Catalyst

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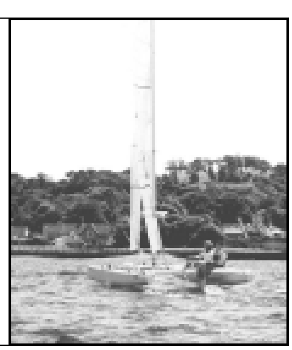
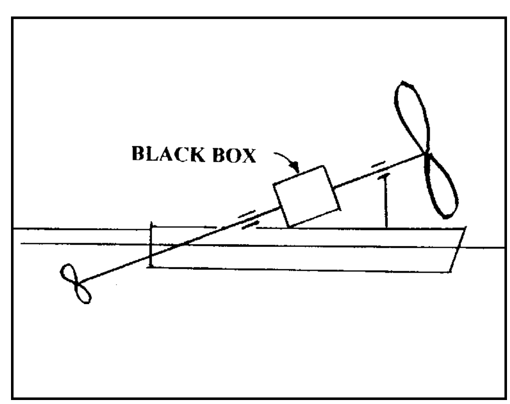


George & Joddy Chapman's catamaran hydrofoil Ceres

Photo: by courtesy of George Chapman



Catalyst

Journal of the
Amateur Yacht Research Society

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Another year

As I write this, the rain is slating down outside, and the winds are starting to blow. I had an email yesterday from someone in USA who says the temperature has dipped below freezing. For us in the Northern hemisphere, the winter is coming, and the sailing season is drawing to a close. It's time to put the boats away, and reflect on what has been and start to plan what to try next year. Maybe that should include a letter or an article for Catalyst telling what has been done and trying out ideas for the future. We look forward to hearing from you.

Maybe you should think about getting together with a few other AYRS members in your region and spending a few evenings or even a weekend of discussion. AYRS members in and around London have done this for many years. OK, that might be helped by having the AYRS' office relatively close by (although it was not always so); but the AYRS' office cannot organise everything, although they can certainly help with advice, experience and contacts. Once there were regular meetings in the USA, but the people who organised them have moved on. Could you do something?

For those in the Southern hemisphere meanwhile, their winter is over and they can look forward to longer days and more evenings on the water after work (if they are lucky enough to be so positioned). Time to try out the ideas that have been germinating over the past few months. Some of those ideas we have in this issue. Ian Smith has been steadily developing a line of proas and catamarans towards a safe, easily handled, family sailboat. We have a report here on his work. I know of other things happenning in the South, a new line of proas under construction for example. I hope we will have something on them in the future.

An Expanded Team

Sharp-eyed readers will have already seen that the number of names on the masthead has increased. The existing editorial team has been joined by Owen Llewelyn, Ignacio Oliva-Velez and Peter Westwood. Owen is at Southampton University, UK, Ignacio is a designer, and has editing skills already put to use in this edition, and Peter is an engineer and technical author and has his own small printing business. You can expect that they will become more and more involved in Catalyst, and improving the production of specialised booklets.

Simon Fishwick

Weymouth Speed Week 2002

Weymouth Speedweek this year was plagued by light winds. In fact throughout the whole week the recorded mean wind seldom got above 16 knots. In these light conditions, boards did not really have a chance to speeds of any magnitude, and in fact only nine boardsailors were not dissuaded by the weather forecasts and turned up.

The week therefore belonged to the boats, but even these had difficulty in the light conditions. Outstanding performer of the week however was Joddy Chapman in his catamaran hydrofoil ***Ceres***. Joddy recorded the fastest speed of the day on all days but two, reaching a peak of 19.5 knots on 29th September, the only day when the wind blew with any force; but on this day he was beaten by the boardsailors, the fastest of which (Pete Martin) recorded the highest speed of the week at 23 knots.

Looking at a plot of speed against mean windspeed ***[unfortunately this graph is too complex to reproduce here - Ed]*** it is clear that Ceres is capable of getting close to a speed of 18-20 knots in any wind of more than about 10 knots, but it is equally clear that her maximum speed under almost any wind is unlikely to be much more than about 22 knots. Board sailors only start to come into their own in winds of more than about 12 knots, when the best of them can sail at 17 knots or more, but at anything less than that they are unable to get on the plane, and have difficulty going at more than 5 knots. In terms of speed/windspeed ratios, ***Ceres*** was consistently performing at 1.25 or above, the boards, once they got going, were doing better yet, but few of the unfoiled boats were performing at better than windspeed.

It would be interesting to know the performance that ***Ceres*** could record were the foils to be optimised for takeoff in windspeeds of 16-20 knots instead of the present lower range.

Entrants 2002

	No	Name	Description of Craft
Boats (b)			
	141	Joddy Chapman	Ceres - Hydrofoil Catamaran
	458	Bob Date	Flash Back - Dart Catamaran with Hydrofoils
	99	Philip Middleton	Trimaran
	508	John Peperell	Twin Rigged Trimaran version of a Catapult
	66	Slade Penoyre	Catapult with Naish Kite Sail
Sailboards (w)			
	8	Les Paley	JP 160 - 130, 106 Neil Pryde V8 9.4 - 5.2
	9	Mike Pearce	
	124	Richard Trubger	Gaastra F1 6.6m2 - Trubger Special 36cm Fin
	181	Pete Martin	
	27	Trevor Whatford	
	213	Richard Jones	Thommen 270, Haleaka 278, Gaastra Sails, Northshore Fins
	90	Andrew Ramshaw	269 F2 Slalom, 290 Kinetic, Gaastra Sails, Northshore Fins
	171	Sean Carroll	
	53	Richard Holgate	

Weymouth Speedweek Results

28 September 2002

First day sailing with light winds of around 10 knots. Hydrofoils reign supreme - Ceres records 17+ knots. A 518 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	17.10	b Joddy Chapman	21	141
2	11.19	b John Peperell	28	508
3	10.15	b Philip Middleton	16	99
4	5.94	w Trevor Whatford	6	27
5	4.76	w Sean Carroll	4	171
6	4.71	w Richard Holgate	5	53
7	4.47	w Les Paley	6	8

Total number of runs = 86

29 September 2002

Windspeeds were around 12-15 knots the fastest boat speed was just shy of 20 knots (Ceres Hydrofoil) and the fastest board was 23 knots. A 14 foot skiff tried two runs and achieved 15 knots. A 510 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	23.08	w Pete Martin	14	181
2	20.81	w Richard Holgate	7	53
3	20.25	w Mike Pearce	12	9
4	19.57	w Trevor Whatford	13	27
5	19.53	b Joddy Chapman	6	141
6	19.08	w Sean Carroll	2	171
7	18.78	w Les Paley	5	8
8	14.99	14 Foot Skiff	2	75
9	14.78	b Philip Middleton	25	99
10	14.58	b Richard Jones	5	96
11	14.05	b Bob Date	21	458
12	13.55	b John Peperell	12	508
13	13.50	w Roger Crabb	1	88
14	10.40	w Richard Trubger	1	124
15	7.94	kite boat Slade and Ge	4	66
16	2.83	b Richard Pemberton	1	777

Total number of runs = 131

30 September 2002

Very light winds in the morning dropping to virtually nothing mid afternoon. A 542 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	18.46	w Richard Holgate	6	53
2	18.34	b Joddy Chapman	11	141
3	17.55	w Nick Povey	6	111
4	12.14	b John Peperell	6	508
5	11.95	b Bob Date	8	458
6	9.71	b Philip Middleton	11	99
7	4.32	b Richard Pemberton	2	777

Total number of runs = 50

1 October 2002

Southerly wind of 5-10 knots, overcast with prolonged showers. Not speed sailing weather! Despite this Joddy Chapman put in a superb set of times on Ceres the foil borne catamaran. A 529 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	17.69	b Joddy Chapman	21	141
2	10.30	b Bob Date	5	458
3	7.11	b Philip Middleton	8	99
4	6.49	w Trevor Whatford	4	27
5	2.22	b Richard Pemberton	1	777

Total number of runs = 39

2 October 2002

Very little wind but a very good day for discussions and testing. Memorable for George Reekie holding onto a 23 m2 kite whilst on Slade Penoyre's catapult. A 500 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	13.42	b Joddy Chapman	9	141
2	8.68	b Bob Date	15	458
3	8.16	b Fred Ball	17	10
4	7.24	kite boat Slade	2	66
5	6.88	b Philip Middleton	8	99
6	6.08	w Trevor Whatford	10	27
7	5.22	w Richard Holgate	7	53
8	4.57	w Pete Martin	1	181
9	4.43	w Mike Pearce	1	9

Total number of runs = 70

3 October 2002

A 500 metre course between boats in the harbour was used.

RANK	SPEED	NAME	RUNS	SAIL No.
1	16.92	b Joddy Chapman	27	141
2	14.69	w Nick Povey	10	111
3	11.46	b Bob Date	14	458
4	10.52	b Philip Middleton	11	99
5	8.36	w Richard Holgate	6	53
6	6.97	w Trevor Whatford	9	27

Total number of runs = 77

4 October 2002

Report not available at time of going to press.

WEYMOUTH SPEEDWEEK WEDNESDAY EVENING SEMINAR

2nd Oct 2002.

John Perry

Pemberton, Evans, Rogers & Stebbing

Weymouth Speedweek is an annual sailing event with speed trials for sail boards, multihulls and all types of experimental craft. For the 2002 event we had exceptionally light winds throughout the week and this was presumably the reason why few sail boarders attended. Those sail boards which did make timed runs discovered that for the first time in years they were not always the fastest craft under sail. As usual Michael Ellison chaired a meeting on the Wednesday evening at which a number of entrants briefly outlined their projects. My notes on this meeting are as follows:

SLADE PENOYRE

Slade continues to work towards his ultimate aim to revolutionise sailing by using a kite and hapa combination to fly the hull(s) of an ocean going craft clear of the sea. A hapa is a wing, or hydrofoil, towed underwater to generate a force in the towing line which resists leeway and can also reduce or eliminate heeling under sail. Slade showed us his latest hapa prototype which was made up from dinghy mast spreader extrusion, broom sticks and sailboard skegs. Despite being a fairly crudely constructed prototype it had functioned satisfactorily when towed by a motor boat at up to ten knots. Slade is now sufficiently convinced that hapas can be practical devices that he has chosen to concentrate for the time being on the air side of the system. To this end he has acquired three kites of the type manufactured for kite boarding and whenever the breeze was strong enough he was practising flying these kites from the shore or from one of his two catapult catamarans, the second catamaran being fitted with a 15hp outboard motor for use as a support/rescue vessel. Slade also mentioned the possible use of kites as emergency propulsion for broken down motor boats or for liferafts.

Triton's Chariot

ROBERT NEVITT

Robert races advanced radio controlled model multihulls and he took this opportunity to tell us about the British Model Multihull Association (BMMA). This group races two classes of models, both being restricted design classes limited by dimensional constraints. One class has limits of 1.2m by 1.2m plan area with up to 0.9m^2 sail area, the second larger class has limits of 2m by 2m plan area with a 2.8m maximum mast height. Robert brought an example of the larger class to Speed Week this being a trimaran with three equal length hulls, from a distance you could almost mistake it for a full size 60 foot racing trimaran. This speedy model actually made a run down the speed course steered from a support boat and recorded about 6 knots which was a better speed than many of the full size entrants managed that day. AYRS members have often built models to test new concepts and Robert suggested that anyone thinking of doing this might well like to contact the BMMA. The BMMA membership can offer a wealth of experience in making the miniature electric winches and other bits and pieces needed for effective radio control of a sailing model.

GEORGE RICCI

George travelled from the States to attend Speed Week for the first time this year having seen details on the Internet. About a year ago he acquired an interest in speed sailing and his initial thoughts centred on rigid wing kites. Having spent several days at this SpeedWeek assisting Slade with kite flying he now recognised the potential of commercially available soft wing kites with inflatable stiffening spars and perhaps he will make these a starting point for a future project. George (who is really Australian) rounded off by picking up a broken carbon fibre sailboard mast and using it in the manner of a didgeridoo to raise a great round of applause. It was an accomplished performance, I don't think it could have been the first time he had tried this trick.

CHRIS EVANS

Last year I happened to be on board Chris' 24ft trimaran ***Triton's Chariot*** when it nose dived into the seabed wrecking the lee float and damaging other parts of the structure. As promised Chris has now rebuilt the craft as good as new with larger floats with flotation raised to 260% of total craft weight. The surface piercing inclined hydrofoils which had been mounted below the main cross beam have been removed and replaced by smaller inclined dagger board foils mounted in trunkings fairly far forward in each float. The photograph (top) shows the new float design.

