, the speed falls, the electric power would cut in and provide the needed impetus.

In this way you could achieve the best of both worlds. Better than a pure electric boat, with undreamt of range (since it uses the wind when available). Better also than a pure sailing boat since it can overcome any loss of speed by providing power during tacks, calms, and harbour manoeuvring.

Construction.

I've devised these construction methods as an easy and quick way to get wings built for testing. They work, but I don't claim that this is the only way to build them. As long as the sailing wings are sufficiently light and preserve a good aerofoil, other construction methods are quite valid too. For instance, for ruggedness and strength, stressed skin metal construction as used on aircraft would be quite appropriate for larger wings. The wings I have built so far come out at about 1lb per sq. ft. This is a little heavier than sails and masts. Sails and masts, if you weigh them, are heavier than you might think.

Constructing wings for boats might seem a little daunting to people familiar with sails, but in reality it is not difficult.

The method I use would be familiar to anyone who has made flying model aircraft or even fullsize light aircraft that use traditional wooden frame with cloth covering.

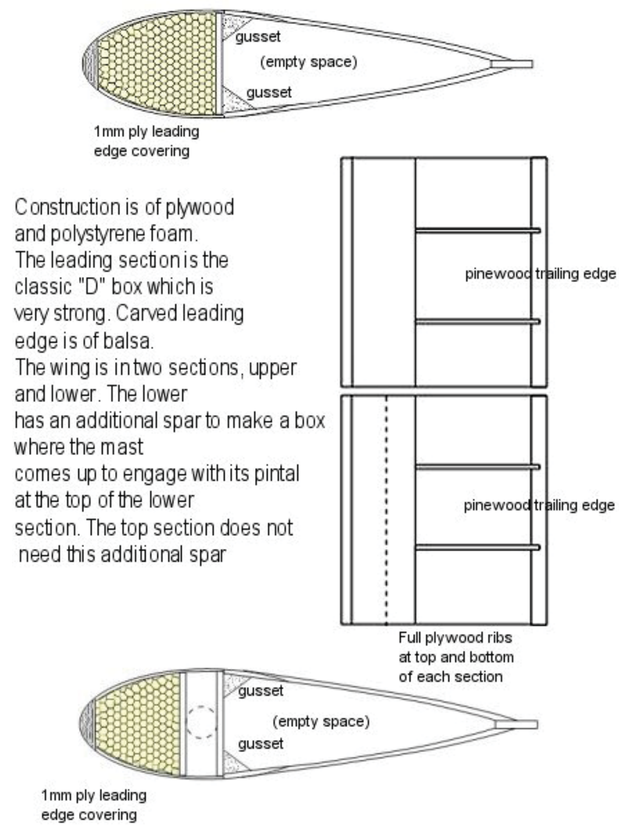
Cloth wing coverings, both for models and fullsize aircraft are being superseded nowadays by plastic films which after covering, are shrunk by heat to produce a drumtight finish.

These wings can withstand any forces they might encounter from the wind, when they are in use, but are less durable than sails when handled by people. You just have to be careful and don't stand on them!

You might think that heat-shrink plastic film coverings primarily produced for model aircraft would be unsuitable for the larger kind of sailing wings, but I have found them surprisingly strong and have never so far torn any.

As an example: the covering on a sailing wing I made over six years ago is still perfectly usable. I also have model wings over twenty years old which are still ok. Admittedly, these wings have been kept indoors when not in use. How they would fair in the open has not been proven, but even if they only lasted one season, it is not difficult to re-cover a wing and quite quick too.

The design is based on the classic "D" box for strength, and everything comes from this. The "D" box is the area between the leading edge and the thickest part of the aerofoil where the mainspar is. This area is covered with thin plywood and therefore forms a "D" shaped tube upon which the rest of the wing is attached.



Mainspar is plywood (with lightening holes).

Leading edge is balsa (this makes it easy to carve for good aerofoil shape)

"D" box filling is polystyrene foam (cut to shape with hot wire cutter).

Leading edge covering is 1mm ply.

Trailing edge is pine strip.

Battens are also smaller pine strip.

Everything is glued with PVA adhesive which is particularly good for attaching the plywood covering to the polystyrene foam. This adhesive may be thinned with water where necessary.

