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AYRS 112

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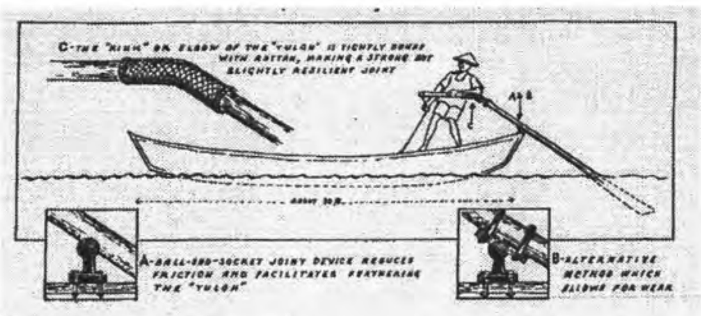

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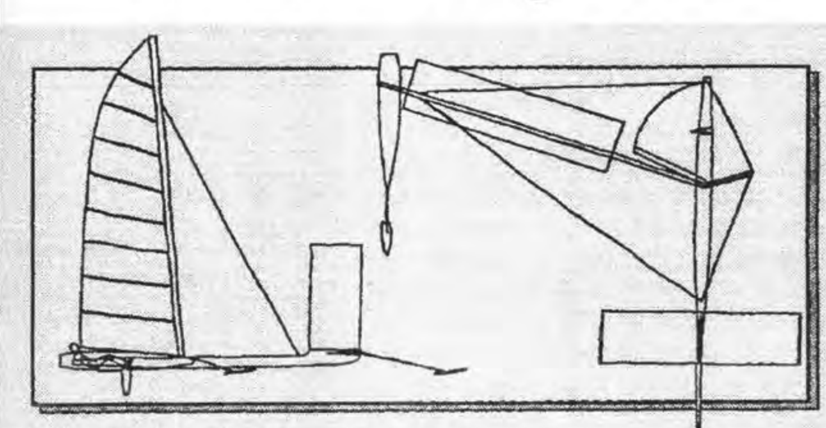

What is it?

Postscript

Since writing the introduction to this issue and editing the contents I have thought some more about AYRS projects. It occurs to me that we have a rich fund of knowledge, skills and experience within AYRS. The problem often is that no one person has all the knowledge, skills and experience to complete his project. What we need is a way to put these individual abilities together and to apply them to projects.

You have a great sailing project designed but not the constructional skills to carry it through? Someone else is looking for a boat to build for Weymouth next year. The two problems (that you share a similar goal) solved.

You have a new concept or sail design but no boat on which to try it. Someone else has a boat to carry new sails. The same problem.

I have been thinking about a computer dating agency for AYRS projects. If you let me know what you want to do and what help you require to do it, I will check whether anybody else has expressed related complementary needs and resources.

There is no such thing as a free lunch. The price of this service is that I will know who is working on a project and will pester you for progress reports.

The strength of AYRS is in the variety of knowledge and skills possessed by members. Let's get these harnessed into more projects and then I can edit two issues a year on "members' projects".

Final Thoughts

After reading the contributions for this publication our administrative rather than dreams I now have a dream. I see a 50 ft sailing catamaran powered by Greenup's ... but with Dick's self digging rails, rigged, standing on Jon's roller reefing mast. The hulls are cut to the water courtesy of Will's submersion, and the whole is self-steered by Henry's steering gear and controlled by Captain Ullen's windvane. We are fully automated.

I am lounging on the deck with nothing to do but sort through the mountain of contributions for the next issue of "Members' Projects" (that really is a dream!). Could someone please design me a wind/water/sun (yes, it is sunny in my dream) powered generator to run the computer for the next editing session?

Tony Kinnear

The Amateur Yacht Research Society

Founded in 1955 to encourage Amateur and Individual Yacht Research

The Society (open membership) furthers the theory and practice of nautical science and related subjects. Educational Charity (No 234081) and a company (No 785327) without share capital, limited by guarantee.

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AYRS Projects – 1993

With contributions from;

Captain Uller

Henry Gilfillan

Dick Hazelwood

Josef Dusek

Giusseppe Gigliobianco

Wil Gillison

George Chapman

Miles Handley

Roger Glencross

Adrian Nutbeem

Tony Blofeld

Tony Kitson

Simon Fishwick

Dave Culp

Edited by Tony Kitson

February 1993

CONTENTS

Introduction	*Tony Kitson*	5
Windvane Steering Gear	*Vagn Uller*	7
Rudderless Steering	*Henry Gilfillan*	9
The Flowtiller	*Dick Hazelwood*	19
Anybody for a flying jib?	*Josef Dusek*	24
Tripod rig	*Josef Dusek*	26
Windmill Catermaran	*Giusseppe Gigliobianco*	29
Submerged Bouyancy Trimaran	*Wil Gillison*	33
Calliope Catermaran	*George Chapman*	36
Sting	*Miles Handley*	40
Sailingcraft Hagedoorn	*Roger Glencross*	42
Free Energy V	*Adrian Nutbeem*	44
Trifly & Speedwing	*Tony Blofeld*	50
Are you really Serious?	*Tony Kitson*	56
Nimanoa	*Simon Fishwick*	59
One oar in the water	*Dave Culp*	62
Postscript	*Tony Kitson*	67
Final thoughts	*Tony Kitson*	67

Introduction

I am particularly pleased that my first AYRS publication is a report on 'member's projects'. For many years I have been an 'armchair' member of AYRS. Reading about the projects conducted by enterprising members has consoled me through the years of living in London with a young family, when any contact with boats was a rare luxury. AYRS publications have provided my 'Virtual Reality'.

For people like me, the importance of the publications is obvious, but publications are only a part of the function of AYRS. The society has a mission to encourage active experimentation by members. The subject coordinators are part of this, the London meetings are excellent for those living near enough to attend, and Speed Week provides a focus for those interested in fast sailing. But do we do enough? What more could we do?

Before editing this issue, I was complaining that there is too much talking and not enough doing in AYRS. The contents of this issue, 'achievements not dreams', have proved me wrong, but I think we are still only scratching the surface. There are projects out there that we have not yet heard about. If you have a project that you are working on, write to me.

There are also projects not yet started for a variety of reasons.... can we help? If you have any ideas about how AYRS can help you to get started on the project you have been dreaming about, write to me. If you have any ideas about how you could help someone else realise their dreams, write to me.

If you just want to keep dreaming, happy dreams. My dream is to edit a **'Members' Projects'** issue every year, I can only do that with your help.

The Contributions

The only rule that I have set for entry in this publication is 'achievements not dreams'. All (but one) of the contributions represent concrete achievements. Some projects are complete and others are continuing, but all are examples of the effort and commitment required to make progress in any research.

Our first trio concerns the bits that go in the water. **Captain Uller** has produced a new and compact form of wind vane self steering which is claimed to be easily fitted to any hull. **Henry Gilfillan** requires no wind vane nor even a rudder. He describes an experiment to steer by fore and aft movement of the centreboard. **Dick Hazelwood** revives the rudder, but as a means of propulsion rather than steering.

The next two contributions, both from **Josef Dusek**, concern the bits in the air. In his first contribution Josef describes his experiences with a flying jib on *Dalibor*. Josef's second contribution is the exception to my rule,;it describes an idea for a derivation of the pyramid rig, called, by Josef, the tripod rig. I include it with two excuses. Firstly, Josef's record of innovation and implementation of ideas. I am sure that we will see Dalibor with a tripod rig before too long. Secondly, Josef's proposal bore such a resemblance to the, contribution from **Giusseppe Gigliobianco** that I thought the two should be published together to encourage further development of both. Giusseppe brings water back into the equation with his development of combined vertical windmill and vertical (Voith–Schneider) propeller.

Wil Gillison takes us to a further domain, beneath the water, with his development model for a submerged buoyancy sailing craft. **Simon Fishwick** takes us backwards, and forwards, quite literally with his proa, *Nimanoa*.