Chris explained that the original craft had been slightly disappointing as a pure speed sailer but with this round of modifications it had been converted into a practical and exciting day sailing boat and that will be its future role. Meanwhile Chris is working on a project to build a series of smaller day sailing trimarans which he terms 'canoemarans' and to follow that he has some ideas for a pure speed sailing craft.

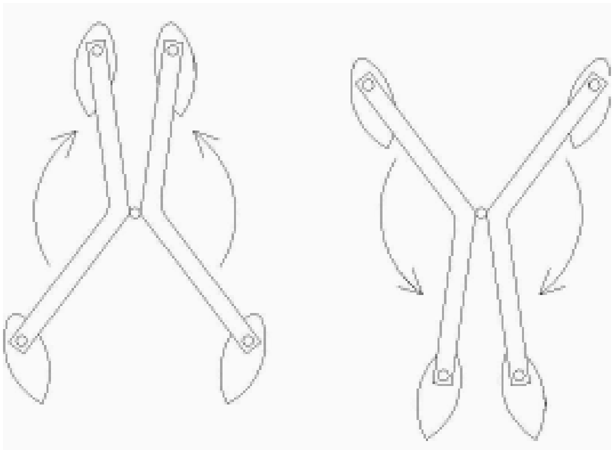
RICHARD PEMBERTON

We were pleased to welcome a new speed sailing team to Weymouth this year. Richard acted as spokesman, other members are Mark Evans, Ben Rogers and Martin Stebbing. All are post graduate students at Southampton University but it is not a University team as such. The craft they have built and which is in the early stages of testing is shown in the photograph ***[page 5]***. The main hull is from a Dart catamaran and the cross beam is a section from a broken Mumm 30 carbon fibre mast. Just visible in the photograph are the inclined surface piercing hydrofoils which fold down from under the cross beam. As one might expect there is an inverted steering tee foil at the stern. The hydrofoils are nicely made in female moulds using expanding epoxy foam to consolidate the carbon fibre skin and provide a core. The team was pleased that at this Speed Week they were able to tow the craft behind a motor boat to lift it onto the foils for the first time. Stonger winds would be needed to achieve this under sail.

BOB DATE - BRISTOL SPEED SAILING TEAM

Bob Date spoke for the BSST and as on previous occasions his talk was so packed with jokes, covering the spectrum from pink to blue tinted, that he had no time to include any technical content whatsoever. Hence I will have to base these brief notes on some interesting bits of BSST hardware that I could see and photograph on the slipway. The grey objects in the photograph (below) are some nicely constructed hydrofoil/float assemblies, showing a clear resemblance to certain parts of the Longshot/ Trifoiler design. We will have to wait to see how these are to be deployed on the water. The second photograph is a land sailer of a rather amusing design. Although not a likely contender for any land sailing speed records it did sail gently around the car park in a light breeze. The really interesting feature of this land yacht is the lightweight carbon fibre ribs in the rigid wing sail, as photograph below. These ribs are precisely made frameworks of carbon struts each thinner than a toothpick. Johnie Smith of BSST designed and made the computer controlled machine which automatically manufactured these structures from a spool of carbon tow. One immediately starts to wonder what other items might be produced by such a machine.

MARK TINGLEY



Mark has postponed his plans to build a small cruising trimaran until such time as he can acquire suitable workshop space. In the meantime he has been thinking about a somewhat offbeat project and has got as far as trying out a possible construction system using plastic foam and brown parcel tape. The sketches above show the idea in plan view. The teardrop shapes are hydrofoils which are of large enough cross section to be buoyant in the water and to float the weight of the craft. The little circles are vertical axis pivots. The rider (not shown) sits on top of the craft and 'rows' with levers which operate a suitable mechanism (not shown) to oscillate the craft between the two configurations shown in the sketches. Clearly this will cause the hydrofoil shaped floats to swim though the water making the craft move forward (i.e. towards the top of the page). A pure fun project and perhaps an exercise machine to encourage over stressed executives to get out of their stuffy gyms and onto the water.

JOHN PERRY

I tried to make the point that yacht research does not have to be focused on sailing faster. There must still be scope for amateurs to improve the comfort and/or seaworthiness of cruising boats or to reduce the cost of sailing. Such improvements are likely to be improvements in detailed design rather than whole new concepts but this is still development work and should be relevant to AYRS objectives. As an example I discussed a 15 foot sailing dinghy which I designed and built more than twenty years ago and which has a number of unusual design features intended to improve its suitability for cruising using a tent suspended from the boom for overnight accommodation. Immediately prior to this Speed Week Josephine and I completed one of the best of many cruises we have made with this boat, sailing from Portland harbour southward as far as the river Villaine in North Biscay. We had a wonderful time helped by exceptionally good weather (good weather for dinghy cruising that is - mostly very bad weather for speed sailing). At the end of the trip we ran out of time to sail all the way back so on reaching Brest at the western extremity of France we returned with the boat on a car ferry. This was not as satisfying as sailing all the way but it does show the versatility of this kind of small cruising boat. If I built another boat of this type I could make some further design improvement and I am sure that there is scope for others to do so also.

JODDY CHAPMAN

Joddy brought to this Speed Week the hydrofoil sailing catamaran Ceres which is the culmination of years, decades even, of painstaking development by Joddy and his father George. This craft is now finely tuned and it completely dominated the results of the speed trials this year, taking the trophy for fastest boat on every single day that trials were held and proving to be faster than other catamarans and even sail boards in the light winds of this week. The general concept of this hydrofoil will be familiar to readers of AYRS publications. In brief it is a catamaran sloop with retractable inverted tee hydrofoils mounted under each hull near to the main cross beam and a steerable inverted tee hydrofoil supported from a cross beam right aft. The hydrofoils under the hulls have lifting sections which are pivoted on horizontal axles to give variable incidence which is controlled though a complicated looking linkage by mechanical 'feelers' mounted forwards on each hull and sensing the height of each hull above the water. These feelers are quite tiny by comparison with, for example, the surface sensors on the Longshot/ Trifoiler design, they consist of just a length of something like 10mm square aluminium extrusion immersed only at the tip and yet these accurately control the main lifting foils.

I had the opportunity to sail on Ceres one afternoon. We motored away from the slipway using the auxiliary engine which is a specially made outboard motor based on a garden strimmer engine and which is probably lighter than any outboard you could buy off the shelf. While in shallow water the hydrofoils were retracted to a few inches below the hulls and the boat was steered with a conventional kick up rudder. Once we were well out into deep water the sails were hoisted then the engine was switched off and packed away in a little canvas bag. The boat lay quietly hove to with the tall narrow jib backed while Joddy lowered the hydrofoils, retracted the conventional rudder and switched on the custom made electronic system which data logs boat speed, apparent wind speed and apparent wind angle. Soon we were sailing at a good pace close hauled in non-hydrofoil mode. Joddy was not quite sure that we had enough wind to go foilborne, the true wind was somewhat below 10 knots. To try it he first operated the control to set the windward foil to lift and the craft immediately tilted over as the windward hull came up and the boat speed and apparent wind speed climbed a little. Then on switching the leeward foil to lift the craft returned to practically dead level as the windward hull rose. The sound and vibration of little waves slapping on the hulls disappeared to be replaced by a smooth almost silent ride, there was just a slight whistling noise from the hydrofoils. As we gradually bore away to about 100 degrees off the true wind the boat speed climbed to 16 knots with no noticeable change in apparent wind angle and hence no need to make any adjustment to the sails. Indeed it struck me that there was no need for the crew to do anything much on this boat, the hydrofoil system automatically keeps the boat on the level so you don't have to bother with moving crew weight around to fine trim the boat. You do move across the boat when tacking but there is no need for athletic hiking out and there are certainly no trapeze wires. In stronger winds than we experienced the windward hydrofoil moves from lift into dive so as to stabilise the boat. In a couple of minutes the far shore was fast approaching so Joddy dropped the boat down from the foils to make a quick and easy tack then we lifted back up going the other way. I took the helm briefly and found the steering to be remarkably light and precise.

If results count for more than words then perhaps this was the excuse for Joddy to say relatively little at the seminar. However he did make some pertinent remarks concerning the potential problems of sailing hydrofoil craft in rough water making the point that the orbital motion of water particles in waves can play havoc with the dynamics of a hydrofoil sailing boat.

MICHAEL ELLISON

Michael briefly updated us with his progress on fitting out his 38 foot ferro-cement monohull yacht which is now registered with the name 'Maid of Portland'. This is a fairly long term project so in order to get some sailing meanwhile he has purchased a Snapdragon twin keel fibre glass yacht. He attempted to sail this to Speed Week but was held back by strong winds, Speed Week must have been missed the weather this year. Michael has also recently travelled to the Caribbean to act as an official observer for a three week attempt on the speed sailing record by a team from the University of Barcelona. The attempt was made using sailboards equipped with solid wing sails and special asymmetric section skegs. The trailing edges of these skegs were sharp enough to shave with. The wing sails showed potential but were perhaps a bit heavy and clumsy. Two of the worlds top sailboard experts were hired as pilots and Michael felt that this could have been a mistake since some slightly less experienced pilot might have been better able to adapt to using the non-standard equipment. No records were broken since apart from any thing else the weather was not particularly suitable.

NICK POVEY

Speed Week is now organised by a team consisting of Nick Povey, Bob Spagnoletti and Norman Phillips. Nick thanked the entrants for coming and I am sure that all present would also thank his team for making the event possible. The low number of entries this year was in part due to the weather being unsuitable for sail boarders but Nick did say that even after allowing for this year's weather more entries were needed to make the event financially viable. One idea the organisers have in mind is to set up a 'University Challenge' to encourage student entries. I expect that Nick would be pleased to hear from anyone who could help with such a scheme or who has contacts that could help.

BOB DOWNHILL

Now that Bob is relieved from the duty of organising Speed Week he has been doing further experiments with his 'garage door'. This is a test rig for a configuration of four inclined surface piercing lifting hydrofoils mounted two forward and two aft. The aim is use this hydrofoil configuration on a speed sailing craft equipped with a biplane rig adapted from a pair of glider wings. The current version of the garage door is lighter than the one we saw last year and has some shaping to the underside. It successfully lifted onto the foils under tow from a motor boat and Bob was delighted with the resulting measurements of lift and drag.

Some explanations about Frank Bailey's article on Catalyst No. 7

I read Mr. Bailey's article about the precision problems he encountered with his home-made wind tunnel. Since Frank's e-mail was not published with the article, I would like to kindly ask you to send him the following analysis I made on the problem. I think it would be very useful for everybody if Frank could tune his wind tunnel to give better results.

Some considerations about the precision of wind tunnel measurements

On Catalyst No 7, Jan. 2002, Frank Bailey published the results he obtained with his homemade wind tunnel. He found that the values of Cd he measured for several bodies were not completely in agreement with the technical literature on the subject. He textually described the results in these terms:

"As you can see, the experimental drag coefficients developed here are not in particularly good agreement with standard handbook values, except perhaps in the case of spheres. In general, they seem to be low. I don't think any of my readings could be off by more than 10% and maybe much less, so there is something inherently unknown here. I speculate the problem might be with the surface roughness and the limited outlet area of the tunnel".

We'll try to find what's the "inherently unknown" factor or factors affecting the measurements. The explanation is quite simple indeed, although some maths is needed.

We all know that the expression of the drag is:

$$\boldsymbol{F} = \tfrac{1}{2}\rho \boldsymbol{C_d} \boldsymbol{A} \boldsymbol{V}^2$$

So the drag coefficient can be calculated with

$$\boldsymbol{C_d} = \frac{2\boldsymbol{F}}{\rho \boldsymbol{A} \boldsymbol{V}^2}$$

where $\boldsymbol{F}$ is the force measured with the spring, $\boldsymbol{A}$ is the transversal section of the body (or the planform area in the case of wings/foils), ρ is the air's density and $\boldsymbol{V}$ is the measured speed of the wind.

Since it's impossible to measure any physical variable without errors (or uncertainties), it's very important to analyse which is the maximum error one could find in the final result of a formula if each of the measured factors has a certain amount of error.