Latest Automatic System

The boat is now fitted with automatic control system which permits single lever control.

I have now been granted a UK patent for this system which controls the tail using a sliding circular cam. It adjusts the wing to the correct angle at all times based upon what direction the boat is heading in relation to the wind. I developed a system to do this easily, using pulleys and string, which I tested on my radio controlled models -

But the big step forward was the introduction of the sliding cam simple mechanism which allowed the sailor to turn off and on and indeed adjust the power of the sail at any time from "neutral" to full power in either forward or reverse.

Safety is assured because the sailor can always neutralise the sail angle .

You only have to steer the boat and the sail works completely automatically just like a throttle control.

As fitted to the boat

This is a complete "Windthruster" unit and can be lifted off and fitted to any boat

Close up of "Throttle Control".

Push forward to go forward - pull back for reverse. No other sailing control is necessary

News from AYRS

October 2014 Newsletter from Fred Ball

I hope you have all had a good summer, I've been busy and managed to get a little sailing with my sons. I'm just back from Speedweek having had an enjoyable time and am hurriedly typing this to remind you of the Thorpe Meeting on Sunday 9th November at Thorpe Village Hall.

The full results of Speedweek are on www.speedsailing.com. Impressively the results were available each day very quickly after the course closed. I recommend a look at the website and go to their Facebook page and look at the videos, Tuesday was quite windy with gusts approaching 40 knots and some spectacular dismounts occurred!

Only three boats appear to have recorded speeds although another one was taking part.

Some of the results:-

Fastest Kiteboard

Benoit Gaudiot 36.441kts - a French 16 year old who cut chunks off his raceboard and was rewarded with an extra 6 knots!

Fastest Sailboard

Patrick Van Hoof 34.567

Amateur Sailboard

Tim Laws 30.945

Lady Sailboard

Tania Mertens 23.44

Boats

Katherine Knight 22.048
International Moth

Alan Blundell 21.441
Vari-Swift

Alec Powell 21.136

Next years event is 3 -9th Oct.

In September I visited the Southampton Boat Show which was extremely busy with lots of boats of all sizes on display; I was able to inspect three boats on the water and as usual felt they were designed for lounging around in a marina rather than for serious sailing , I did however find some that were practical to use; "Solent Whisper" a foiling beach cat designed by Southampton Solent University (photo below) with a take off speed of 5 knots was particularly interesting. LOA 6.2m Beam 2.4m All up weight 78kg main sail 12.6m^2 Jib 3m^2 Spinnaker 14m^2 www.solent.ac.uk/news/news-articles/2014/whats-the-whisper-about-whisper.aspx

The front foils have a trailing wand to control ride height of a "T" foil using a trailing flap , the horizontal part of which has a downturned end plate just about visible in the photo.

Another very practical boat was the Wheelyboat designed for use by disabled people, essentially a dory with a landing craft type bow to allow easy access by wheel chairusers, a nice level floor running the full length with a substantial drainage channel to keep the surface as dry as possible.

AWOL leaving the dock to go on the course. She was awarded the Ward Mug for innovation, Alec Powell has fitted a system to be able to adjust the angle of attack of the main foils using a hand operated dynamo and actuators normally used in large model aircraft. Stored energy is not allowed in Speedsailing.

AYRS North West UK Forum Meeting 13th December 2014

The meeting commenced at 12.30 pm prompt with six members and three of their wives enjoying a glass of wine and a delicious buffet lunch (thanks Col!).

A debrief took place, reflecting on the meetings and outings enjoyed by the members during 2014. The consensus was that we had established a nice balance between three or four meetings and two or three outings each year. Several members expressed how they had enjoyed the trip on the Paddle Steamer *Waverley*, but that it had been a long day. Although the outings are not expressly aimed at technology relevant to AYRS, lively discussions and the exchange of information always seems to occur.

In John Alldred's absence, Mike Howard presented the meeting with a photograph of John's latest creation using *Correx* fluted polypropylene sheet. It is in the form of a catamaran with a solid bridge deck. For the benefit of the members who had not attended the previous meeting, Mike Howard explained how he had come across the material on the Internet and 'sold' the idea to John who had gone out and bought several sheets of *Correx* to experiment with. Mike and John had had an ongoing discussion via e-mail on the merits of various adhesive systems, many of which John had trialled and documented.