The final group are all involved directly or indirectly with speed sailing. **George Chapman** describes his new boat *Calliope*, not strictly a speed sailing boat but a fast, foil assisted catamaran owing much to George's extensive experience in speed sailing. The contributions from **Miles Handley, Roger Glencross, Adrian Nutbeem, Bob Downhill** and **Tony Kitson** all describe craft participating in the 1992 Weymouth Speed Week. Finally, **Dave Culp** describes his latest speed sailing boat, designed by **Greg Ketterman**, of *Longshot* fame.

Tony Kitson *January 1993*

ULLERMATIC WINDVANE GEAR (pat.pending.)

Capt Vagn Uller

The **'Ullermatic windvane-gear'** – is a simple design of sturdy construction which can be attached to all kinds of yachts – single, double or triple hulled. The concept is revolutionary, the design slim and elegant, and is easily attached to any yacht. The steering capacity is perfect under all weather conditions and it makes no difference whether the windvane–gear operates with tiller or steering wheel – the effectiveness is guaranteed.

Before the first model was released for sale it underwent very serious testing on different boat types under all weather conditions. The 'Ullermatic windvanegear' proved itself to be very reliable and strong, the feedback from purchasers has confirmed this.

The system makes it possible to attach the windvane–gear for test–sailing on different boats without drilling holes. This also improves the possibility of mounting the windvane–gear at the most suitable spot on the stern of any individual boat.

Steering Principle

When the boat deviates from her windward course, the changed wind direction will cause the vane to tilt to one side or the other. This activates the connecting rod, and the angle of the blade in the water is changed by the trim tab. Now the changed water pressure will cause the blade to be sucked up or down.

The blade will move the inner tube upwards or downwards depending on the tilting direction of the vane.

The ropes will now move the rudder/wheel to steer the boat into the desired course, thus bringing the vane back to its original desired position. The windvane gear is once again ready to react promptly to any alteration of course.

Ten Facts about Ullermatic

1. Manufactured entirely of stainless steel, fibreglass and Delerin bearings.
2. No custom–made components.
3. Compact not disfiguring the yacht.

4. Light weight, approx 11 kg in water.

5. Simple mounting by means of fittings.

6. Fast mounting/demounting without tools.

7. Small vane.

8. Can be mounted conveniently anywhere on the stern, not necessarily in the centre plane of the yacht.

9. Easy to operate.

10. Steering transmission to main rudder (tiller/wheel) resulting in high steering force.

Capt. Uller invites those interested to Faaborg Harbour (Pos. 55 05 N – 10 15 E), Denmark for a test sail on your own yacht – or to write for further information:

Ullermatic,
Bjernevej 53,
DK–5600
Faaborg,
Denmark.

Ed. Ullermatic is also available in England from;
009 Hamble Point Marina, Southampton, SO1 5NB

RUDDERLESS STEERING

by Henry W Gilfillan

Introduction

All sailboat steering systems reduce essentially to means for controlling the instantaneous positions and transient migrations of the craft's aerodynamic centre of effort (CE) and the hydrodynamic centre of resistance (CLR) with respect to each other. Misalignment of the horizontal forces acting through these centres results in the imposition of turning moments on the craft which persist until alignment is restored.

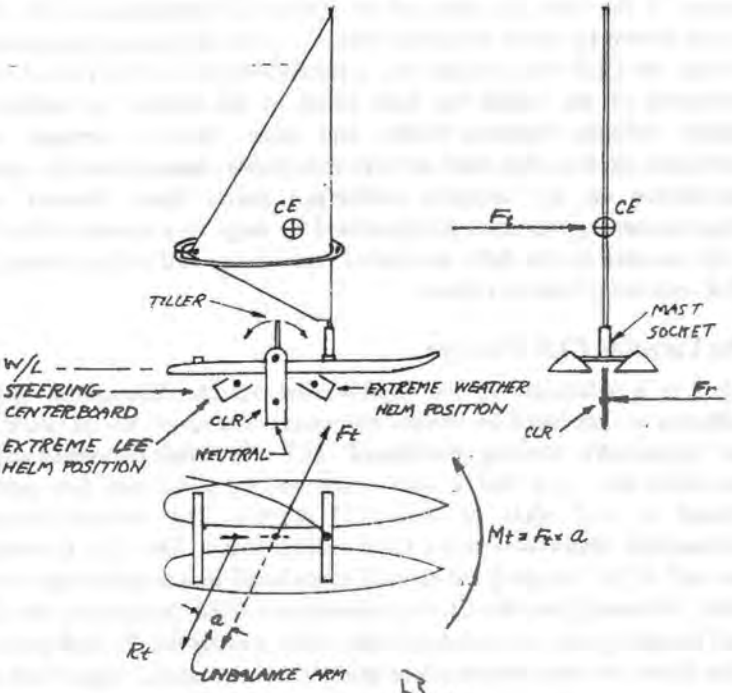
Most sailboats rely upon a large lateral plane(s), such as a keel or centreboard(s) to provide most of the required lateral resistance, with smaller contributions from the hull(s) and rudder(s).

The conventional rudder, which pivots about a substantially vertical axis, is usually thought of as generating a turning moment about the centre of gravity of the craft by virtue of its horizontal hydrodynamic lift. It is readily shown by vector resolution that this is the mechanical equivalent to moving the CLR with respect to a comparatively fixed CE. In any event movement of the rudder has little effect in the absence of substantial relative velocity between rudder and water, that is, steerage way. Sailboards, on the other hand, achieve remarkable manoeuvrability without dependence on any movable submerged lateral plane. Instead, very adequate turning moments are generated by large movements of the CE, made possible by the fully articulated mast, boom and sail assembly, the CLR remaining relatively fixed.

The Variable CLR Concept

Fig 1 is a schematic of the experimental vehicle. Substantial turning moments are produced by manual movement of a single lateral plane that may be termed a 'steering centreboard' (SCB). The blade is pivoted about a horizontal axis such that it may swing and be positioned fore and aft through a wide angle of about 135 degrees. The unstayed mast is continuously rotatable within a fixed vertical socket. The CLR is movable fore and aft by swinging the pivoted centreboard in a longitudinal vertical plane. Assuming that the CE is comparatively fixed, positioning the CLR well forward produces a weather helm, while moving the CLR aft produces a lee helm. At some intermediate point there is a neutral helm with zero turning moment. Now the total aerodynamic force, Ft is equal and opposite to the total hydrodynamic resistance, Fr. Shifting the CLR away from neutral introduces an unbalance arm (a) between Ft and Fr, and the resulting turning moment, Mt = Ft x a. Note that if either the moment arm, a, or the wind generated force, Ft, is zero, there exists no turning moment, and hence the craft will tend to move in a straight line or remain at rest. Also, it is very important to note that Mt is independent of boat speed and can be controlled in magnitude and direction even though the craft may be moving backward, forward, sideways or not at all. The unexpected result and special virtue of the concept is that the boat may be yawed at will to, and maintained at, any desired angle with respect to the apparent wind regardless of boat speed and/or wind velocity. This is in contrast to a conventional rudder which depends almost entirely on substantial boat speed to be effective.

FIG. 1
TEST VEHICLE



The Test Vehicle

Specifications of the actual experimental catamaran used to explore the Variable CLR design approach are as follows;

LOA	12'6"
LWL	10'0" (approximately)
Beam	5'2" (adjustable up to 6'4")
Weight	160lb (can be much reduced)
Sail Area	65 sqft
Hulls	'Fanatic 300' (220 litres each)
Mast	Aluminium, unstayed, fully rotatable
Wetted Area	40 sqft (approximately)
Draft	(Board down) 30"
	(Board up) 1.5" (approximately)
Disp.	320 lbs (crew 160 lb)

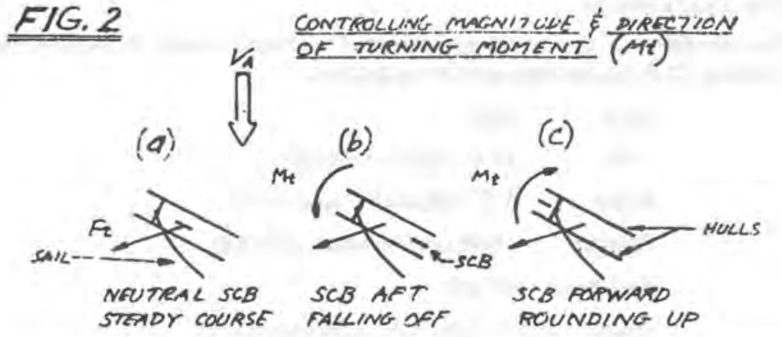
Fig 1 shows a single sail with the mast centred between the hulls and positioned longitudinally such that the CE lies nearly vertically above the CLR of the SCB when the latter is vertical.