We'll need here some maths. Let's first analyse the case of a simple formula $A = b.\,c$

We'll define:

DA = maximum absolute error of the result
Db = maximum absolute error of b
Dc = maximum absolute error of c
A+DA = Calculated value of A
b+Db = measured value of b
c+Dc = measured value of c

So, when we try to calculate A using the measured values of b and c, we'll obtain:

$$A+DA = (b+Db).(c+Dc)$$

Developing the parentheses:

$$A+DA = bc + cDb + bDc + Db\,Dc$$

Dividing both terms by the "true value" A and its equivalent bc we obtain:

$$\frac{A + DA}{A} = bc + \frac{cDb}{bc} + bDc + Db.Dc$$

or

We'll call

$$\frac{DA}{A} = \text{relative error of A} = e(A)$$

$$\frac{Db}{b} = \text{relative error of b} = e(b)$$

$$\frac{Dc}{c} = \text{relative error of c} = e(c)$$

(all of them usually defined as %)

And we'll assume that

$$\frac{Db.Dc}{b.c} \lll \frac{Db}{b} \quad \text{and} \quad \frac{Db.Dc}{b.c} \lll \frac{Dc}{c}$$

(in fact, if suppose Db = Dc = 0,1, then Db.Dc = 0,01)

So: $e(A) = e(b) + e(c)$

The same result could be obtained for a function like $A = b/c$

Turning back to our example, if – as Frank himself states – a 10% of maximal error in the individual measurements is possible, then the maximum error (or uncertainty) in the calculated value of Cd will be:

$$e(Cd) = e(F) + e(r) + e(A) + 2\,e(V)$$

$$e(Cd) = 0{,}1 + 0{,}1 + 0{,}1 + 0{,}2 = 0{,}5 = 50\ \%\ !$$

So Frank's results are not so bad after all! They lay within the maximum error one could await from the test method he's using.

The conclusions we can derive to improve the precision in the accuracy of the wind tunnel results are the following:

1. Try to increase the accuracy of the dynamometer, maybe by using a "mild" spring with higher elongation per unit force (the relative error is smaller when measuring longer deformations)

2. Check air temperature, pressure and humidity. In fact, ρ is not a constant! (probably Frank treated it as if it were). So the most approximate value of ρ should be calculated depending on the atmospheric conditions of the test environment.

3. Highly improve accuracy of V measurement. Since it's a squared term, the relative error has double weight in the final formula of the drag!

4. Carefully determining the area A. Again, since A = a.b, the max. error is the sum of the two individual dimensional errors. So don't think that the area you calculate is absolutely exact. You can't avoid errors while measuring the body's dimensions!

5. Be careful with the units! Using SI units reduces the risk of dimensional inconsistencies while calculating numerical values, since it is a "coherent" measurement system. (Please, note that in the formula, F was measured in "pounds force" while ρ was probably measured in "pounds mass"/cu.ft . Between both types of pounds there's a g factor equal to 9,8066). ***[Slugs/cu.ft is OK because the conversion from pounds mass to Slugs includes the g factor – Ed.]***

Obviously, also the speed gradients inside the wind tunnel, the turbulence induced by the fan and the surface roughness (rugosity) of the tested objects play an important role. Furthermore, while taking values from a handbook to compare, we must be sure that the Reynolds number in the wind tunnel is the same stated in the handbook for the chosen comparison value.

(Exercise for the reader: Calculate the error in the Reynolds numbers calculated by Frank. Please note that the kinematic viscosity n also varies with the temperature, humidity and pressure! Since n is a very small value, very small absolute variations of it can lead to big relative errors in the determination of Re.)

A comment about downwind sailing :

The theorem of Betz states that the maximum energy one can drive from a fluid in movement is a fraction of the total energy contained in the moving fluid. So no matter what's the shape of the sail, the maximum theoretical speed one can sail downwind is about 2/3 of the wind speed. Suppose that, to be absurd, you were sailing at the same speed of wind. Since the relative speed sail/wind would be 0, then there would be no pressure on the sail, which means no drive, so you would automatically stop. If you want to sail faster than 2/3 of V, then it's necessary to have a certain angle with the wind direction (some Australian light cats with rotating jib do so. So the aerodynamic force is higher than "pure drag" and "Vmg downwind" can be higher that 2/3V).

If I can be of further help, just e-mail me. Best regards

Mario Rosato
Barcelona
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Autogiros

Ref Catalyst July 02, Notes from Toad Hill , Kites & Whirling Things, "one such abomination ... autogiro". The article was written to stimulate comment.

Microsoft Encarta has a short informative article on Autogiro mentioning counter rotating rotors and rotors powered on takeoff which, whilst not abominating the Autogiro , agrees with Frank Bailey to some extent in inferring that they are useless.

I have never seen an Autogiro but have seen very impressive film of one - a modified bicycle with a small engine.

I understand that the emergency procedures on an Autogiro are (to an experienced helicopter or airplane pilot) counter-intuitive and that the spectacular and fatal crash of a very experienced test pilot at a big air show more or less sealed the fate of the Autogiro although the developer survived many, many years flying a succession of machines.

Greenweld Mail Order (Tel: 01277 811042 or www.greenweld.co.uk) sell a little toy "Windcopter Heli-Kite" (wind powered and with foam floats for the water) for £ 12.99 plus £ 3.50 post and packing which could be a starting point for a developer. -

I confess that I have not got one of these toys or even seen one and am an armchair member of the society.

Yours sincerely,
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[The autogiro crash referred to occurred when the pilot attempted a manoevre that took all the load of the rotor. As a result, the rotor blaades folded, struck the tailboom of the aircraft, and broke off. Whilst autogiros have a long history, and a number of theoretical advantages, they have seldom been used for manned flight since. - Ed]

Downwind Faster than the Wind

My explanation [of this] may be clearer if we consider a map of the track of the 18-ft skiff sailing at 27° to the true down wind direction. Roll the map about the wind direction and we now have a first impractical model of the skiff windmill travelling straight down wind faster than the wind without any energy input other than the wind in the sails. This is where the centreboard is important. Remove the centreboard and the skiff will not generate the relative wind, but will simply slip down wind at a speed less than the wind speed. Similarly, if a skiff windmill were allowed to run unrestrained down wind, with no gearing to the wheels, there would be no centreboard effect, and nothing for the sails to react against, and nothing to encourage them to rotate and develop the required relative wind. I do not believe the wheels would drive the windmill round, as the skiffs drive themselves forward in free sailing without help, but rather I believe the wheels would initially slow the speed of the vehicle to encourage the windmill to rotate. I suspect a model with no coupling between rotor and wheels would move down wind at greater than wind speed work if the wheels had sensitively progressive brakes for the 'sails' to react against!

I am convinced that the wheels are not feeding mechanical energy to the rotor, and nothing in the Catalyst, Vol. 1, no3, page 29 makes me change my mind. When I wrote my first e-mail I hadn't read the Catalyst article since scanning it when I first received it, and then I had simply accepted the Bauer's model as practical. The paragraph in Catalyst starting at the bottom of page 28 starting 'When accelerating —' refers to the 'turbine' becoming a 'propeller'. I think this is a misunderstanding. If the vector diagrams for each stage are examined, and the reaction of the centreboard (in the skiff example) included it should become obvious that the blades (skiffs) are driving themselves forward. The comment about the transition from turbine to propeller mode being smooth does not surprise me, as I believe it does not happen! (If it did, what would be driving what at the so-called transition point? There would be no drive????)

My own 'practical model' is exactly the same as Bauer's with pitch control and steering. As explained for the 'impractical 18 ft skiff' model, the pitch angle would have to vary from close hauled and vehicle stationary, through to the tacking down wind angle of 27° to the true down wind direction, when the relative wind is 38° to the track. In this case the rig (pitch?) varies from close hauled at bout 40° to the true wind (at about 25° relative wind), to about (27+38)=65° to down wind. This is a change of 'pitch' of 15° to 115°, i.e. 100°. Bauer's 180° makes sense if you want to aerodynamically stop the model.

The point in the Catalyst article about wind gradient near the surface is very pertinent with small and low models.

Sorry if the above is helping to cloud the issue.

Must go and do something useful; Cheers

Slieve.McGalliard

AYRS Newsletters' Index

With reference to CATALYST No 9, page 21. Frank Bailey is, not surprisingly, unaware that I indexed the AYRS UK Newsletters, 1991 - 1999, last year. Graeme [Ward] had sent me a disc with the current Index of Publications 1-120, and I returned the compliment by compiling and sending him an Index of the Newsletters, assuming that he is the Indices boss for AYRS.

Perhaps not, since I heard no more from him and there has been no mention of either Index since in CATALYSTS.

I am posting a disc with the Newsletter Index to Frank, but I regret I am unable to provide a service for other individuals. ***[It will however appear on the AYRS website www.ayrs.org - Ed]***

I could comment at length on the points Frank mentions: suffice to report that for years I have used a windsock very like the one in AYRS 64, perhaps with a l/d ratio of 3 and a bit more taper, which flies on the stick above the burgee. It is quite dead-beat and mounted so as to be sufficiently sensitive. On CALLIOPE and CERES we have one at the masthead but my neck suffers less by looking at the wind vane for data recording mounted on the bowsprit.

Best wishes,

George Chapman

HYDROFOIL CATAMARANS - AN UPDATE

By George Chapman.
August 2002

Introduction

This article updates the paper on CALLIOPE in CATALYST 2 (June 2000), and reports on some of our experiences with CERES.

First, a correction to the CALLIOPE paper as printed in CATALYST 2. Figure 9 on page 18 has the graphs and captions mixed. From the top, the graphs are d, c, a and b. The captions as printed are in themselves correct.

CERES is a scaled-up clone of CALLIOPE, dimensions increased by a factor of $1^1/_8$, and pro-rata for areas and weights. The hull length is increased to 19 ft, the length-equivalent we wished we had made CALLIOPE. There are other changes, particularly an increase in sail area. The main can be reefed in two steps. This is done by folding. After two folds the bight of sail from the first fold is secured with toggles to the sail so that the fold lies flat on the sail. This is an easy way of reefing with cold wet fingers and avoids an untidy and aerodynamically draggy bundle. A general arrangement drawing (Figure 1) and photos illustrate the boat.

CERES is normally sailed with two up, though when Joddy has sailed her single-handed the heavy task is hauling her up the slipway. The hulls, which were built by Rowsell and Morrison at Exmouth, are over the weight we predicted or expected, so this has affected performance slightly. Overall performance corresponds with that of CALLIOPE, the main difference being that flight is smoother due to the larger size and weight giving increased damping. The ability to reef has allowed her to be sailed in stronger winds without any apprehension or feeling of insecurity. 25 knots has been touched with Dick Ogilvie at the helm, and 22.3 knots logged over 500 metres in 13 knots of wind. We were disappointed that CERES could not be at Weymouth in 2000, the reason will be reported below.

As with CALLIOPE, CERES has fully moving foils rather than flaps. We discovered, as have others, that the foils in their active mode but set so that the hulls just touch the water provide enhanced stability and performance in a mode which we call ‘Flying Displacement’. We now use this at all times when not flying high, instead of simply locking the foils in a neutral attitude.