A discussion took place on the various attempts that John had made to stick the material to itself. Mike Howard stated he had come to the conclusion that a large bond area coupled with a high strength *'No Nails'* type polyurethane adhesive together with strategically placed mechanical fasteners was the simplest solution. The two proponents of the use of this material for boat building were based in the USA where the philosophy was to produce a 'quick and dirty boat, use it for a season and then throw it in the dumpster.' However, here in the UK we tended to over engineer our boats to ensure their longevity.

Mike Howard stated that the best results had come from an adhesive which required a primer to be applied first. Adrian Denye commented that SIKOFLEX were now insisting that their recommended primer be used prior to the application of the adhesive as several failures had been experienced when it had not been applied properly. Mike Howard stated that in his opinion it was pointless investing in an adhesive system which cost twice the cost of the materials.

Colin McCowen demonstrated to the meeting how he had successfully converted a Canadian canoe with a sailing rig of his own design. Colin showed several photographs and explained his system. A single ama stretches across the main hull which supports a small emergency buoyancy float at each end. Below the float, a vertical aerofoil shaped permanent keel is suspended. The keel is provided with a 'fence' at both the top and bottom such that it has an I-shaped longitudinal cross section. The canoe has to be heeled five degrees to leeward to effect the full penetration of the keel. The sail rig is a custom made four square metre sprit rig. Colin went on to explain how he has enjoyed many hours of sailing on the upper reaches of the river Mersey near Warrington, while tuning his rig.

Other subjects covered during the meeting ranged from two eye witness accounts of instances of cars entering the water involuntarily and the difficulty their occupants found in escaping before the vehicles sank; to the development of modern yacht designs using computer software (Adrian Denye). This latter subject led to the fact being stated that the modern generation wants to procure the latest designs 'off the shelf' rather than develop them themselves with 'sticks and string' as our generation had done. This opinion, which was shared by the majority of members, rather reinforces the current situation where AYRS finds it exceedingly difficult to recruit younger members.

The final discussion was to what the AYRS North West Local Group might enjoy during 2015. As well as four quarterly meetings a visit to Ellesmere Port Boat Museum is planned for the Spring followed by a trip up the Manchester Ship Canal and another 'up the cut' canoe trip in the Summer.

The meeting concluded around five o'clock with a vote of thanks to Mike Howard for organising the AYRS North West Local Group, an act which was reciprocated by Mike Howard in thanking the members for their loyalty in attending the meetings on a regular basis.

AYRS North West UK Forum -Visit to the National Waterways Museum, Ellesmere Port.

The morning of Tuesday 17th February 2015 turned out to be bright and sunny with just a hint of a cold breeze coming off the river Mersey as a total of fourteen of us, AYRS members, wives, friends and colleagues, met in the car park of the National Waterways Museum at Ellesmere Port on the Wirral, Cheshire. On entering the reception area we were warmly greeted and having paid our Group Entrance Fee of £7.50 per person we were directed towards the café were we enjoyed a complimentary cup of tea/coffee accompanied by biscuits.

Our Tour Guide, Gaynor, introduced herself and led the party on a guided tour of the site which extends to seven acres and is the former port of the Shropshire Union Canal Carrying Company, where the canal entered the river Mersey. (It now enters the Manchester Ship Canal). An upper basin was used for the loading and discharge of narrow boats into and out of canal side warehouses, while a lower basin was used to exchange cargoes between narrow boats and sea going ships. Extensive stabling facilities together with workshops such as a smithy (still working) and other workshops associated with the repair and maintenance of canal narrow boats are set out to allow the visitor a glimpse into the past.

A diverse array of both narrow and broad beam canal boats including tugs and icebreakers, are held in the collection. Although there is an extensive fleet of fully restored boats on show, around the back of the former warehouses lie an equally large fleet of semi derelict, semi sunken boats awaiting their turn to be restored. The Heritage Boatyard is an intrinsic part of the museum and is run by a team of full time boatbuilders, apprentices and volunteers.