The surface piercing SCB is pivoted between the hulls and can be swung aft completely out of the water for beaching.

Fig 1 shows the craft close reaching on the starboard tack. As long as the SCB remains in a position of neutral helm, a steady course will be maintained. Should the SCB be moved aft, the resulting Mt will cause the boat to fall off, and when the new desired heading is achieved, the helmsman will seek a new

neutral SCB position, which he will find to be somewhat aft of the prior neutral. Similarly, if the helmsman desires to steer a more windward course, he moves the SCB blade forward to cause the boat to round up. Again, he will seek and find a new neutral SCB position, which will be further forward than before. The foregoing applies to either tack, that is, SCB forward to round up, aft to fall off. Sail trim, of course, is coordinated with changing headings and other conditions, which will be examined in more detail below.

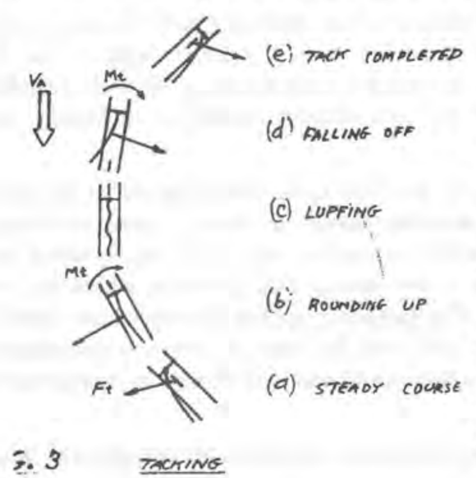
In order to explore and explain the basic and advanced manoeuvres with



this steering system, a more or less shorthand form of pictorial representation will be resorted to hereinafter. For example the conditions in Fig 1 will be represented as in Fig 2.

On–the–wind Steering and Manoeuvres

Fig 3 illustrates the tacking manoeuvre. Prior to initiating the tack, Mt is zero and the course is steady, as at (a). At (b), SCB is moved well forward and the sail sheeted amidships, resulting in a strong windward turning moment. At (c) the sail luffs as the bows pass through the eye of the wind and Mt drops to zero. At (d) the sail is back winded restoring a high value of Mt in the same, but now leeward, direction. At (e) the tack is complete. with appropriate sail trim and SCB in neutral.



Large turning moments are available whether the boat speed is fast, slow, zero or negative. Angular velocities achievable are of course less in lighter than in stronger winds, but the required sea room is comparable in either case. Immediately upon completing the tack, say to starboard, the helmsman may elect to tack again to port without first getting on way. He may change his mind at any point during the tacking manoeuvre, albeit at some expense of windward position. Extremely short tacks are thus possible. In fact, with the test vehicle, it has been possible, in light winds, to sail indefinitely within a 40 ft square enclosure without touching the boundaries.

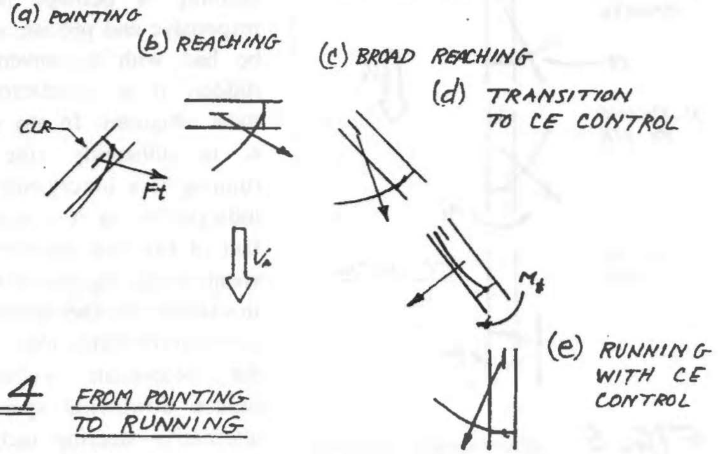


FIG. 4 FROM POINTING TO RUNNING

Off–the–wind Steering

Fig 4 illustrates how, as the course steered becomes more and more off the wind, from pointing to reaching to running, and the neutral position of the SCB moves further aft, the effectiveness of moving the SCB to produce turning moments is diminished. This is because the sail is normally sheeted further out on these courses and hence the direction of Ft through CE is shifted forward, resulting in a smaller change of moment arm, a, per increment of CLR movement. This particularly reduces the availability of leeward turning moment,

as the SCB is already near its aft limit. (An excess of windward moment is still available because the SCB may be moved radically forward.) However, adequate leeward turning moment may be had by momentarily sheeting in, thereby swinging the aerodynamic force vector Ft forward of the CLR. Thus, the burden of steering gradually shifts from SCB positioning to sheeting angle control as the craft falls off to a dead run

Directly downwind, SCB is maintained in the extreme aft position and steering is entirely by means of boom positioning, as in Fig 5. At (A) Ft passes through the CLR and course is steady. At (b), sheeting in slightly moves Ft forward of CLR with a resulting leeward Mt, in this case to starboard. At (c) sheeting out slightly rotates Ft to the other side of CLR, Mt changing to port.

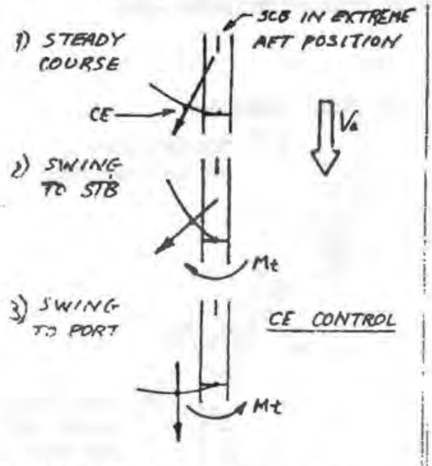


FIG. 5 DOWNWIND STEERING

Although steering solely by sheeting is perhaps not as responsive and precise as may be had with a conventional rudder, it is satisfactory in most situations. In any event, it is unhappily true that running is a luxury not often indulged in. as it is a sailing fact of life that most of it is spent struggling to windward. In extreme weather conditions, or when for some other reason the helmsman wishes to reduce downwind speed, an alternative steering technique is available. As illustrated in Fig 6, if the boom is released the craft will proceed more slowly downwind, driven only by the aerodynamic drag of the luffing sail and all other air immersed parts. Steering moments can be produced by filling the sail on one side or the other.

Freestyle Sailing

The Variable CLR design approach makes possible a variety of new manoeuvres, and opens up the specialty of "freestyle sailing" (hitherto largely monopolized by windsurfers) to flat bottomed multihull and perhaps to other sailboats. Following are freestyle or "figure sailing" tricks and manoeuvres found to be possible with the test vehicle. The list is incomplete as new choreographic stunts are still being discovered and perfected.

Henry describes a number of other manouvres both conventional and 'freestyle', space precludes their inclusion but the sample of his pictograms illustrate the variety attained. (Editor.)

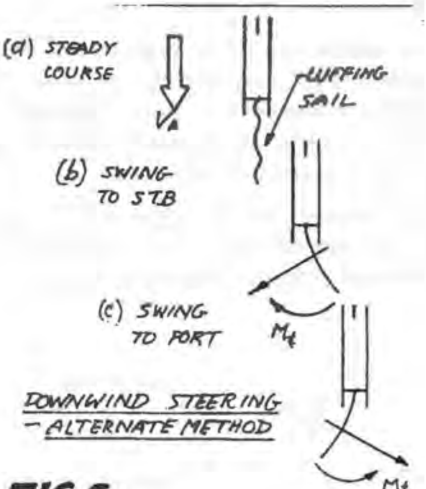


FIG. 6

Going Aground And Beaching

Beach launching and haul–out are facilitated by the design feature which allows the steering centreboard to be swung completely out of water. There are no other pro-trusions below hull bottom to be snagged or damaged, and the draft is of the order of 2 or 3 inches.