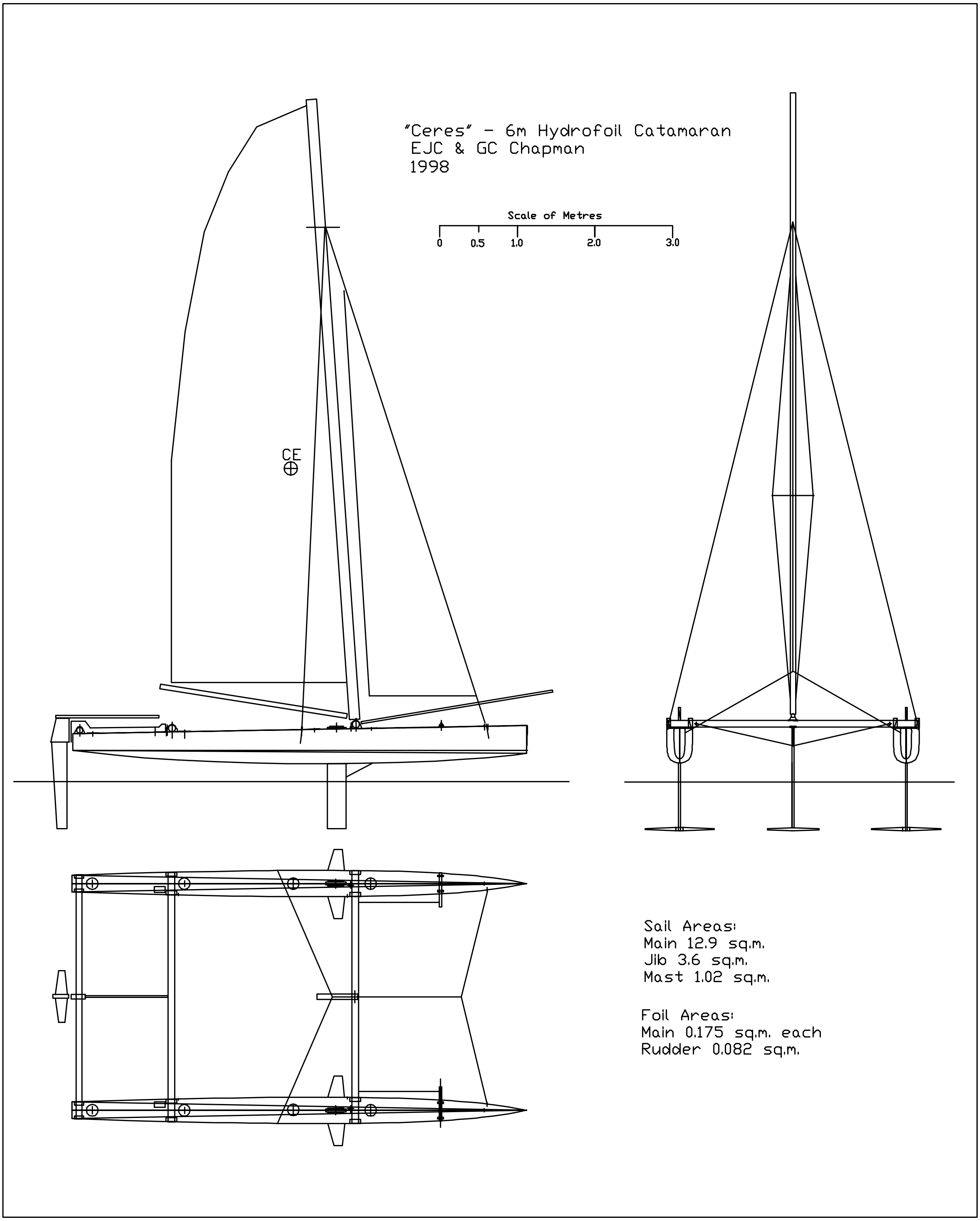

Figure 1 CERES general arrangement

General Design - Comparison with conventional cats

Compared to, for example, a Hurricane 5.9 the rig is significantly further forward. Also CERES has proportionally a greater beam, as does the TORNADO, which markedly improves sail carrying ability at the cost of longer assembly time. CERES in her design condition – flying – is supported primarily on the main foils and to a lesser extent on the rudder foil, whereas the Hurricane is, of course, supported by the buoyancy of the hulls. In both boats the crew sit in much the same fore-and-aft location relative to the sails and the centre of support.

There must at all times be a balance of the forces and moments in plan, front and side elevation. For the latter, the forward force on the sails acting at the centre of effort and tending to tip the boat forward about the main foils must be matched by the total weight whose CG must be far enough aft of the main foils. The rudder foil may assist or not as appropriate. On a beach cat, variations in sail force rock the boat to and fro - hobby-horsing - and the long bows are there to resist forward pitching moment. On CERES, when flying, the bows are well clear of the water and only of possible help in a rough sea or large wake waves. Sail force variations are countered automatically by the feeler/foil mechanism, which adjusts lift to match the need, and the rudder foil stabilises the boat in pitch. The foils when subject to vertical forces provide considerable damping, so hobby-horsing is minimised.

The longer sterns place the centre-line rudder far aft and keep the transoms clear of the waterline. CERES was made an extra foot longer than the scaled-up CALLIOPE length suggested to assist this; we will probably stick with the proportions we have.

As sail force increases either the weight (crew) must move aft, or the rudder foil loading must change, or both. So far we have managed with the rudder foil incidence pre-set and have shifted crew weight aft as forward drive and speed increase. Where the crew cannot move, as in the RAVE and TRIFOILER, a means of adjusting rudder foil incidence or flap angle is essential if correct trim is to be maintained.

The forces and moments seen in plan must balance, preferably to give a small amount of weather helm for safety, comfort and to let the rudder carry a share of the leeway force. So the Centre of Effort (CE) of the sails must be sufficiently abaft the main struts' CE or Centre of Lateral Resistance (CLR). We have found that on CERES the sail CE as shown in Figure 1 may be a little too far aft, so that for most of the time there is more weather helm than is desirable. Generally CERES sails closehauled - so-called 'apparent wind sailing' - and the helm balance does not change. Occasionally, when sailing off the wind at high speed, the boat's bows depress moving the sail CE sufficiently far forward for lee helm to set in. This is unnerving, so any future re-arrangement of the geometry to reduce weather helm must be accomplished with that it mind. Maybe we should accept the present amount of weather helm force.

Foils - Design Considerations - Control

There are various ways of varying and controlling the lift afforded by submerged inverted-T foils. On CALLIOPE we started with flapped foils that were inherited from BANDERSNATCH.

We use the word 'flap' to refer to a hinged rear percentage of a foil, generally full-span, which in use is deflected either way to vary the camber overall. This device is like the elevator on the tail plane of an aircraft, or a full-span aileron on a wing. Strictly a flap is a separate foil deployed abaft a main foil.

These flaps were some 27% of the chord. Hansford and Bradfield use a lesser percentage, which requires less force to hold the flap in position against the flow of water. As a result of needing a larger force, and hence a stronger shock-cord to hold our flap to DIVE, we decided to change to symmetrical section foils which do not have flaps but are fully moving about an axis at 25% of the chord. Such foils are self-feathering to zero lift and require little torque to move them. Catering for gusts requires the foils to be able to go smartly and smoothly to DIVE; this the symmetrical foils do well with the help of a shockchord elastic.

There was another reason why we adopted fully moving foils: we did not have hard information on the characteristics of flapped foils for both the deflection of the flap to the body of the foil (henceforth called the flap angle) and the incidence of the main part of the foil relative to the free stream (body angle). Without such data we were doubtful of the efficiency of a lifter if, for example, the boat had a bow-down attitude and the control system was demanding upward lift from the foil or vice-versa. In both cases the body of the foil would be at the "wrong" angle to the free stream and the flap would have to be over-deflected the opposite way. What then would the lift/drag ratio be? It is only now that we have looked more closely into this problem.

We have found two NACA papers (Report No 603 by Platt and Shortal and No 688 by Silverstein

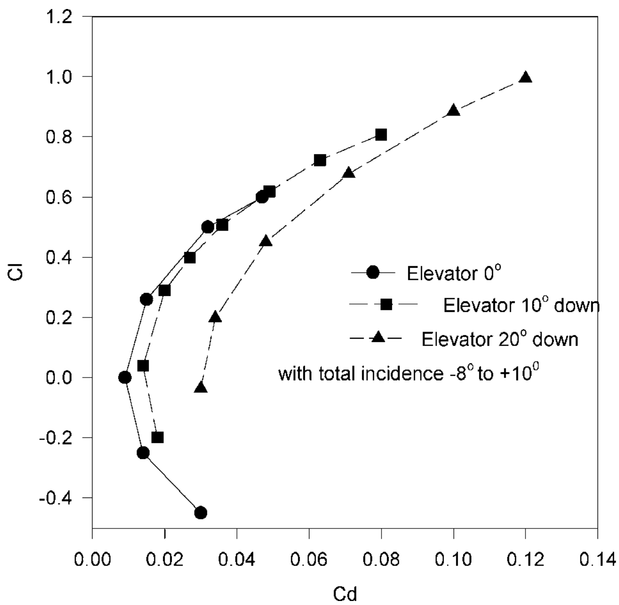

Figure 2 - Experimental results from NACA Report No 688

& Katzoff) that report wind-tunnel measurements of airfoils with elevators. From the latter it is possible to derive curves of Cl/Cd for an aerofoil with a 25% of chord elevator at zero, 10 and 20 degrees depression of the elevator, Figure 2. The section is Gottingen 409, similar to the NACA 0012. In this case the aspect ratio is 4.3. The small drawing in the paper does not define the nature of the gap between the main part of the wing and the elevator. As might be expected, when the elevator is depressed, and the body rotated nose down to give an equal lift, the drag increases. At Cl = 0.3, the increase is 22% for elevator 10 degrees down and body just over zero degrees up, and 122% at elevator 20 degrees down and body -2 ½ degrees nose down. These differences reduce as body incidence rises, but a 2½ degree pitch up or down attitude is not uncommon for a small hydrofoil boat.

For comparison we have started to use MIT's XFOIL program that has become available for downloading from the Internet. Applying this to the NACA 63(2)-015 with a 15% flap to calculate the section characteristics at Re = 2x10^6 suggests that a flapped foil has an advantage over the unflapped foil. Figure 3 shows the NACA experimental Lift/Drag (Cl/Cd) curve for the infinite aspect-ratio section (the section data) together with XFOIL computed curves. Abbott and Von Doenhoff reproduced NACA's published data, and it is of interest that the Cl/Cd curves on either side of the zero Cl axis differ by up to 11% in Cd for values of Cl from about 0.5 to 0.9. The experimental curve shown in Figure 3 is the optimistic one (Cl +ve) and is close to the XFOIL 'No flap' curve. The XFOIL curves assume no leakage at the foil/flap hinge and a smooth surface over the join, so I suggest they be treated with caution. Also, it would be difficult to make a flapped foil with this section due to its thin and concave trailing edge. In any case there are sections, such as the NACA 16- and 66- series and Eppler series, which may be more suitable as hydrofoils than our choice.

Applying the usual formulae to the XFOIL results, Figure 4 shows the foil with flap and no-flap at aspect ratio 6.

The incidence of ***fully moving foils*** is set at all times by the feelers to exactly match the loading applied. Flying height will vary over a small range with variation in speed and load because the feelers are directly connected via the linkage to the foils. This range is small and not a problem. Variation in the boat's pitch attitude will also slightly vary the flying height, but the important thing is that the foils are always set for the required Cl. The resultant Cd is that of the symmetrical 63/2-015 section that we use. This section has the 'drag bucket' typical of foils with hollows towards the trailing edge, and is thick enough to accommodate the stub shafts - see later. At the top speed design condition the Cl for the lee foil is about 0.3, and at the optimum Lift/Drag ratio, Cd is about .0055. The weather foil will be unloaded, unless you press the boat harder. Then a little more speed may be possible. It is difficult, even sitting next to the weather strut, to see exactly what the foil incidence is, and even more difficult to see the lee

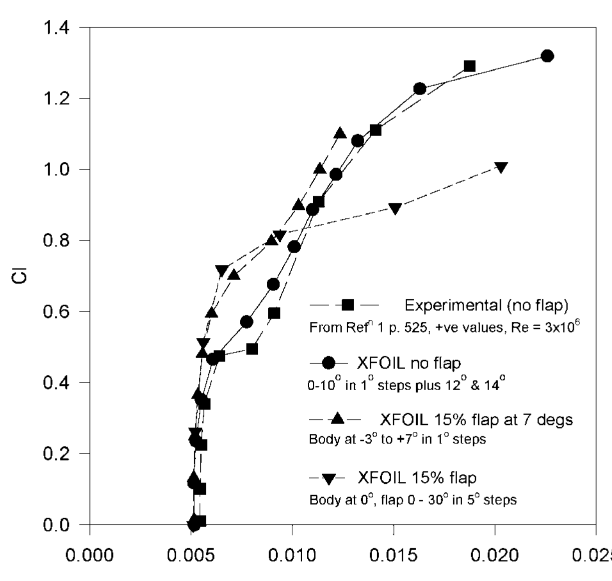

Figure 3 - Section data for NACA 63(2)015

incidence. My impression is that the foils seldom go far to DIVE, if at all. Their movement is small and well damped.

Practical advantages of fully moving foils are that they can be changed, e.g. for different foils; and that the outer foils can be removed to get the boat through the boatyard gate.

So on CALLIOPE and CERES we can most of the time sail happily without having to adjust the rudder foil. At top speed - over 22 knots - we either get a bit of a bow-down attitude or we move aft to keep the stern down. The design problem that we have not approached is how, on a wide catamaran, to enable the crew to adjust rudder foil incidence at speed.