They recently won £790,300 from the Heritage Lottery Fund as well as £50,000 match funding from the Wolfson Fund to restore the Mersey Flat MOSSDALE. This seagoing ketch rigged vessel, built in 1860, is the last remaining flat constructed of timber. She is representative of thousands of similar vessels which traded around the coast from Aberystwyth in North Wales to the Solway Firth in Scotland.

On the conclusion of our tour of the site, we settled into a narrow boat which has been equipped with seating and a glazed cabin, and enjoyed a short tour up the canal towards Chester. A running commentary about the interaction of the canal with local industry revealed a few facts that even I, as a local, had not heard before. On the conclusion of the boat trip, which had taken about forty five minutes, we formed into small groups and enjoyed a variety of lunch time snacks in the café. For myself, I engaged in a discussion with John Alldred and John Shuttleworth about the use of CORREX as a boatbuilding material. After lunch the Group dissipated with most of them enjoying a further period looking around the museum.

I am sure that I speak for all the AYRS members who attended this first meeting of 2015 when I say it was very enjoyable and a welcome break in what tends to be a rather inactive period in the year.

Mike Howard

AYRS North West UK Forum — Meeting held on Saturday 14th March 2015

Mike Howard opened the meeting by welcoming three of the members, to what was the first meeting of 2015 and the start of the sixth year of the North West Local Group. Apologies for absence had been received from Roy Anderson, Adrian Denye, Peter Gilchrist and John Morley. Mike Howard explained that John Morley's health now precluded him from attending further meetings. However, he was still actively pursuing his Tethered Kite Sail Rig using a radio controlled scale model which was currently under construction by one of the members of the Southport Model Boat Club.

After some initial thoughts on the future programme for the Group the conversation turned to John Alldred's FLIP FLOP. John showed a short video of his radio controlled model working in a three metre long test tank which he has constructed. John then demonstrated his latest incarnation by presenting the scale model itself for scrutiny. This comprises a canoe body constructed of 2mm thick Correx sheet with a long horizontal fin suspended under the centre of the boat, with its operating mechanism coming up and fixed to each gunwhale. The chord length is approximately a fifth of the length of the fin. John stated that immersing the fin deeper in the water and positioning it amidships had eliminated the fore and aft pitching he had experienced with previous models and his full size prototype.

John Shuttleworth was looking at a practical Yuloh for a small boat. John then showed the members a YouTube video of an elongated vertical blade type Yuloh (Powerfin test by Mr Kozakai and other videos) and Mike Howard pointed the Group to Paul Elkins uPVC tube version of a similar device (www.elkinsdiy.com - boats - Coroplast fin boat). After viewing several Yuloh videos on YouTube the members came to the conclusion that a true Yuloh tended to be more efficient on heavy displacement craft and that if used on small lightweight craft the Yuloh action tended to 'wriggle' the stern athwartships. Mike Howard pointed out that a number of articles had appeared in previous edition of CATALYST (Iss. 34 - April 2009) and that he had used the information to draft out a Yuloh for a three metre long dinghy. The Yuloh had finished up about one and a half times longer than the dinghy!

After tea and home made Banana Cake (thanks Col) the conversation moved on to small boats constructed from CORREX. John Alldred explained the difficulty he had experienced scoring and folding 3050 mm x 1524 mm x 8 mm sheets. He eventually achieved the fold lines by routering out the skin on the inside of the fold. He had produced a 3.0 metre by 1,5 metre catamaran using three such sheets. This had produced a very lightweight craft but due to its volume it was very cumbersome to manhandle. Mike Howard stated he believed that composite construction utilising plywood transoms and strip wood chine logs and gunwhales secured with building construction adhesive and self tapping screws with washer heads was the way he intended to proceed.

Mike Howard had mentioned in a previous conversation how he had had a dinghy kit of parts routered from standard sheets of plywood and John Alldred stated he had approached a local company to see if he could get the Correx sheets routered out on a CNC controlled machine. However the company stated they could only router solid materials and that Correx sheets tended to slip when routered. John told the group, on a recent visit to his daughter in Australia, he had access to a slipway a few yards from her home. He had endeavoured to purchase a battery powered router so he could build a Correx canoe. His search had proved fruitless until the final day of his holiday when he discovered such a tool in the Australian version of B & Q!