Touching bottom with the SCB while under way, however, introduces unexpected expected difficulty. Since when grounded the blade cannot be moved through vertical, it is restricted either to forward (weather helm) or aft (lee helm) positions, and SCB cannot be moved from one to the other. In some situations the helmsman can steer well enough with sail alone to work into deeper water. In many cases judicious use of a paddle blade as a movable lateral plane can substitute temporarily for the SCB to control the CLR sufficiently to go somewhat to windward.

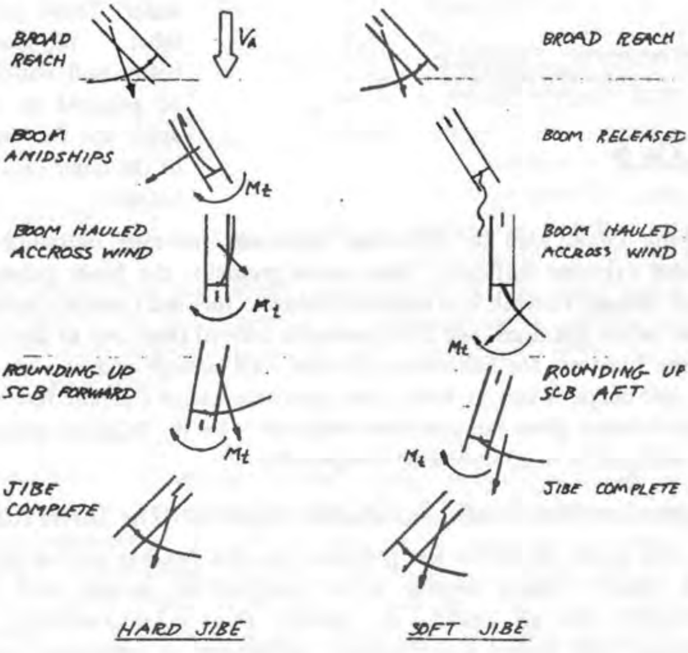
Comparison With Traditional Rudder Steering / The Down Side

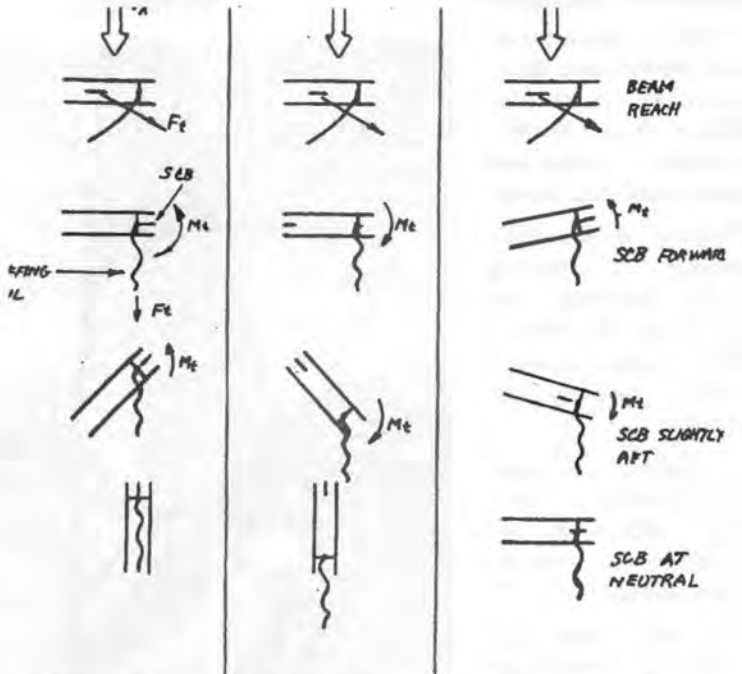
Up to this point, the author was persuaded that his steering innovation was in all respects clearly superior to the conventional system with fixed centreboard and aft rudder. To confirm this belief absolutely, the centreboard was locked in the vertical position and an appropriate rudder installed aft. To his dismay, it was immediately apparent that the traditional system was much more responsive to the tiller, once sufficient steerage way was achieved. It was judged that at about two knots the competing systems performed equally well. Below that, the steering centreboard reigned supreme.

Miscellany

After more than fifty outings, the author has yet to capsize, and hence righting techniques remain undeveloped, imprudently awaiting the inevitable. He was once humiliated by a windsurfer's classic "slam dunk", being swept overboard, but as the boom was automatically released, the boat did not sail away and he was able to reboard quickly.

The general design shows some promise as an improved "cruising sailboard". Camping gear could be carried above deck in removable watertight containers, and the option of sitting would reduce fatigue over time and distance.

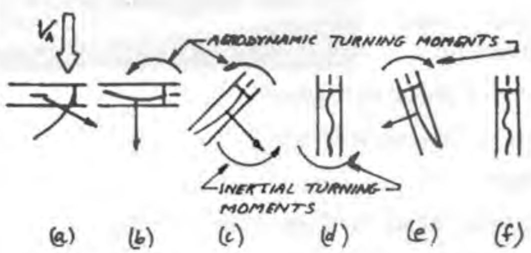




(1) LUFFING HEAD TO WIND. SCB FULL FORWARD

(2) LUFFING DOWN WIND. SCB FULL AFT

(3) LUFFING ABEAM WITH MINIMUM DRIFT. SCB NEAR NEUTRAL POSITION



(a) AERO FORWARD DRIVE.
(b) INERTIAL FORWARD DRIVE ONLY.
(c) AERO PLUS DIMINISHING INERTIAL DRIVE.
(d) DIMINISHED INERTIAL DRIVE ONLY.
(e) GREATLY DIMINISHED INERTIA DRIVE MINUS AERO DRIVE.
(f) COMPLETE STOP

Sailboard Catamaran

Advantages:

1.Small, inexpensive, high performance beach catamaran assembled largely from standard sailboard components (hulls, mast, sail, boom).

2.Highly manoeuvrable because of steering system innovation. Can sail indefinitely within a 40 ft. square enclosure without touching the boundari

3. Capable of many choreographed 'free-style' manoeuvres not possible with conventional sailboats.

4. Good speed and windward performance. Adapts exceptionally well to shifting and gusting winds. Very stable downwind.

5. Beachable, easily paddled, cartoppable.

6. Sailed sitting, kneeling or standing.

7. Convertible to "cruising sailboard".

Disadvantages:

1. New, unfamiliar sailing techniques to be learned.

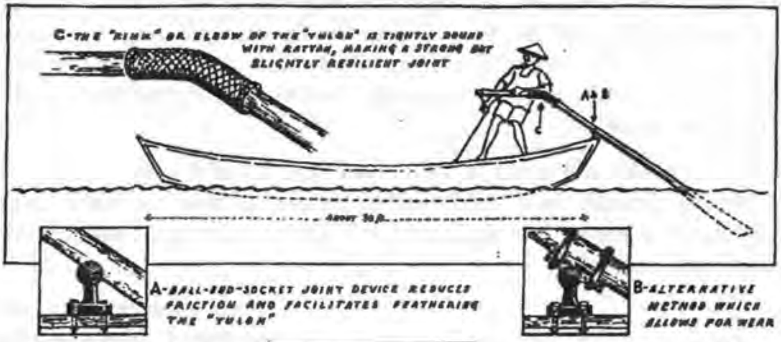
2. Comparatively deep draft (about 30 in.), but centreboard folds for beaching.

THE FLOWTILLER

ANCIENT CHINESE ART WITH A NEW TWIST

by Dick Hazelwood

I have, over the past year, been messing about with what can be described as an automatic sculler for small boats, only to find out recently that what I have devised can be viewed as a "better yuloh". Before giving details of the "flowtiller", I had best first describe the yuloh, since it is not that well known in the West, and came as a complete surprise to me.