Choice of foil area

Hansford's foil areas on MAYFLY and DOT were clearly satisfactory. We do not know how he arrived at them, except to say that the 1972 MAYFLY surface piercers were of much lesser chord and area than the originals of 1970, and Ben Wynne's later MAYFLY foils were narrower still. We copied Hansford's areas, and gradually increased those from BANDERSNATCH onto CALLIOPE, see Figure 8 in CATALYST 2. Increasing area for the same root chord led to increased span and aspect ratio. By the time we designed CERES we had a working Velocity Prediction Program (VPP) and could better decide on the area. CERES's foils are slightly larger again (in due proportion) than CALLIOPE's. The obvious variables are that small foils are desirable for top speed, large foils assist early lift-off. But it is no good having such small foils that you need a gale to get lift-off - average UK summer wind speed is around 10 knots - and equally no good having such large ones that you never get over the drag hump and lift off. We think CERES has it about right.

Feelers

We prefer trailing feelers because they can be mounted inboard of the hulls, which carry the strut/foil units, without impinging on the trampoline, or possibly the beam structure; whereas, for example, the RAVE's wands, which hang down from the struts, have no choice of fore and aft location. Connecting the feelers to the foils via wires and crank arms allows for ready adjustment of flying height (wire length) and gain (moment arm on the crank). Varying the wire length by about 1.6mm varies flying height about 24mm, so an adjuster with coarse and fine increments of 1.6mm (1/16")

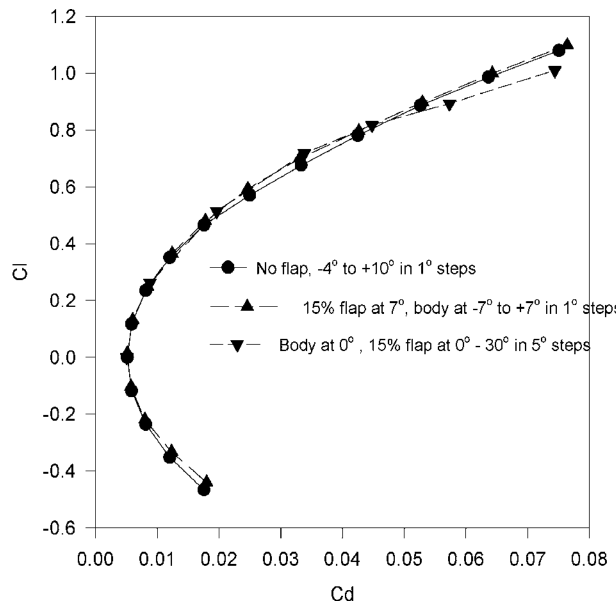

Figure 4 - NACA 63(2)015 at aspect ratio 6, Re = 2x10^6 (Xfoil)

achieved with small shackles is convenient for cold wet hands. Note that the wire tension can be up to over 40lb and quite jerky. The point of connection of the wire to the crank arm is by a shackle into one of a range of holes, to vary gain. There is a coarse gain adjuster forward where the feeler arm crank is attached to the wire. Once set up at the start of the season these settings do not need to be changed.

Clutches

Between the crank arm connected to the wire and the push rod is a clutch mechanism. The first clutch was operated by a pair of cords, either of which pulled a shuttle one way or the other to vary the angle transmitted by the crank. Initially we had two positions, either with the foils locked in neutral, or allowed to respond to the wire for flying. This served quite well until we discovered by chance that 'flying displacement' is a useful ability. In this mode the feelers and foils are active, but the height demanded is reduced so that the hulls are at or just above their displacement water line. The active use of the foils improves stabilisation in roll, the proximity of the hulls to the surface improves pitch stability, and the struts are fully immersed with the hulls acting as end-plates. The result is that for sailing to windward this gives a better Vmg than either flying one or both hulls. Indeed, trying to fly both hulls to windward fails to fly the lee hull properly and simply adds the drag of a fully-to-RISE lee foil. The modification to the clutches to allow for flying displacement required

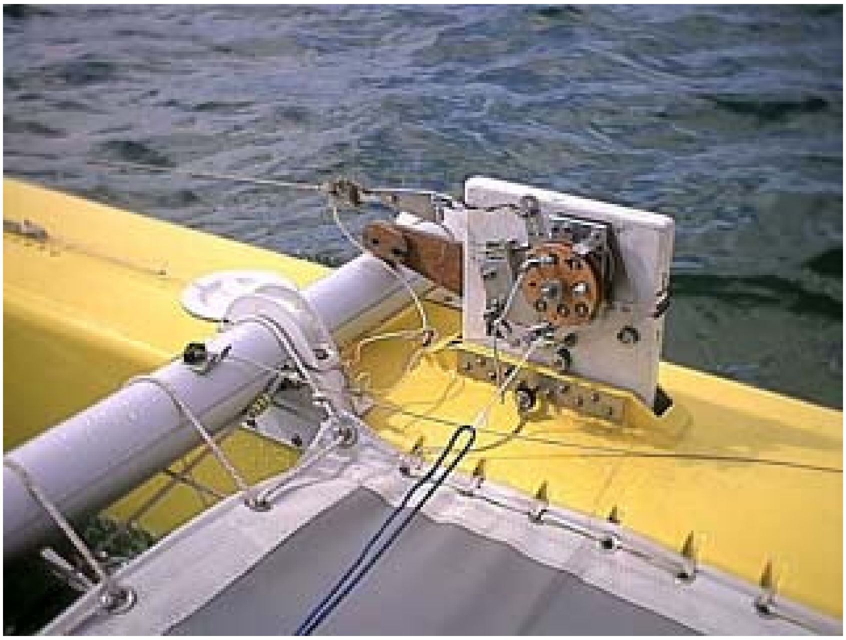

Figure 5 - Ceres' 2002 single line operated clutch.

two wing nuts and two 40mm radius pieces of 2mm plastic. A cord has to be pulled 75mm to shorten or lengthen the feeler wire by 12mm, a mechanical advantage of 6.25 at a reasonable pull of less than 7lb.

To reduce the number of strings on deck new clutches in 2002 have only a single cord. When this is pulled to change the wire length it must be pulled the full distance and then released so that it is recovered into the mechanism by a spring. The mechanical advantage has been slightly increased.

On a large enough boat, for example Bradfield's 25ft EIFO, with wands, hand control of the foils is possible with an operator on each float and the wands disconnected. Our boats do not have this facility, and we have enough to do anyway without hand control. Fly-by-wire works!

Struts

The NACA 0012-34 section struts perform entirely satisfactorily, we have not been aware of any ventilation.

Manufacture: Flapped Foils.

Our only flapped foils were made of softwood covered with glass and carbon in appropriate places, care being taken to ensure that the strut-foil joint was well reinforced. The half-flaps were made in a mould in a similar manner to the fully moving foils (see later), with a glass outer surface and solid filler. A 1/8" rod was built into each and supported at the foil tips and centre-line, with a small crank connected to the push rod that passes up inside the strut. DOT's strut/foils were made similarly, but with the flap hinge pin supported periodically along its length. Quite how this was put together was not evident! What is important is that the foil/ flap hinge is close-fitting to avoid leakage. With a monolithic construction thinner foils are possible than with fully moving foils.

On the RAVE the struts and foils employ similar alloy extrusions, so the joint is welded, and the pushrod emerges from the trailing edge of the strut to be connected to the back-end of the flap which is abaft the trailing edge of the strut. We understand the rudder/foil and main foils are basically the same for ease presumably of provision. The rudder flap is set by a control in the cockpit.

Manufacture: Fully Moving Foils.

At the bottom of our struts there is a 'hub', profiled like the root of the foils and some 80mm wide, very firmly attached to the strut. Through this at the 25% of chord axis passes the stub shaft, mounted in roller bearings and with neoprene seals. On the centre-line a crank arm connects the shaft to the push rod.

Each foil has a GRP tube built in which embraces the stub shaft; the foil is firmly attached to the shaft with an Allen head 6mm bolt which seats into a short hole in the shaft. The foils appear to be raked forward because at all points along the span the axis of rotation is at 25% of the chord.

First make the plug. We prepared two plywood formers to represent the root and tip of a foil, as accurately shaped to the specified profile as we could. These were glued, correctly oriented, one each end of a sheet of rigid foam the length of the foil. Now the tricky part! The foam and the way it is supported must be sufficiently rigid so that each surface of the foil may be cut with, e.g. a Surform and then a sanding board, and ***end up correct.*** It is better to shape one side and cover with GRP before shaping and covering the second side. This also eases the task of making the trailing edge as thin as it needs to be. If great care is not taken, the foam will yield when the second side is cut and the plug will not be truly symmetrical: it will have an element of camber. We used lightweight insulation foam but a structural foam such as Airex would be preferable. If you have access to a numerically controlled milling machine to do the shaping, so much the better.

The ply formers will have been made with an allowance for the glass and epoxy covering which is now applied. The final surface, after filling and we suggest coating with polyester resin, must be brought to a mirror finish by successive wet-and-dry grinding dowm to 1200 grade paper and final polish with rubbing compound. 'Mirror' finish is when the image of a lamp or window is reflected sharply. Mould release polish is then applied in successive applications, preferably spread over several days to allow the resin and wax to set properly. How many rubbings? Never enough! The two ends must have been chamfered and epoxied so that they are slightly convex, to ease mould release, and polished.

A two-part mould box is built of timber, each half deep enough to allow both for the half-thickness of the foil and for stiffeners. Lugs screwed to one locate the other half. The internal size allows say ½" all round the plan profile of the foil.

One half mould is clamped to the bench and the foil mounted in it using clay. This need not be continuous except round the edges where it forms a continuation of the top surface of the mould across the gap to the centreline of the plug. The foil must be firmly supported by the clay, and all that will be visible above the mould and clay will be an exact half foil.

Apply mould release polish to the clay and the top of the mould, also the corresponding surface on the other half mould, locate the latter on the lower half and clamp it.

The upper half mould can now be laid, starting with two gel coats, then tissue and cloth to make the important surface of that half mould. Polyester resin suffices. When the lining has set, and not before, apply reinforcement in the form of plywood cross pieces, glassed in. These ply pieces should, for convenience, not protrude above the top of the upper mould. If the reinforcement is applied immediately after laying the lining, the lining will distort and the resultant mould and foils will have a very slightly wavy surface.

After allowing adequate time for setting, invert the mould, remove the clay and the (new) top half, and prise the plug out of the mould. The plug may need repair afterwards!

Making the second half mould follows the same procedure, after re-polishing.

While making the moulds and working resin it will save time to make the tubes for the stub shafts and the securing bolts. Both are made by wrapping Melinex round a former, a stub shaft and a length of round bar the diameter of the 6mm Allen head, secured with paper tape. Lay glass tape in helices, overlapping and cross-pitched, to about 2mm thick. When set these will slide off the formers, the Melinex will probably be rendered unusable in removal. Cut the shaft tubes to length, and plug one end of each shaft tube with foam resined in. The stub shafts are stainless steel, 7/8" diameter.

A stainless steel strip some 75 x 15 x 6mm (or two 3mm thick) with a tapped 6mm hole is secured to each shaft tube with resin filler and then bound with carbon and impregnated with resin.

Timber extensions to each mould half will support a shaft, which fits into the mould through hollows cut in the mould root, to support the tube during final assembly. Smaller hollows accommodate the small tube in line with the 6mm Allen bolt. So the mould is also a jig to ensure that the stub shaft and securing bolt will align correctly with the finished foil.

Foil shells are laid down in the mould halves. It assists removal from the mould to resin to the tip end of the shell a tape 'handle' to pull that end up from the mould. Each shell is faired off flush with the centre-line plane, and the tube hollows in the mould are continued in the shells. Polyester resin, coloured to taste, used as a gel coat provides a UV screen and is easier to polish than epoxy, which should be used for the rest of the structure.

The upper shell of each foil must have its shaft tube strongly glassed on; so care is required to keep track of which shell is for a left or right foil. It is an interesting thought that a foiler, like an aircraft, is held up by the top layer of paint on the foil or wing; and because there is a ***negative*** pressure under the foil/wing also (up to an incidence of perhaps 8 degrees) the forces are conspiring to pull the foil/wing apart. When we failed to get this right, the suction on top pulled the shell off a foil whose shaft tube was fixed to the bottom shell. And CALLIOPE remarkably continued flying with one shell removed! Twice.