A discussion took place on the legal requirements for the use of a manually propelled vessel on the waters controlled by the Canal & River Trust. John Shuttleworth stated that he is a member of Canoe England (formerly British Canoe Union) and his annual fee of £42 gives him the right to use 4200 miles of canals and rivers while also providing him with the required Third Party Insurance. Mike Howard stated that he believed that having the necessary Third Party Insurance was the only requirement and that his Enterprise Dinghy insurance included this cover, while Brian Shenstone stated that his Home Contents Insurance covered him against Third Party claims while using his canoe.

The meeting broke up around five o'clock.

It is refreshing to see how the North West Local Group grows in strength with at least three individuals actively involved in developing their own projects with active interaction from the other members.

Mike Howard

AYRS Devon Meeting held at Wembury, Saturday 11th April 2015

Nine people attended the AYRS Devon meeting held at Wembury near Plymouth. I think it must have been a good meeting since the chat about boats started when the first people arrived at about noon on the Saturday and continued until after midnight. At that point people realised it was bedtime since we had been invited to come for a short trip on Michael Ellison's catamaran in the morning and that required a reasonably early start.

During the afternoon we discussed the recent changes that have been made to the 35th America's Cup event (AC35) and Charles Magnan showed us pictures of the trimaran he is building from re- cycled Tornado catamaran parts.

The main hull of Charles's trimaran is a Tornado hull split down the centreline and both widened and lengthened to allow basic cruising accommodation, the floats are two further Tornado hulls. The new parts are being built in Corecell foam with epoxy glass skins and the deck and superstructure of the main hull will be done the same way. Charles is making good and steady progress despite having to do much of the work in the open air in a sailing club dinghy park.

As for the America's cup, I think we were all surprised to hear of the decision to race in 48 foot catamarans (the AC48 class) rather than 62 foot ones. Current information is that these much smaller boats are to be largely one-design. The defending Oracle team will stipulate the basic design of the wing rig, the cross beams and the main features of the hulls, leaving some scope for innovation in the details of the hydrofoils and things like steering and ergonomics. The relatively open nature of the 'box' rule used for the last cup lead to some of the most exciting advances in sailing technology in all history, so perhaps it is disappointing that this advance is now likely to be slowed if not curtailed. Having said that, the AC48 can be expected to be a very fast boat, quite possibly reaching straight line speeds at least equal to those achieved by the AC72 class at the last cup or that would have been achieved by the AC62, but probably with better manoeuvrability. The main reason to go to a smaller boat was to reduce costs in order to encourage more teams to compete. However, team Luna Rossa, one of the most experienced teams, has already decided to walk away having spent millions of dollars on the initial development work for an AC62, money now wasted. If you believe some of the commentaries on the internet, law suits may follow. One can't help thinking that there is one team that will be happy - Ben Ainslie is rather good at racing smaller one design sail boats!

After some refreshments we continued with Simon Tytherleigh's presentation on the fine 10m LOA catamaran 'Nellinui' that he has built with the assistance of Andi Bartram who was also at the meeting. It is based on a design by American yacht designer Kurt Hughes but with modifications by Simon to improve the aesthetics and provide a much more practical interior. At a previous AYRS Devon meeting Simon showed us pictures from the building of this catamaran, this time he was able to give us more detail about certain aspects of the construction as well as the sailing that he and Andi have done since launching the boat, this including a trip to the Scilly islands.

Figure 1 - Nellinui being launched into the river Dart at Totness – July 2013

In the early stages of building Nellinui the forming of compound curvature hull panels as a double layer of thin plywood sheets caused a lot of difficulty with voids forming between the two plywood layers even though they had been vacuum bagged together. These voids were only detected once inner layers of end grain balsa and fibreglass had been added and the external hull fairing completed. Rectification required routing out the top layer of ply over quite large areas then scarfing and vacuum bagging new plywood and re-fairing the hull.

Figure 2 - Trying the sliding rigger row boat on Chichester harbour

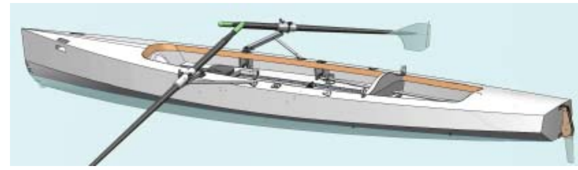


Figure 3 - Proposed rowboat, configured to carry a passenger

The rotating wing mast was made by laying up unidirectional carbon over an armature constructed mainly from plywood of about 1.5mm thickness. This plywood inner structure was in effect a male mould that remained in place after the carbon had been laminated. Andy once worked at a firm that made wooden rowing eights and this experience was useful for making this mast which required long scarf joints in the very thin plywood.