I was referred by a friend to Eric Hiscock's "Cruising under Sail". Hiscock considers the yuloh, a Chinese sculling oar, as an alternative to an auxiliary engine, for small yachts entering port etc. Despite a helpful letter from Mrs Hiscock, his widow, I only got detailed information more recently, from library searches in the local university and the National Maritime Museum at Greenwich. The picture above is copied from the Mariner's Mirror Journal Vol 36 (1950) in which Sir Frederick Maze describes the yuloh as "a scientific development of sculling". As can be seen, the Chinese boatman propels his sampan standing at the stern, moving a bent oar in a figure of eight fashion. The combination of the bend in the shaft and a ball and socket support, means that the yuloh blade is automatically rotated to give an angle of incidence to the water suitable to give "lift" (actually a mainly downward force) perpendicular to the motion. The downward force on the blade is resisted by a cord linking the handle to the deck, the combined force keeping the yuloh on the ball. Despite the seemingly unfavourable geometry, the yuloh is evidently efficient. Maze recounts a race between a British naval four oared boat, challenged by a comparable Japanese sampan with four yulohs. The sampan won.

This came as welcome evidence to support my view, that the use of bluff bodies dragged through the water (e.g. oar blades held perpendicular to their motion) is inefficient compared to the use of a well designed hydrofoil propulsion. Oars will shed continuous vortices from both edges, which dissipate power. By comparison, a foil should only shed vortices from its ends. This is, in part, an explanation for the benefit of screw propellers over paddle wheels.

However, last September, well before I knew all this, I was intrigued by the opportunity to try the forward facing oars devised by another contact, Howard Goddard of Fleet. His ingenious hinge allows the oarsman to sit on a standard sliding seat, but to row forwards. The principle snag, for me, an unaccustomed user, was the need to fix the oars to the outriggers, and consequent trouble escaping from the clutches of the reed beds of the Basingstoke canal.

This experience was followed by a sail in a friend's Lark on Rutland Water, in virtually zero wind. Whilst amazed at how the Lark could respond to imperceptible zephyrs, I still spent some time waggling the rudder and meditating.

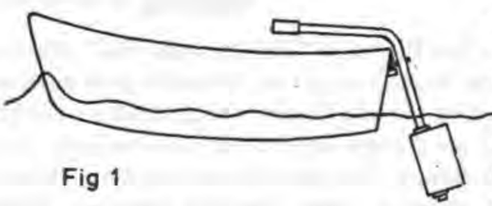


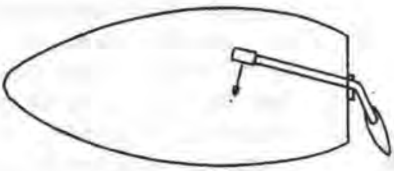
Fig 1

After some initially unsuccessful experimenting in our garden stream, I came to the conclusion that I needed a foil which would align itself. Much to my surprise, I found this to be entirely feasible.

The "self–aligning" foil idea has since been tested in a sequence of prototype "flowtillers".

The more recent foils (Mk.2 is shown in the photo) are modified NACA 0012 symmetric sections, made of marine ply (data from Ross Garrett, The Symmetry of Sailing). The novelty lies in the support, which consists of an aluminium shaft through two plain PTFE bearings. The foil (Fig 2) is thus quite free to pivot about the shaft, on a line parallel to the leading edge. The bearings are positioned so that the pivot line lies between the 1/4 chord centre of effort (C.E.) and the 1/3 chord maximum thickness position (see Fig 4). It is thus unstable at zero incidence ($\alpha=0°$); but rather than rotating to the $\alpha=90°$ attitude as expected (like a typical slalom kayak when inadequately controlled), it stabilises at a high lift position ($\alpha=15°$).

When mounted as a standard rudder it then applies "full lock" of it's own accord, but in a random direction.



However, if the tiller is itself pivoted on a backward projecting thole pin (Fig 2), and driven from side to side (Fig 3), the boat moves smartly and very quietly forward. There is no splash or fuss, and no great impression of speed, but speeds close to the "waterline speed" (10ft dinghy) are achieved. As the tiller handle is pushed and pulled sideways, the shaft supporting the foil also moves sideways, and the foil flips at the end of each stroke to align itself to the consequent relative flow. If the tiller is held to port or starboard, the boat turns as normal.

The device is easy to use. In contrast to other sculling methods including the yuloh and Gondolier's oar, you can sit down safely near the stern. This precludes the use of body weight, so less instant power is likely to be available; but I was not primarily aiming at speed. Another notable virtue over oars became apparent in a trial in a very small square dory on the Avon in Bath. When rowing there was barely room for one passenger, whilst two could easily fit in with the flowtiller.

Watching the action of the foil is fascinating, although prone to wreck the trim of the dinghy. I found it best to use 25 or 50 litres of water ballast near the bows, to allow me to look down over the transom. At low speed the foil flips through well over 90°, as it is swung to and fro. However, as the boat gathers way, this change in angle is reduced. This is due to the automatic control of the angle of incidence, α. As the boat speed increases, the total velocity vector of foil through water (V in Fig 3) rotates toward the forward direction. The foil alignment follows, and the angle of the foil to the forward direction diminishes. This automatic foil incidence control seems to me both wonderful and potentially valuable, and a patent has been applied for.

The commercial virtue of the flowtiller as an application of the self aligning foil is still unproven, and needs more work. Current prototypes are still prone to mechanical failure, and seem to have an efficiency which diminishes with speed, when the "fish tail" action becomes less dramatic, moving back and forth through a smaller arc. A rather different mounting awaits testing which should give a higher lateral foil speed and hopefully a higher forward boat speed. A higher aspect ratio would also help.

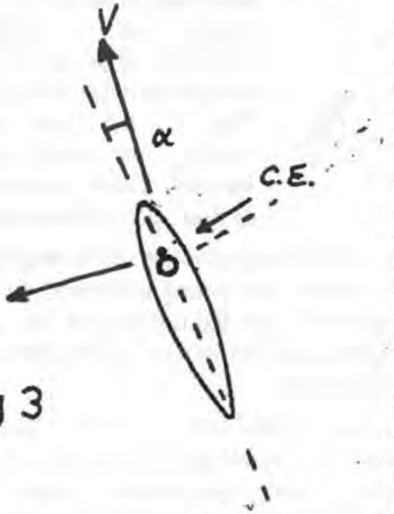
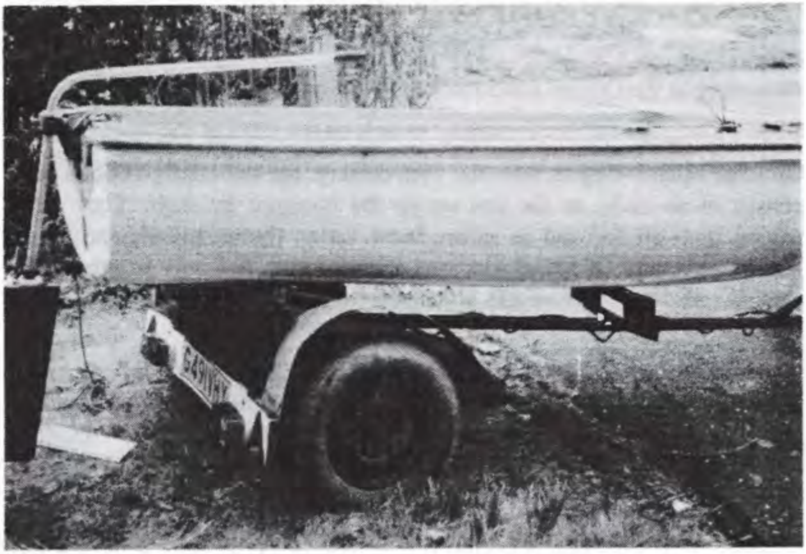


Fig 3

One reason for writing this is to proffer the self aligning foil as a possibly more generally useful device. I have recently lent the Mk2 foil to Dr Alan Packwood of Surrey University, for wind tunnel testing as part of a student project. I hope to learn some more about how and why it works. Hydrodynamic theory is fine for the prediction of the effects of attached flows (potential theory, boundary layer theory etc), but of limited use for partially detached flows, which I believe occur around this device.