The bolt tube will require some filler to support it and hold it in line with the 6mm bolt which (suitably waxed) is screwed in place, and to seal it to the shell and the shaft tube. Filler is also applied around the edge of the shell to make a ledge, which will carry the 'glue' to stick it to its twin shell. This twin must be similarly prepared in its half mould, and the two placed together to confirm that the gap between is closed all round.

Gluing the two shells together and filling them with lightweight rigid filler is done as one operation. The glue is resin with appropriate thickeners, coloured to match. Our filler is a mix of resin, filler, and polystyrene beads used for cushion filling. With a red filler this looks rather like Baked Beans without the pork. It is laid in each half to slightly above the centre-line plane, the glue laid around the edges, and the two placed together and clamped. The beads deform to allow the filling to compress, but to make sure that the void is well filled we push strips of Airex foam, 10mm x 25mm, into the root end of the mould through previously prepared holes. So far foils made in this manner have held together.

Figure 6 - Foil shell halves filled with "baked beans" prior to joining

Manufacture: Struts.

To be sure that our struts would be strong enough in compression and bending, and not having experience of foam cores, we used timber, cedar for choice, for the cores, also marine ply for the cores of the hubs that carry the stainless steel bearing tubes. The push rod is accommodated in a plastics tube (small electrical conduit) built in. The timber is shaped below the keel level so that when the sheath of glass, carbon and resin is applied and faired the section is as specified. Above the keel the strut is rectangular. As with the foils, a mirror finish is required. For both CALLIOPE and CERES we did a bending test to confirm that the stiffness appeared sufficient, on the principle that if it does not bend too much it probably will not break. They haven't.

Manufacture: Rudder.

As this is less heavily loaded we made the rudder/foil unit with a core of Airex, with wood inserts at stressed points like the pivot and up/downhaul cord attachments. The two 10mm layers of Airex were joined with a layer of 100gm glass cloth, resined, to provide some initial stiffness and mark the centre-line clearly for subsequent shaping. The speedometer-sensing coil – a sewing machine bobbin – sits in a recess beneath the foil and a small plastic tube leading up to the top rear of the rudder carries the cable. The Speedwatch impellor, which comes on a neat little skeg, clips into a socket fixed to the rudder on the port side just above the foil. Perhaps it is this location which explains why CERES seems to go faster on starboard tack than port?

During construction, as with both boats' struts, bending tests were recorded and compared as layup proceeded. While the rudders are not as stiff as the struts, and the bending of CALLIOPE's is at times visible, they have not shown signs of stress.

The hack rudder, of plain ply and used during launch and recovery at the slipway, works beside the foil rudder in a single stock, and it is the stock which, despite careful design in timber, shows signs of stress. Either or both rudders can be raised aftwards: they are interlocked so that the foil rudder, which is held down by a spring-loaded catch, can only be raised when the hack rudder is fully down.

The Disaster.

In 2000 we decided to make a set of foils some 33% larger in area to see what effect they had on performance. With the same root length the aspect ratio would rise to 6, compared with the 4.5 of the smaller foils.

When first afloat these new foils behaved oddly. We had expected to have to reduce the gain and height settings, but we found that the foils had the unfortunate tendency when at RISE to stay there, resulting in excessive lift-off. Raising the shock-cord tension to pull them towards DIVE only helped slightly. So we reduced the range of incidence available and went back to adjusting gain and height. With reduced gain and height we discovered the merit of 'flying displacement' and, because of light winds, settled for that mode for a couple of outings. We looked closely at the foils and found that the hollow towards the trailing edge was deeper on one side than the other, on all four foils.

Figure 7 - Ceres on 22 June 1999 with Joddy Chapman and Phil Morrison.

We followed two lines of enquiry: the degree of asymmetry and the location of the shaft axis; was it truly at 25% of chord? We tested the propensity of the foils - and of the original smaller foils - to feather in line with the stream by mounting them vertically on a freely rotating shaft, hanging down from our test-tank carriage, and travelling along the pool. We found that they would rotate one way to a stable position with quite a large 'negative' (in aeroplane terms) incidence. Even the smaller foils showed this property, but to a much lesser degree. This was characteristic of the "nose down" pitching moment exhibited by cambered aerofoils, so we had to concede that our foils were not symmetrical.

As a cure we filled in the deeper hollows and polished, and filled in and polished, and drew near to shapes that might be acceptable. We also managed to move the shaft holes slightly forward in the foils, although this seemed to have little curative effect.

Incidentally, even NACA, the forerunner of NASA, had difficulty making perfectly symmetrical foil sections. The Cd/Cl curves for 63/2-015 look slightly asymmetric, and for example at a Cl of 0.6 there is an 11% difference in Cd between the two ways 'up'. Full marks to Abbott and Von Doenhoff for publishing the raw data.

On the last outing with these foils we found it still difficult to achieve a satisfactory gain setting, and concluded that they were too big.

Note that if a foil on the right or starboard side of a hub is cambered to lift, it's opposite number will be cambered to dive, and one has a torque imposed on the hub which will be anti-clockwise seen from astern. There must have been some slight unbalance somewhere that accounted for the propensity, particularly on the starboard side, for the foils to stick at RISE initially.

But worse! These foils, like their predecessors, were secured to the shafts by simple 6mm bolts bearing on flats on the shafts – as had been successful so far. On the last outing before going to Weymouth 2000, and within minutes of lowering sail and returning to base, we did one last run up river. Just foilborne, we came to an abrupt stop; the bows, starboard in particular, burying. Fortunately the rudder foil held and we did not pitchpole.

What had happened was that the starboard outboard half-foil had slipped round on its shaft due to its propensity to go to DIVE. This had produced a very large torque, clockwise seen from aft, which tore the hub from the strut. The drag forced the hub plus foils aft, still connected to the push rod. The rod split the strut up the trailing edge so that the hub/ foils came up to the keel inflicting a slight dent in the bulletproof hull. At this point the split pin securing the shaft's crank arm to the rod sheared.

Fortunately, despite the weight of the solid shaft and the bearing tube and bearings the buoyancy of the foils and wooden hub kept the hub/foil remains afloat so we could retrieve them. Once we had recovered ourselves and secured to a buoy we removed the clutch from the top of the strut and withdraw the strut downwards.

A replacement strut + hub was built over the winter, and in 2001 CERES was sailing again.

All this shows:

Figure 8 - "16 knots is boring..." (The log reads 16.7 in not much wind).

For tacking we drop down to flying displacement as the boat comes up to the wind, tack, and carry on. If one does not clutch down the bows rise up as the drive comes off the sails, which looks rather absurd, is uncomfortable and slows the boat.

Variation in crew weight and sail area will slightly vary the flying height, but once set the gain and height adjustments are satisfactory. We aim to show about 6" of strut above the average waterline, the criterion being that in average flying conditions we do not want the waves slapping the keels.

At speed - 22+ knots - the boat pitches forward about the main foils. This reduces the foils' incidence, which must then be restored to keep flying. To do this requires the feeler tips to rise relative to the boat, so the boat flies slightly closer to the water. This seems to improve the feeling of solidity and stability. We did try 'pitch compensation' on CALLIOPE by placing the feelers further forward so they would detect a bow-down attitude. It seemed to make little difference and removed the feelers from ready access so we reverted to the location shown in Figure 1.

Our experience of rough water is limited; what is evident is that on entering rougher water the feelers demonstrate that they sense the wave tops as the boat rises higher and seems to go faster. The natural damping action of the foils allows this; the feelers can drop into the troughs, loosening the feeler wire, but the shock cord is not strong enough to pull the foils rapidly towards DIVE due to their damping action. With larger foils (in absolute terms) and greater mass, CERES gives a smoother ride than the lighter CALLIOPE, which can feel rather like riding a Land Rover over a ploughed field.

Various constraints have so far prevented us from sailing, even informally, against comparable-size catamarans round the buoys. So we have had to rely on instrumentation to determine whether we are improving the performance. Recent advances in devices have enabled improved data rates and discrimination so that smaller differences in performance can be detected.

Symmetrical foils must be truly symmetrical - or else!

The optimum size of foils must be carefully determined, as must the gain from feeler to foil or flap.

The area of the rudder foil for optimum performance must also be carefully chosen.

How lucky many of us have been, achieving the success we have; largely by building on what previous experimenters have succeeded with, and by introducing changes gradually, preferably with appropriate justification by theory and e.g. VPP work.

Sailing a Flying Foiler.

Foilers like ours cannot sensibly be operated as beach cats off sandy beaches into onshore wind and sea, and in UK this limits the number of places where they can sail. We are fortunate in having ready access to a public slipway, thanks to Plymouth City Council ***who keep it weed free***, which is sheltered by the pontoons of the Mayflower Marina. So we motor out into the Tamar using my 24cc converted strimmer outboard, weight 5kg.

With foils and rudder down, sails up, engine inboard and clutches to 'Flying Displacement' we can sail off in the same way as any other boat. As remarked above, for windward work flying displacement is best; once we have borne away beyond about 100 degrees from the true wind and speed has risen to 9 knots we clutch the windward foil to flight. If there is enough wind - say 11 - 12 knots - to raise the speed to 10-11 knots, we clutch in the lee foil and ***fly***.

George Chapman
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OTHER NEWS.

Dr Sam Bradfield's 40ft SCAT hydrofoil trimaran has been sailing off Florida for some months. This boat is a step towards a 60ft version, to take on the ORMA Open 60s at their own game (see below).

The International Hydrofoil Society's Spring 2002 Newsletter carries a report by Brian Douglas of his crossing of the Gulf of Mexico in a Windrider RAVE. The foils provided 'an incredibly stable craft when they are deployed in displacement mode. I would "heave to" under bare poles quite comfortable in major storms at sea and go to sleep below, hardly ever having water slop over the rear coaming....' 'Going to sleep below' in a hull barely larger than an AYRS hull, with gear, food and a dulcimer stretches the imagination. So what are we worrying about?!

L'Hydroptere has been repaired again and in May 2002 sailed across the Channel from Douarnenez to Southampton, entering the Solent at 38 knots. The web site is not very forthcoming on the trip except that it came up to their expectations.

[Hydroptere in fact made an attempt on the (anticlockwise) Round Britain Record after this crossing, but suffered from foil failure when passing Dover - Ed.]

In the International 14 Class and the Moths the benefit of T-foils on rudders has been realised. In the former they are used not only to improve pitch stability but also to control positively the attitude up and down wind. In Australia both Classes have sailed boats with lifting foils on the main centreboard, with presumably adjustable rudder foils to trim pitch. Except that the crew are higher off the water than when planing, balancing the boat on a knife-edge may be no more difficult on foils than on the plane. Four photos in the March 2002 SEAHORSE magazine are sadly not printed together in the right sequence to give convincing evidence that each is not a momentary leap upwards. There is not enough background scenery to register the photos together. The adjustable rudder foils are controlled by a 20:1 purchase to a push-rod to give fine but positive control, the crews being used to pulling strings to vary so many other 'tweaks'.

Figure 9 - SCAT off Florida, summer 2002 (picture courtesy Hydrosail, Inc.)

At the other end of the size scale, the ORMA 60s of the predominately French trimaran circuits now regularly 'fly displacement' on their lee hull, with a single curved foil (centreplate or J-foil?) in the each float. Very recently, one of them at least has fitted a foil to the main hull's rudder which can be racked fore and aft to vary foil incidence. How long before they fit the rudder of each float with a foil, and incline the rudder so that it is vertical when the other two hulls are airborne?

In January 2002 the Australian By Design Group launched their 40ft trimaran foiler. This looks like a sleeker ICARUS II with a centre hull, and has surface-piercing foils. She touched 30 knots in 18-25 knots of wind.

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PROJECT WINDRIGGER

Ian Smith

Photo 1 - Windrigger 5600 powered by 2 sailboard sails of 7 sqm each.

During 1992 I started a project aimed at developing a trailer boat that would attract all members of a family to sailing it. To achieve this I decided that this family-sailer should fulfil the following requirements: safe, comfortable, simple to rig and sail, affordable and fast as my Flying Dutchman, which I sailed in the 1960s. The requirement for safe includes - seaworthiness and particularly the ability to return to a safe shore when the winds become dangerous.