Another irritating problem that continued for some time after the boat was first launched was the sealing of the cabin windows. A double sided foam cored adhesive tape (3M VHB tape) proved to be better than the original design but slight leakage still occurred at the bottom of a couple of the most steeply sloping windows. The cure was inspired by car door windows - these have a slight leakage but it drains into the cavity in the door then to the exterior, not into the car. For the catamaran, tiny drain holes were drilled below each window, these draining the small space between the back of the glazing and the outer surface of the window mounting flange, this has cured the problem.

I followed on from Simon's presentation with a description of the rowing boat that I have just started to build. For some years Josephine and myself have thought that it would be nice to have a lightweight boat that we could use from our local beach in fine weather, there is no vehicle access to the beach so it would be necessary to wheel it down a footpath on a trolley. Then in 2013 I had the opportunity to try a rowing boat with moving rowlocks (a 'sliding rigger' arrangement as opposed to the more usual sliding seat arrangement). This was a prototype made by a boat builder but I don't think it became a production boat and a friend of ours acquired the prototype, so I was able to take it for a row on Chichester harbour. I liked this boat but we felt that we would prefer a boat that could be rowed either by a single rower or by a rower and a passenger and that could also carry its own launch trolley and some camping equipment. Being able to take a second person as a passenger should allow longer river trips taking it in turns to row whereas two people rowing together would only tire out both at the same time. We wanted to limit the length for ease of carrying on a car roof rack and this made it difficult to include the sliding rigger with a passenger so the resulting design is intended to be a sliding seat boat with a passenger or with just one person it can be either a sliding rigger arrangement or a sliding seat arrangement.

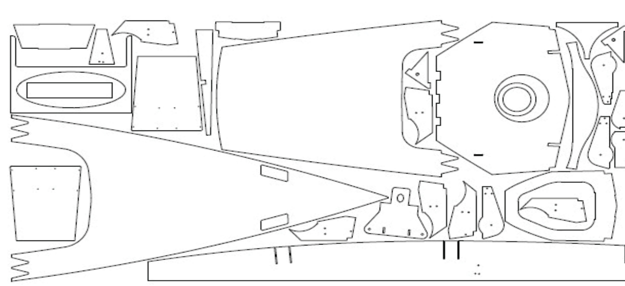


Figure 4 - Example of automatic 'nesting' of plywood parts for cutting from a standard size sheet

It will be interesting to compare these options in the same boat.

I have drawn the row boat and produced computer files to cut out all the parts from four and a bit sheets of plywood and I hope to get this done by a firm that has computer controlled cutting equipment. I have also fabricated most of the metalwork using the basic lath and milling machine in my small home workshop but I haven't yet had the plywood cut or started any woodwork. We have recently been wondering whether we should make it possible for the two of us to spend a night on board this boat, as we can do with our other open boat - a good example of 'mission creep'! I think the only way to do this would be end to end berths, that would be a re-design and perhaps I should just get on and build the boat as currently drawn - 'mission creep' has caused the death of many projects!

There was some interest in computer aided design and I was asked if I could make the boat drawing software that I produced

Figure 5 The OOPS assembled in our hallway

years ago available to the public. I don't really want to do this since the software is dated now, it stems from some basic Fortran algorithms that I produced right back in 1976. It has been updated since then and the code is now in C++ using OpenGL graphics and a Windows user interface that works under Windows XP but I am not sure about Windows 7 and onwards and I don't think the help file format that I used is still supported. To get the software right up to date and to make it properly verified and crash proof would require a lot of work and I have other projects in mind. In any case, I feel that there is less need for specialist boat design programs now that general purpose 3D drawing programs are much more advanced and in some cases can even do things like working out the hydrostatic properties of a boat hull as well as doing more general purpose drawing work.