I anticipate learning that the penalty for free incidence control is additional drag. However, my tests in a crude rotary flume (a 12ft diameter tank with a central island and outboard motor to spin it up!) showed a reasonably respectable lift/drag ratio. I look forward to some more precise data from the air tests, although I reserve some doubts about the adequacy of modelling water with air when studying flow detachment.

Kites can be viewed as self aligning foils, but depend on being asymmetric. The self aligning Brunton Autoprop is also an asymmetric design. The flowtiller requires a symmetric foil to operate in both directions. I would be interested to hear of any other possible applications for a self aligning symmetric foil. I am also now interested in finding anyone with experience of the use of a yuloh. Why not repeat the race described by Sir Frederick Maze?



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Mariners Mirror 1950, figure reproduced by kind permission of the editor.

ANYBODY FOR A FLYING JIB?

by Josef Dusek

According to the Oxford Dictionary's definition of a jib:–

Jib is a triangular sail set by sailing vessels on the stays of the foremast.

On large square–riggers from the 19th century, the sail configuration could consist of as many as six jibs set on the bowsprit by stays. They were named from aft forward as storm, inner, outer, flying, spindle and jib of jibs, respectively. A set of jibs was a useful tool, not only to propel the ship, but also to trim fore and aft the centre of effort and assist in steering the ship.

FIG 1.

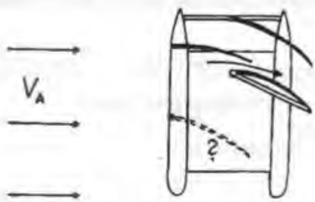


FIG 2.

FIG 3.

But how did we start using such an ancient device on modern multihulls? Naturally most multihulls use jibs of various sizes and shapes in front of the mast but rarely flying. What does it mean? The wide platform of multihulls allows us to set up a jib on a movable stay (which can be sewn to the luff of a sail itself) to windward, fixed to the float of cat–tri–foiler etc, (Fig 1). Added sail area will help light wind performance though the sail might have to be smaller in heavier weather for windward work.

On a broad reach, (Fig 2) the flying jib brings back into play the "slot effect" over the mainsail and doubly improves the efficiency of the configuration.For running, (Fig 3) two flying jibs are set, wing to wing, sheeted inward allowing elimination of the mainsail and the danger of an accidental jibe. By trimming the jibs, the vessel can be partly steered in an emergency, eg. lost rudder. Most of the spare jibs can be used.

This system was tried in Sydney Harbour in the early eighties (see picture 1) using a jib from the pyramid rig. When I changed rig on Dalibor–Foiler (Multihulls Publication) from pyramid rig to cutter rig, the main reason for experimenting was to explore the benefits of sloping sails which produce not only power but also a handy stabilising effect as on the pyramid rig.

During 1987 Dalibor cruised from Seat to La Manga del Mar Manor (near Carragena – Spain). The flying jib proved to be a real benefit for cruising distance made good. Light sea breezes along Spanish coast called for more sail area (Genacar did not exist at that time) and by playing with the flying jib, I discovered the slot effect over the mainsail during a broad reach. An additional one knot increase in speed was the deciding factor in getting to the next port of call ahead of the rest of the fleet of cruisers (both sail and motor) and finding a spot for the night for my wide Dalibor beam, which is a problem for any multihull, especially in the Mediterranean.

Dalibor is now day chartering in La Manga on a natural sea lagoon, Mar Manor, and I frequently use the flying jib (see pic).

It would be selfish of me not to share this idea with other multihullers when this system could help improve performance, comfort and safety. Happy jib flying.

TRIPOD RIG

by Josef Dusek

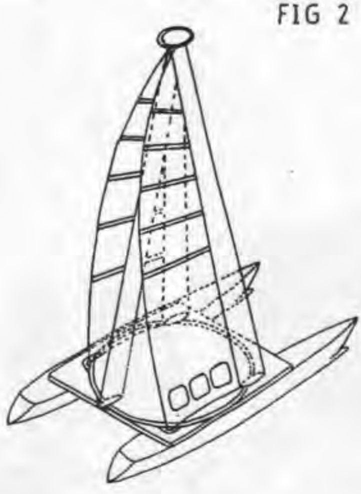
The Tripod Rig was not born on a whim of nature but rather by logical development from the pyramid rig. Dalibor sported the pyramid rig, an idea of Jack Manners–Spencer, for three years and I have been very happy with the arrangement. But, unfortunately, not being able to increase the sail area on the pyramid rig over 400ft^2 and needing more power, I returned to the conventional cutter rig with the bonus of an additional 200ft^2 of sail.

Regretting this decision later, the idea of the excellence of the pyramid rig has haunted me for some time until the tripod rig evolved, using a more aerodynamically clean and efficient configuration.

How it looks. The tripod rig consists of three wingmasts arranged in a tripod fashion. the masts are attached to the circular base guided by rollers or bearings allowing the rig to rotate 360°, (fig 1 and 2). To the two forward wingmasts two fully battened sails are attached, with provision for slab reefing. The configuration has a clean, efficient and sporty appearance.

FIG 1

FIG 2



How it works. Practically the same as the pyramid rig. The wingsail always works in an efficient aerodynamic mode even when running, (fig 3). The rig is balanced so that only small forces are needed to turn the rig into the wind. The rig is weather–cocking on any point of sailing, which is one of the primary safety features. The ability of sternward drive is also a great asset (backing off a mudbank). The rig has an anti-heel effect similar to a sailboard, which helps to balance the boat further.

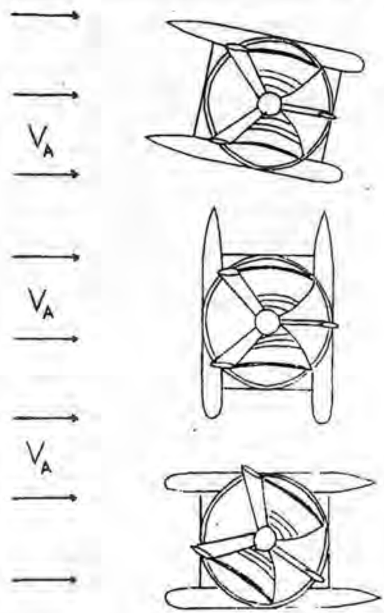


FIG 3

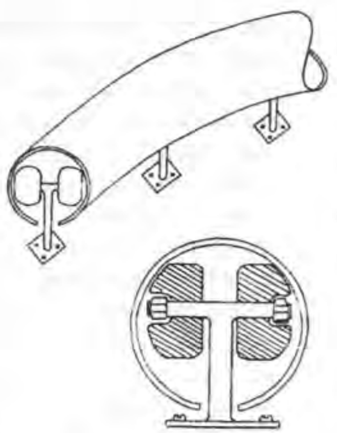
Construction. Basics of the rig are three wingmasts and a tubular rotating base. For economy's sake the three masts can be from the same mould. The base can rotate on a circular track using hardware from mainsheet track and travellers, preferably using strong aluminium circular tube with a slot cut-off from the bottom section. (fig 4). Inside the tube numerous off-the-shelf rollerskating rollers will be fixed. protected from the weather by the tube itself. The shafts from the rollers protruding from the tube will be fixed to the reinforced deck and beams. The rig can be operated in smaller and more simplified versions just by holding the rotating tube and securing it by a stopper. Otherwise, the endless sheet with free loops can be used over the small winch. Ultimately the use of mechanical gearing can be adapted from the 'coffee grinder' winch from which power can be transferred to the rim of the circular tube, perhaps by a friction wheel.

Advantages. The rig is aerodynamically clean and more efficient compared with conventional 'mast and wires' nightmares, so can be smaller for the same power.

The rig is balanced, so expensive winches are eliminated.