I first concentrated development on the Flying-proa configuration and, by 1995, I had developed a functional proa incorporating a balanced sailrig, twin spade-rudders and capsize recovery system. But it lacked potential for achieving the comfortable accommodation requirement, so I switched to the catamaran configuration and eventually produced the catamaran shown in Photo 1, which I labelled Windriggercat 5600 (WRC 5600). It has Dory-shape hulls with hard chines, a midship cross-section of 500mm across its bottom, 800mm across the deck, 500mm deep and 5600mm loa. It is powered by two 7 sqm sailboard sails. The hull is symmetrical fore and aft and the surface-shape of it sides is that of a cone. I constructed the hulls from 4.5mm marine plywood and used the West System boat building techniques.

I have sailed it during the last 7 years on inland waters and river estuaries, whilst trying various features and now are confident that it fulfils these requirements. The main features responsible for this result are relatively large beam, low centre of effort (C of E) sailrig, bi-plane sailrig, sailboard sails and unstayed masts. A lot of testing was devoted to developing a lateral-resistance system tailored to suit inexperienced sailors. During this time I produced a second catamaran labelled WRC6800, designed for sailing along seashores with the capability of negotiating surf to land on surf-beach shores. The hull is 750mm diameter amidships and this curvature extends for the 6800mm length of its hull. I constructed the hulls using epoxy and non-woven fibreglass. Each hull weighs about 80 kgs.

I designed the hulls of both of the catamarans using mathematics and transferred their coordinates to Hullform hull-design software to obtain the hydrostatic parameters.

Features of these catamarans are described below.

BEAM -CHANGE

Both catamarans have a sailing beam of 3.8m compared to 2.5m of most trailerable cats. This is due to the beam-changing scheme which for WRC5600, operates as follows: - Photo 2 - the catamaran on its trailer prior to launching, with its hulls folded under its bridgedeck so that its beam is 2.5m, the legal maximum towing width. Photo 3 - floating on its topsides after launching. Photo 4 - A sailrig is added whilst the hull is floating on its side and then the hull to be rotated until the free-ends of the arms contact stop-brackets attached to the bridgedeck. This is a lot easier than erecting a sailrig with the hull upright.

Photos 2, 3 and 4 - launching WRC 5600

Note the way the hulls are unfolded after the rigs have been added, and also the stub keels fitted to these hulls.

Compared with existing trailerable catamarans, this big beam provides exceptional stability. I have never experienced a threat of capsize or unintentionally flying a hull, and never had to move to the windward hull after tacking. I have sailed the catamaran with young children onboard, without their mother expressing concern about their safety.

Photo 5 (overleaf) shows WRC6800 with its hulls folded under the bridgedeck for trailing. Its beam-change scheme was developed to facilitate launching the larger catamaran. Its launching procedure is as follows:- Photo 6 - the trailer is tilted causing the catamaran to slide off it and the hulls spread apart due to water upthrust as its sterns enter the water. Photo 7 - as the hulls spread apart, the ends of the hull pivot-arms rotate until contacting stop-brackets mounted on the bridgedeck where, ultimately the ends are bolted to the brackets. Also, brackets near the pivot point on each arm takeover the load carried by the pivot bolts during rotation. Note that the catamaran is carried on the trailer by rails mounted on the trailer, supporting it on the underside of the bridgedeck. This was designed to eliminate damaging the hulls by the point-contact loads caused by trailer-rollers supporting the hulls - which occurred with the first trailer I made for this boat.

Photo 5 (above) - the cat is carried on its trailer with the hulls folded under its bridgedeck so that its beam 2.5m, the legal maximum towing width.

Photo 6 (left) - the trailer is tilted, the cat slides off the it as the hulls are spread apart by water upthrust as its sterns enter the water.

Photo 7 (below) - hulls spread to its sailing beam of 3.8m and the ends of the swing arms are bolted to the bridgedeck fittings.

SAILRIG CENTRE of EFFORT and HULL LENGTH

Existing catamarans have a very tall sailrig (high C of E), relatively short waterline length and bow sections with very little reserve buoyancy in comparison with monohulls. Consequently they have a high probability of pitchpoling. Although this provides exciting sailing, these catamarans are very difficult to recover from a pitchpole and capsize, and therefore I consider they are unsafe for sailing with children on-board. The bi-plane rig reduces this problem by using two sails instead of one, resulting in a relatively low C of E. Concerning hull length and reserve buoyancy - although WRC5600 has never shown a tendency to pitchpole, I have noticed

whilst sailing in high winds, it has a noticeable bow-down pitch - so I explored ways to reduce this.

The tendency to pitchpole is due a force couple amounting to the sailforce multiplied by the height of its C of E above the waterline, and it depresses the bow by an amount determined by the fore and aft pitch stiffness of the hull. The Moment to Change Trim (MCT) parameter quantifies this pitch stiffness and I used it as an indicator of pitchpoling resistance of a hull - the higher the MCT the greater reaction of the hull to pitchpoling. According to Hullform hull-design software, WRC5600 has a MCT of 1.4 Kg m/cm for one hull. By comparison a 14 foot sailing dinghy has a MCT of 64. I drafted various bow sections in an effort to increase the MCT and concluded that the best way to obtain a real gain in MCT is to lengthen a hull - for example lengthening WRC5600 by 500mm results in a MCT of 2.4

I used this parameter when designing WRC6800. It has a hull length of 6.8m loa and a MCT of 13 per hull.

BI-PLANE RIG

Sail-blanketing is often claimed to be a serious drawback of the bi-plane rigs. I have not found it to be so. It does happen when the wind is directly on the beam and the boat is stationary, but as the boat picks up speed the blanketing disappears - I guess because the wind direction relative to the sails,

moves forward as the speed increases so that the windward sail no longer blankets the leeward sail.

When running directly before the wind, each sail of the bi-plane rig is set outboard of its hull so that the rig is balanced. Do not need spinnakers. It does not produce the high bending loads on the bridgedeck crossbeam caused traditional sailrigs. It is a simple and easy to rig - requiring only 4 pulleys and 2 jam-cleats.

Another reason for using a bi-plane rig is that the sails do not intrude into the accommodation space - as shown in Photo 8 (above). Apart from the foregoing, I selected the bi-plane rig because it has powered the speed-record holders since the 1980s.

SAILBOARD SAILS

I use sailboard sails because they retain their shape and effectiveness in high winds much better than other sails, as proven by the speed records held by sailboards. Also the boom keeps the sailboard-sail leach tight whereas a traditional mainsail requires a multi-purchase mainsheet to do this and exerts very high loads on the associated hull, mast and rigging. Referring to Photo 6, the mainsheet system on my catamarans comprises two stub-masts mounted in the hulls at the aft end of the bridgedeck, which support pulleys carrying a mainsheet from the end of its associated boom, to a jam-cleat mounted on the bridgedeck. In operation, the mainsheet exerts only a horizontal force on the sailrig equal to about half the sail force. This does not require multi-purchase pulley blocks for sail sheeting. If for example, I used a traditional mainsheet, and it was angled 30 degrees to the vertical to sheet-in the sail, the pull on the mainsheet would be doubled and a downward-acting vertical force would be added to the sailrig of 1.7 the horizontal force. Sailboard booms cannot injure passengers and crew in the way traditional mainsails booms do. This is particularly important for sailing on inland waters where winds are more unpredictable and accidental jibes are a more common occurrence, compared with sailing out to sea. Jibes are not a hazard when using sailboard sails and the bi-plane rig in this sailing environment.

UNSTAYED MASTS

Photo 9 shows details of a sailrig I have used on my catamarans. It comprises a sailboard mast housed inside a stub mast with its bottom end supported by a spacer located inside the stub mast. The length of the spacer is set so that the stub mast extends up to the boom attachment point. The stub mast is aluminium tube 60mm diameter and 3mm wall thickness. I first used 2mm wall thickness, but it yielded during trials sailed in 20 knot winds. So I increased the wall thickness to 3mm and eliminated this problem.

For stress calculations, these unstayed masts can be treated as cantilever beams carry only bending loads as they do not have the large compression loads created by mast stays and vertical mainsheets loads typical of traditional sailrigs. These calculations are relatively simple, and the high-stress point is located at deck level where it is easy to monitor - for example with a strain gauge and data logger. When a traditional stayed-mast fails, the stays tether the fractured mast-ends to the hull and generally cause damage to the hull and crew. An unstayed mast should be less of a problem.

The unstayed masts allow the sail rigs to rotate 360 degrees and feather the wind. So at times when the boat is threatened by dangerous winds, one just lets the mainsheets run free, the sails feather the wind, the outboard is started and one heads for the launching ramp. To pass under low bridges, the sailrig is lifted out its hull support and stowed along the deck.

LATERAL RESISTANCE AND HULL/ SAIL BALANCE

Much of the testing of WRC5600, was devoted to experimenting with various lateral resistance systems. The requirements listed in the introduction imposed a number of restraints on the selection of a lateral resistance system had to be compatible with. First of these, the position of the sailrig on the hull was limited to not intruding into the accommodation space limiting its position to not more than 1600mm from the bow. For the same reason I did not consider using centreboards which occupy space in the cockpit. I rejected dagger boards because I considered them not user-friendly. I did not consider using rudders attached to the end of the hulls because I wanted the hulls to be easily convertible to the proa configuration. I could not use the hull alone to produce the required lateral resistance because with the sails were positioned forward, the centre of lateral resistance produced by the hull and rudders would act aft of the C of E, resulting in a lee-helm condition.

The first system I tried was a fixed keel and spade-rudders - which are visible in Photo 5 and Photo 2 respectively. After launching, the two rudders are linked by a cross-bar, or sailed with one rudder after fixing the rotation of the other. Following considerable testing the depth of the keel finished up at 180mm and the size of the spade rudders 200mm square. The keel was 1200mm long and positioned 1000mm from the hull forefoot. This fixed keel/spade-rudder combination made the catamaran simple boat to operate - particularly for inexperienced sailors. The only problem I experienced was the ability of the keel and rudders to hook onto mooring lines.

So I replaced the keels and rudders with chine-winglets (ref. 1) and one lift-up rudder mounted on the bridgedeck centreline. My version of chine-winglets is shown in Photo 10. This system provided a weather helm and windward performance equal to that of most 14-foot catamarans. Also It allowed the catamaran to sail in about 200mm of water. I consider this arrangement is quite adequate and well suited for sailing with the family on-board.

Hull/sail balance that produces a small amount of weather helm was the criteria used for achieving a degree of windward performance. Optimising the hull/sail balance comprised the options of shifting the position of the sailrig and changing the position and size of the keel or chine-winglets and rudders. Ultimately I settled upon size and position of the keel and chine winglets and provided three mast positions to allow for optimising windward performance. The big problem I had with this aspect was testing the windward performance resulting from of these changes. I now have access to a GPS that helps solve this, although I consider sailing against another sailing boat is the best answer.

On one of the WRC 5600 trials, I walked from the stern to the bow whilst my mate steered and noticed that he shifted the tiller from lee-helm to weather to maintain his heading. This means that these hulls experience appreciable changes in windward performance every time the boat pitches because the hulls develop considerable lateral resistance. The hulls of WRC6800 were designed to produce practically no lateral resistance and require a centreboard system to develop the required lateral resistance. This centreboard fixes the centre of lateral resistance regardless of pitching of the hulls, and therefore its windward performance should not be degraded by pitching.

OTHER ASPECTS OF THE PROJECT

DRG A (below) shows details of the hull shape of WRC6800. This shape is an outcome of my experiences canoeing white-water and surf in slalom canoes. These canoes have round cross-sections and are relatively easy control in fast moving water and waves, compared with canoes with chines. I was taught to negotiate beach surf in a slalom canoe by sliding side-ways beam-on to the waves whilst using a support paddle-stroke to prevent rollover. I successfully repeated this in my first proa - a slalom Canadian canoe with a pipe outrigger. This is the way I would to negotiate surf in WRC6800. This catamaran has one lift-up centreplate mounted on the bridgedeck centreline and one lift-up rudder. The first hull I made was tested as a non-reversible proa. It went straight through waves with very little pitching and the cockpit collected a lot of water - the second hull has a self-draining cockpit. So far I do not have any experience of its sailing performance as a catamaran.

On one sailing trial, I encountered a fast flowing tide and no wind. Ultimately I had to accept a tow by a motor boat, to the launching ramp. Consequently, I now carry a 3.3 hp outboard every time I go sailing on my boats. This motor drives WRC6800 at 5 knots at about third throttle measured by a GPS.