Robin Gray next told us about the boat building and sailing he did quite a few decades ago while he lived in Malawi. Robins work as a civil engineer was supervising significant civil engineering projects including hydroelectric dams and road building but in his spare time he built first a Mirror dinghy and then a 24 foot cruising yacht. He sailed these boats on Lake Malawi which is a big lake, 350 miles long and up to 47 miles wide. It is also up to 2300 feet deep, so my guess is that it holds more water than the English Channel. It can also be a stormy lake, Robin said that on one occasion the crew of a cargo ship operating on the lake tried to save time by opening the cargo hatches while still approaching the jetty for unloading. It was rough weather and the ship swamped through the hatches and sank. Not surprisingly Robin had difficulty acquiring marine plywood, good adhesives and yacht fittings out in Africa and so his yacht was simply fitted out with minimum gadgetry and no electronics but from the pictures he showed us it looked to be a fine craft. The sailing pictures certainly looked idyllic, showing Robin and Diana sailing the warm waters of the lake with gentle breezes and clear blue sky - it's not always like that on Plymouth Sound where Robin now sails a Flying 15 keelboat.

Mark Tingley arrived late at the meeting, due to matters outside his control. So while the intention had been to assemble Mark's Opposed Oscillating Propulsion System (OOPS) on Saturday afternoon this had to be done with limited time available late in the evening. This system may be detailed elsewhere in AYRS publications but briefly the idea is to have eight vertical paddles moving back and forth through the water, their oscillating motion being perpendicular to the boat centreline. The paddles are mounted on rods that are designed to be flexible in torsion so that as the paddles move through the water they take up an angle of attack to provide a propulsion force. I was a bit taken aback by the size of this equipment - it measures about 5m across and assembled in our hallway there was little space left to work alongside it. Although it was now late in the evening, Mark, helped by Robin, worked hard to get it all together and at around midnight we were able to watch a couple of oscillations of the paddles with the system manually powered. This early test did show up a few problems. For example,

Figure 6 – Michael (left), Josephine and Charles on board 'Teepee'

the system is driven through long flat belts that run over wooden pulleys and the belts kept coming off these pulleys but that seemed to be because in the rushed assembly the pulleys had not been properly aligned, so that should be easily corrected. The plan is that this device will be fitted to the approximately 8 foot long dinghy that has been built by Fred and Slade and it will be powered by a cordless electric drill(s) in order to compete in the Cordless Canoe Challenge at this years Beale Park Boat Show. Mark has done a lot of work to construct this system but, as I am sure he knows, there looks to be plenty still to be done before the system can be ready for the Cordless Canoe Challenge.

On Sunday morning Michael Ellison brought his Iroquois cruising catamaran 'Teepee' across the Tamar to the tiny harbour at Mutton Cove which was convenient for five of us to join him for a quick trip up the Tamar and back. We broad reached up river with Devonport dockside to starboard, then passed under Brunel's famous railway bridge and a little further up the river before turning to tack back to Mutton Cove. It was a nice little outing and a useful start of season shake down for Teepee.

My thanks to those who made this meeting a success by telling us about their projects. The fact that three of the nine present were prepared to travel all the way from the London area suggests that there is still strong enthusiasm from the few who do attend AYRS meetings, but I do wonder what we could do to encourage more interest from other AYRS members in the south west of the country.

John Perry

Not Rowing

(Copy of an email to Mike Bedwell dated 03 February 2015)

I was interested to read your article on human powered craft and pleased to be using one which is not on your list, the Hobie Adventure Island trimaran: http://hobiekayak.co.uk/index.php?route=product/product&path=17&product_id=42 powered by the Mirage Drive: https://www.google.co.uk/webhp?sourceid=chrome-instant&ion=1&espvwww.youtube.com/watch?v=lD6OQhCeXqs.

Being an AYRS member, I have naturally customised my tiny tri (compared to my previous boats) by adding a roller furling jib (ex mirror), having barber haulers on both jib and main, adding sitting out boards and modifying the steering from the stupid little lever to a circuitous piece of string to enable me to steer from any position and to give me plenty of strings to play with.

I used to think that I had to spend lots of time modifying and maintaining my previous boats because they were big. I now realise that I can spend almost as much time on this tiny craft and also have just as much fun!