The weather-cocking ability on any point of sailing greatly improves safety, especially during reduction of sail area. Because the sail foot is sealed on the deck, the 'end plate' effect further improves sail efficiency (up to 15%) and reefing of the sail is easy and safe. The configuration of the sails aerodynamically stabilises the craft, therefore there is less heel.

FIG 4



It is not necessary to jibe the Tripod Rig – it just weather–cocks through the wind astern and the rig is then sheeted in on the other side.

The rig is self–tending when tacking for windward work.

A spinnaker can be set, on reaching and running, to the appropriate corners of the rig, eliminating messing around with poles, topping lift and guys. In light conditions a drifter can be set to leeward.

In heavy winds, the masts alone will provide ample power and stabilisation for the boat.

Because the boom is eliminated, this dangerous weapon is disposed of and sails can be adjusted more efficiently and easily.

But the main advantages of the Tripod Rig lie in the fact that the configuration can better spread the forces (compression and tension), experienced on the rig, through the wide base of the rig, to disperse them evenly into the whole structure of the craft.

Disadvantages. So far I can see there is only one. If a conventional steering position is maintained, the sail right down to the deck could hamper forward visibility. 'Windows' in the sail would help, but a forward steering position, in front of rig, can also be utilised. DALIBOR foiler has had her cockpit in front of the mast for 10 years, adding to a clear view forward and to the comfort of the boat.

Conclusion. I feel that this rig will solve a lot of problems associated with larger multihulls, and I hope that someone will pick up the idea and put it into practice. I wish them lots of luck.

A SELF TRIMMING VERTICAL AXIS WINDMILL PROPELLED CATAMARAN

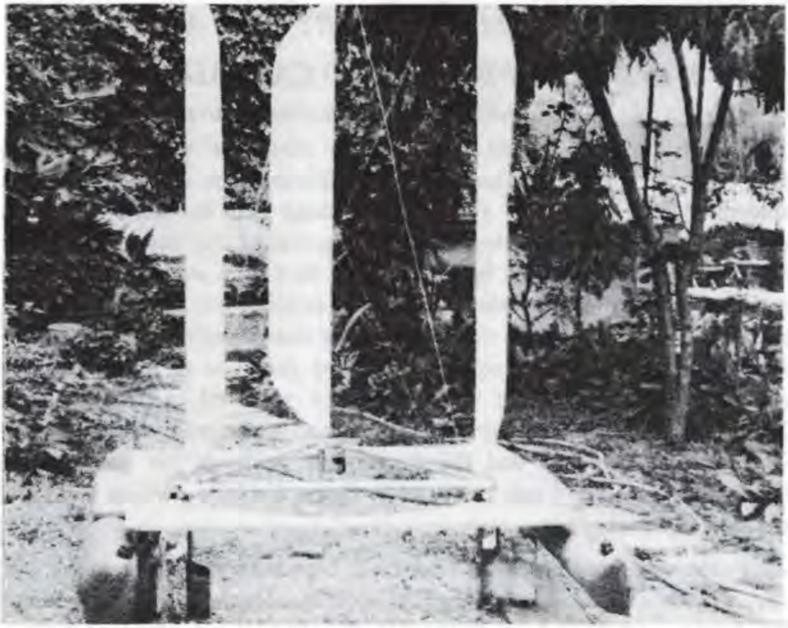
by Giusseppe Gigliobianco, Istituto di Macchine Universita di Bari

Since the first sail was fitted to a canoe the desire and the need to make progress against the wind has heavily conditioned the mind of the boat builders. After hundreds of years spent running with the wind aft of the beam, the first important step was the adoption of the lateen rig in the Mediterranean and the fully battened sail in the China sea. These types of rig allow a boat to sail against the wind by tacking, but a dead angle still exists into which a course is not allowed. The main disadvantage of tacking is that a large channel is required. The next goal was to sail straight to windward. This fascinating target was first achieved in 1920 by Mr. Constantin, a French engineer who was able to make progress in the river Seine against the wind and the stream. He equipped his boat with a propeller in the air and one in the water connected by a vertical shaft and two pairs of bevel gears.

Many other windmill propelled boats have been built since then in the UK, USA and New Zealand, all of them essentially adopting the same scheme. The most recent that I have knowledge of is Revelation. She was built in 1984 by Jim Wilkinson, of Maldon, Essex, (reported by Multihull International December 1985). This craft is aerodynamically very efficient but still has some limitations in practical use. The horizontal axis propeller is probably the most efficient device for a straight to windward course but a conventional sail gives more drive if the wind is on the beam. The propeller is mounted on the top of a cantilever beam that cannot be stayed as a conventional mast can; this may pose some problems in very strong winds. So I would say that the reliability of this craft is not yet that required for an Atlantic crossing. Reliability at sea is more important than aerodynamic efficiency and this is the target of my proposal.

I have built and test–ed a scale model of a vertical axis windmill–propelled catamaran (ref 1). The craft was equipped with an elastically self trimming turbi–ne working on the principle proposed by P. C. Evans (ref 2) directly coupled to a Voith–Schneider propeller.

My idea takes its origin from the linear water–windmill of Barkla (ref 3). This is composed of a vertical air foil fastened to a water foil on the same shaft and in the same plane. The shaft is allowed to revolve about a vertical axis and is supported by a truck that travels on a rail approximately



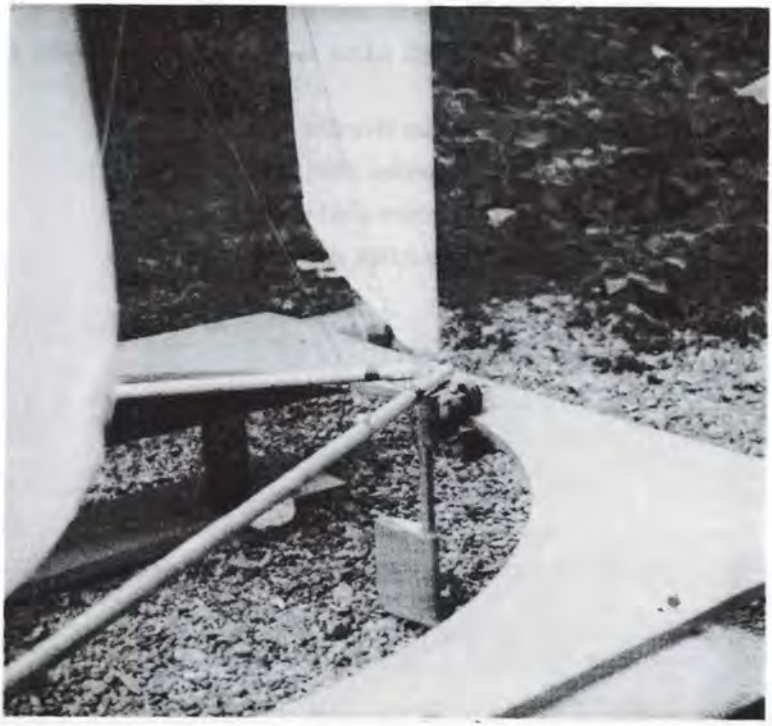
perpendicular to the true wind direction. In the resting position the air foil is feathered and is not self starting. Once an initial velocity has been applied to the truck, the aerodynamic forces on the wing and the hydrodynamic forces on the blade reach a position of equilibrium with the chord of the foil that bisects the angle between the apparent wind and the flow of the water. A lift develops which makes the equipment travel along the rail.

The model is composed of two six foot long hulls connected by two beams with a circular rail set in the square between hulls and beams. Three vertical wings are included in a truss that has the shape of a triangular prism every face of which is crossed by two diagonal shrouds. The lower base of the prism bears three wheels, one at each corner, and these wheels run along the rail. Each wing contains a shaft that extends downward and bears a blade in the water, the chords of the blade and of the wing being in the same plane. The shafts supporting wings and blades are free to rotate. A clutch will be installed on the real catamaran on the shafts between the wing and the blade to allow for a disconnection of these two elements.

When the catamaran is moored the wings feather with the wind and the blades in the water act as dampers thus preventing fluttering.