On a number of occasions on the Canberra lakes, I sailed WRC5600 with four adults onboard, in winds gusting up to 20 knots (white caps on the water) and it was exciting sailing. A lot of spray and although some of my passengers got wet, they enjoyed it. The catamaran felt very safe and easy to control. But looking around there were quite a number of sailing boats capsized and the rescue boats were very busy. This happens on the lake every time the wind gets over 20 knots. Viewed by non-sailors, it looks dangerous and is probably the reason why only about 0.1% of the community are active sailors. So there must be a market for a safe, comfortable and fast sailing boat - such as Windriggercat.

Ian Smith

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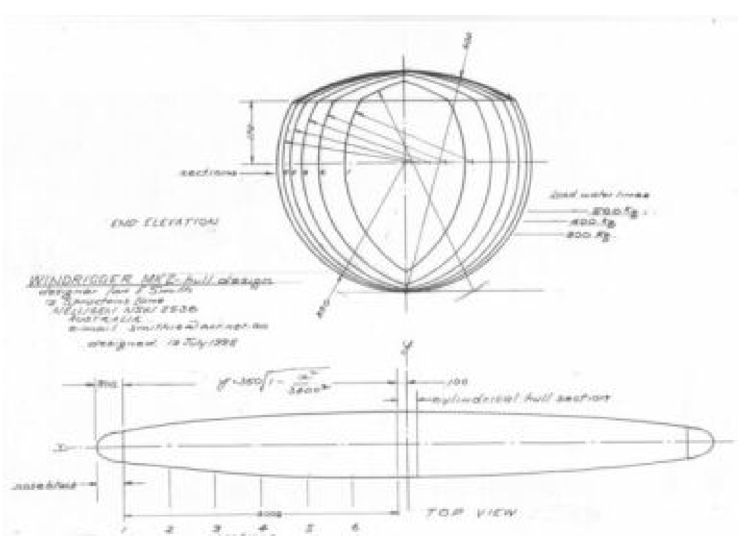


Reference 1 - Winglets and Vortex Generators by Bernard Rhodes, page 35 Multihulls Magazine Nov/Dec 1990.

A Downwind Faster Than The Wind Test Apparatus

Frank Bailey

Periodically, there seems to be a surge of interest in the possibility of a wind-powered vehicle proceeding downwind faster than the wind. Nothing seems to ever bring this project to some kind of conclusion. This paper intends to offer a means of testing a model of a vehicle that is intended to proceed down wind faster than the wind. I would hope the below described apparatus would be assembled and the model tested to shed some light on this idea.

The apparatus consists of a wind tunnel erected over a towing tank. The tunnel is constructed so that a constant air velocity is generated by a fan plus straightening vanes. The velocity can be monitored at four points along the course of the model by digital airspeed meters which are readily available. The inside walls of the wind tunnel should be smooth so that a constant airspeed is obtained its entire length, that is, any bracing should be on the outside. Windows along the length of the tunnel would be useful and it is possible one entire side of the tunnel could be constructed of some transparent plastic material. The test tank could be constructed of ¼ inch ply suitably waterproofed. The moving vehicle is tied to a thread which is wound around the measuring drum and this thread unwinds as the vehicle travels down the length of the tank. The vehicle itself could be constructed so that guide wires stretching the length of the tank could be attached or side rollers mounted to keep the vehicle on a straight course as it traveled down the length of the tank.

It is necessary to determine the velocity of the moving vehicle say, at least at four points, as it travels down the tunnel/tank apparatus. A very low friction assembly of pulleys and thread will do the trick. An apparatus using a photoectric cell could work thusly: Let the cell counting mechanism count, say,. 10 revolutions of the slotted measuring pulley and show the time for this and continue counting for each 10 revolutions as the vehicle proceeds down the tank. This method was used by Edmund Bruce (and me). You then plot this data on graph paper, seconds horizontally and feet vertically. The feet of travel of the vehicle can be determined knowing the number of revolutions of the wheel of known diameter per counting period. The instantaneous velocity of the vehicle can be determined by the tangent drawn at any point on the plotted line. A straight line indicates constant velocity. If the curve slopes upward, the velocity is increasing and conversely if the curve slopes downward the velocity is decreasing.

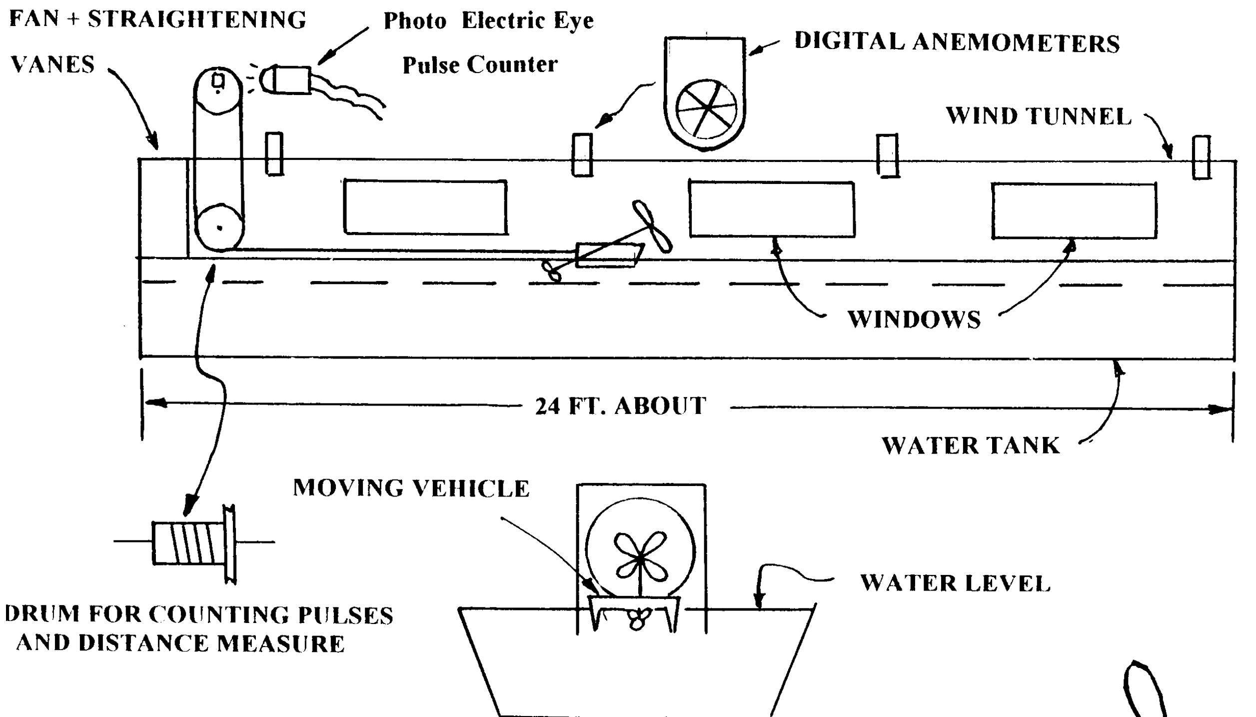
The vehicle itself utilizes a propeller and a windmill type thing on one shaft. It is assumed that the airstream will rotate the windmill so that the propeller will turn so that the vehicle will proceed downwind faster than the wind. There may be other more desirable designs.

And now for a few caveats. It is assumed that downwind faster than the wind means that the vehicle is proceeding exactly down wind and that the shaft for the propeller and windmill is also in line laterally with the wind or airflow, no horizontal angles to the airflow are involved. It is assumed that the test vehicle will approach at some time at least very closely the airspeed generated by the fan. It is also assumed that at some point X-X shown on the ft.-sec. plot that the vehicle will start moving faster than the airspeed. I cannot conceive how this will happen in fact so I have inserted a “black box” between my windmill and propeller. I do not know if this black box is necessary or if it is I do not know what is inside it. I leave that to the theorists or you people in the machine shop. At some point the airflow across the windmill has to reverse, thus a black box may be necessary. A most important caveat is that in previous literature is described what are called “analogies” to this exercise. I submit that in this specific case, any analogy is of no use in deciding the truth or falsehood of the possibility of going down wind faster than the wind. The analogies may possibly be true but I submit that they have no bearing on this specific problem. I have read in some of the A.Y.R.S. publications some of the mathematical theory behind all of this but I am sorry to say I did not at all understand ultimately the mathematics behind all of this. I challenge any of our mathematicians to please explain their theory so that almost anyone can understand their theories and use them to construct this vehicle even if it takes twice the number of pages of your original article. A mathematical theory is of no use to anybody unless it can be readily understood by most anybody with a bit of algebra and basic physics.

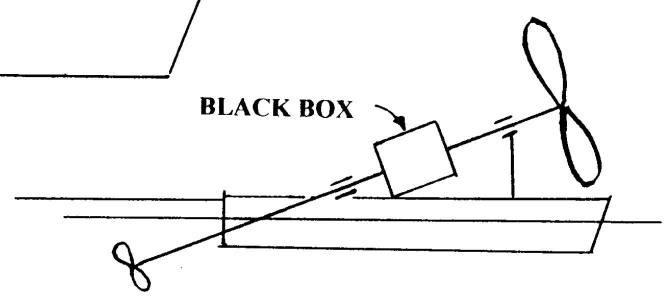
Here is a suggestion. I would like to poll AYRS members asking you whether you believe DWFTTW can be accomplished or not? If you care to, you might want to include the reason for your answer. If you can base their answer on some basic physical fact or formula, all the better, either for or against. Write or email to me at Catalyst.

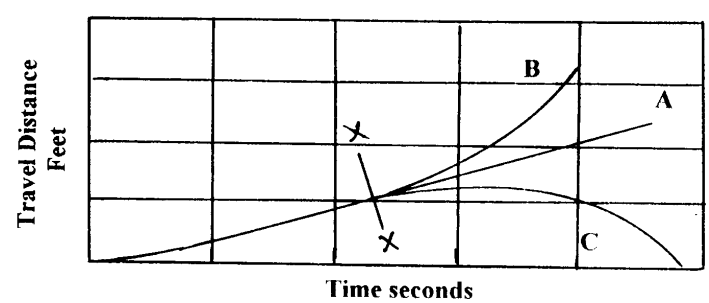
Frank Bailey

TEST APPARATUS FOR DOWNWIND FASTER THAN THE WIND



REQUIRED:
For Prop & Windmill: diameter, pitch, number of blades, and blade area





TYPICAL POSSIBLE PLOTS

Curve A: Constant Velocity
Curve B: Increasing Velocity
Curve C: Decreasing Velocity

<u>A Few (but not all) References</u>

#74	1964, page 117
#91	1979, entire
#98	1983, page 5 and 11
#100	1984, page 27
#101	1985, see list of references page 24
#120-I	1995, page 60 possibly

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@fishwick.demon.co.uk***

November

5th ***AYRS London meeting*** on ***Windmills and Gyroboats*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

December

4th ***AYRS London meeting*** on ***Landsailing*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

4th-6th ***High Performance Yacht Design 2002 -*** Conference at the University of Auckland School of Engineering, Auckland, New Zealand. hosted by the University of Auckland, Massey University and the Royal Institution of Naval Architects. Details from RINA High Performance Yacht Design 2002, Private Bag 102904, NSMC Auckland, New Zealand; Tel: +64-9-4439799 ext: 9560; Fax: +64-9-414081; http://www.hpyacht.org.nz

January 2003

2nd - 12th ***London International Boat Show***
Earls Court Exhibition Hall. Those who can give a day or two, from 15th December onwards, to help build/staff the AYRS stand (***reward - free entry***!) should contact Sheila Fishwick
tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

11th ***AYRS Annual General Meeting*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

February

5th ***AYRS London meeting*** on ***John Hogg competition*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

March

5th ***AYRS London meeting*** on ***Members projects*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

April

2nd ***AYRS London meeting*** on ***Subject to be announced*** 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

AYRS London Meetings

Please note that from December 2002, the AYRS London meetings will be on the first WEDNESDAY of every winter month, not the first Tuesday. Still at the London Corinthian Sailing Club though.

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

On the Horizon . . .

High speed sailing craft - Giles Whittaker
Autonomous Winsailed catamaran - Gabriel Elkaim
Paddle wheels - Ambus Janko
Mill-Prop Paradigm - Peter Sharp
Flying Proa - Roberto Rampinelli
Low drag Displacement Hull - Michael Wingeatt
More sources and resources: reviews, publications and Internet sites

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Amateur Yacht Research Society
BCM AYRS, London WC1N 3XX, UK

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