Because you are nearer the water, the speeds all seem higher but the great advantage compared to all the others is that I can `motor-sail' by pedalling thus keeping warm and active in all weathers. The roller reefing means that I can instantly reduce sail without leaving my seat and the small size means I can keep it ashore and take it to other venues.

However I keep it at Dalgety Bay 5 miles away and so I can be out on the Forth about 30 minutes after leaving the house and then sail across to Cramond and up the river Almond.

Curly Mills.

Catalyst Calendar

This is a free listing of events organised by AYRS and others. Please send details of events for possible inclusion by post to Catalyst, BCM AYRS, London WC1N 3XX, UK, or email to **Catalyst@ayrs.org**

May 2015

22nd– 25th Broad Horizons 2015 AYRS Sailing Meeting, Norfolk, UK
Barton Turf Adventure Centre, Norfolk UK, NR12 8AZ. Note: All boats limited to 1.2 metre max draft! Everyone welcome, overnight accommodation can be arranged. Possibility of a wingsail-building workshop if enough interest. See www.ayrs.org/Broad_Horizons.htm, or contact AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; email: office@ayrs.org.

June 2015

5th -7th Beale Park Boat Show
As usual we will have a stand and would appreciate small exhibits and display material and of course offers of help to run the stand. Contact: AYRS Secretary, email office@ayrs.org

13th @ 2.00 pm AYRS North West UK Area Forum meeting
Contact: Mike Howard, email: ecotraction@aol.com

August 2015

4th (provisional) Paddle up the Cut (AYRS North West UK Area Forum)
A gentle paddle up the Chester Branch of the Shropshire Union Canal with lunch at the Cheshire Cat. For times and meeting place, contact: Mike Howard, email: ecotraction@aol.com

September 2015

11th - 20th Southampton Boat Show
AYRS will not be exhibiting but we want opinion as to whether we should (see London in Jan)

12th @ 2.00 pm AYRS North West UK Area Forum meeting
Contact: Mike Howard, email: ecotraction@aol.com

October 2015

3rd-9th Weymouth Speedweek
Portland and Weymouth Sailing Academy, Portland Harbour, Dorset UK. See www.speedsailing.com

7th "Speedsailing" AYRS Weymouth meeting
19.30 for 20.00hrs, Weymouth Sailing Club, Nothe Parade (near Brewers Quay), Weymouth, Dorset DT4 8TX. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX. Check the AYRS website before going just in case the location changes (unlikely)!
Note: the approach road is single track for about 100 yards, and much of the local parking reserved for residents; the parking at the Council Offices is free after 6.00pm and about 300 yards walk away.

November 2015

1st AYRS London Area meeting
9.30am to 5pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, near Staines & Chertsey Bring your lunch - tea and coffee available. Donations invited to pay for the hall. Details from Fred Ball, tel: +44 1344 843690; email fredball@ayrs.org.

December 2015

12th @ 12.30 pm AYRS North West UK Area Forum Winter Meeting
Including Buffet Lunch. Meeting Point TBA. Contact: Mike Howard, email: ecotraction@aol.com

January 2016

8th – 17th London International Boat Show
EXCEL Exhibition Centre, London Docklands. AYRS may not be there, we may go to Southampton 2016 instead, and any member visiting either exhibition is welcome to offer an opinion. Please contact the Hon Secretary email office@ayrs.org

24th All-Day AYRS Meeting
9.30am-4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey – follow signs to Thorpe Park, then to the village). Tea and coffee available but bring your own lunch. Donations invited to pay for hall. Details from Fred Ball, tel: +44 1344 843690; email: fredball@ayrs.org.

24th AYRS Annual General Meeting
4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (as above). Agenda etc will be posted on the website http://www.ayrs.org
Note: Items to be formally considered by the AGM, including nominations for the Committee MUST be received by the AYRS Secretary before 24th December 2015 (post to AYRS, BCM AYRS, London WC1N 3XX, UK, or email: secretary@ayrs.org)

Catalyst — *a person or thing acting as a stimulus in bringing about or hastening a result*

On the Horizon . . .

Development of a Foiling Laser

Hydrofoil catamaran *Vampire*

Tethered Kite Sail

Wingsail Workshop report

More sources and resources: reviews, publications and Internet sites

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