If one wants to start on a course that is not in the dead angle of a conventional catamaran the blades and the wings must be disconnected by releasing the clutches. The blades must be oriented along the longitudinal axis of the catamaran and work as keels with the further possibility of being trimmed. The wings will be trimmed by sheets as rigid sails.

If one wants to start on a straight to windward course the blades and the wings must be coupled with their chords in the same plane and the freedom of rotation of the wings must be restricted in such a way that the chords remain near (not more than 20° either side of) the tangent to the circular –rail. In this configuration, this windmill behaves as a cycloturbine and begins to rotate. An alternative way to start the windmill (without restricting the freedom of the wings) could be by using an external source of energy to start the revolution of the turbine. As soon as the peripheric velocity of the wings is equal to the true wind speed the blades in the water yield a thrust directed straight against the wind and the catamaran starts to windward.



This double method of working offers the possibility of taking the very best from the wind on every course. According to Hammit (ref 4), if the wind is on the beam, a lift generating device is the most efficient, while for a straight to windward course, the windmill yields the best performance. This craft is the first type capable of working as a lift generating device as well as a windmill. This gives the further advantage of saving ball bearings and noise when rotation is not strictly neccessary.

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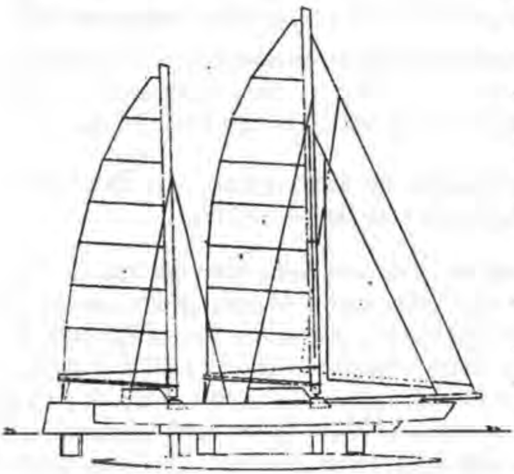
A SUBMERGED BUOYANCY SAILING TRIMARAN

by Wil Gillison

General. In 1979 AYRS published a paper by Prof W. S. Bradfield which contained the advice to those wanting to go fast "Get the hull out of the water". Many have attempted to do this using hydrofoils or planing hulls. For a number of years Wil Gillison has been the lone pioneer of the use of a submarine to lift the main hull above the surface. The principle is that by minimising the amount of boat that penetrates the surface, wave-making resistance is significantly reduced. *[This has been proposed for future commercial ships, giving rise to the acronym SWASH – Small Waterplane Area Surface Hull – Ed.]*.



Wil has produced a model of a sailing trimaran with submerged buoyancy which he calls a tri-sub. This has been used to develop and refine his ideas for a full size sailing submarine.

The principal components of Wil's tri-sub are a main hull (the tri) with submerged buoyancy (the sub) carried beneath it on a short fin. The whole is stabilised laterally by two floats attached by slim beams. Each float carries two canted foils are attached, fore and aft, to give additional stability.

Foils. For directional stability, Wil initially tried a fin on the main hull and used three different sizes before finally abandoning this approach. The problem is that the submerged buoyancy lifts the main hull reducing the effects of a hull mounted fin.

The next approach was to replace the main fin with the same area divided between two fins one mounted on each float. Eventually this was replaced by the present arrangement of the two fins on each float, retaining the original overall area. Steering would be by the after foil on each float.

The balance is improved by moving the foils outboard of the floats by mounting them on stub beams.

Unlike a surface hull, a sub has no better longitudinal stability than lateral, ie it will pitchpole (capsize over the bow) as easily as it capsizes sideways. If the centres of buoyancy of the sub and of the surface hull and floats are not directly one above another, but placed with some separation, in line ahead, then stability is improved. How far ahead? There is no simple answer, since the position of the rig affects this, and it is also useful to make some allowance for trimming ballast.

Wil reports that in very light winds the float foils create too much drag, removal of either pair, weather or lee, allows the model to sail successfully.

Note that in the picture the model carries two different floats. The starboard is a shallow, skimming float, the port a slim, displacement float. Unfortunately, Wil's reports do not say which gave the better results.

Submarine Buoyancy. Originally the sub buoyancy was 85% of the whole. After series of trials this has been reduced to 63%.

"Pair–Hull" Approximation. This idea came from the data on drag values for a range of Prismatic Coefficients in Marchaj [Ref 1] and 'High Speed Sailing', Appendix B [Ref 5]. This data shows that, for speeds in the range of SLR 2 to SLR 4, a deeply submerged hull with a DLR of 200 has about the same resistance to forward motion as a surface hull with a DLR of 25, ie that a 3 ton 25ft submarine at 20Kts has the same resistance as a 50ft surface hull, with the same displacement, at 28Kts. This result can be extended to lower speeds (since, to a first approximation, the sub and surface hulls have the same wetted areas), and again to a first approximation, the resistances are the same.

It is suggested that this result is a specific example of a more general case, the "Pair Hull" approximation, which states that for every sub there exists a surface hull of the same displacement which has the same resistance, and that the length of this surface hull is about twice that of the sub ie. the DLR of the surface hull is 1/8 that of the sub.

The virtue of this approach is that it allows different hulls – submerged or surface – to be compared with some ease.

In theory, these results apply only to deeply submerged submarines. This is normally interpreted as being submerged by at least twice the vertical depth of the sub. Wil reports that, in practice, this is sensitive to the shape of the sub hull, and that hulls with flat tops can be submerged less deeply that curved tops without causing surface disturbances. Quite blunt hulls ie high prismatic coefficients up to about 0.8, can be used successfully, but trials will no doubt refine this.

Construction. The models are made from plywood, and are not of high precision. With nothing much to be found in the literature, the aim is to produce models quickly and easily. Cascamite good enough, but the seams and ends need sealing with epoxy adhesive. Two pack epoxy is better than conventional paints, and can be applied externally with foam pads which avoids brushmarks. Final finish is with 400–grit wet–and–dry.

So far, Wil does not believe that sailing submarines will ever outstrip hydrofoils or planing hulls for sheer speed, however, it is quite possible that a submerged hull will be more seaworthy than either, and significantly faster than a conventional hull.

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2] Graph by Prof Nutku, AYRS 38, p21
3] Articles on canted foils, AYRS 82
4] Articles on submarine drag, AYRS 82
5] High Speed Sailing – Joseph Norwood Jr: graphs p 16–17, plus Appendix B (much data on prismatic coefficients)

Glossary.

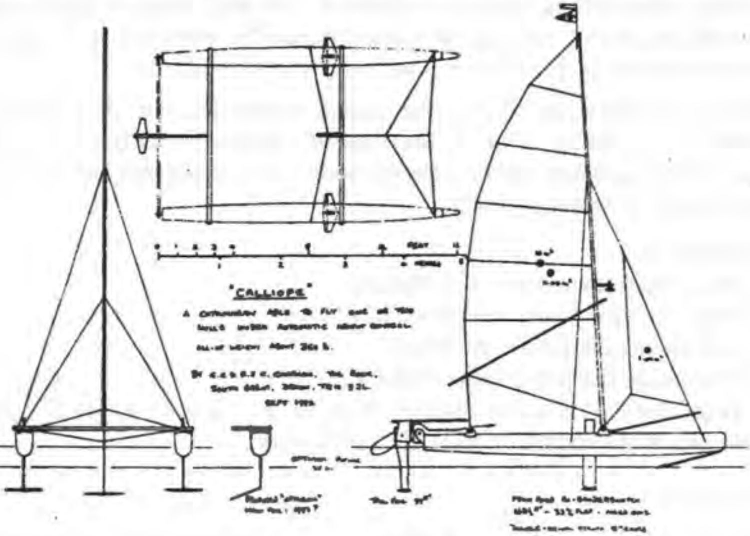
SLR – Speed Length Ratio – Speed in Knots divided by the square root of Waterline Length in Feet. eg. A 25 foot boat @ 10 knots has an SLR of 2.0
DLR – Displacement Length Ratio – Displacement in Tons divided by the cube of the Waterline Length in Feet, and multiplied by 1,000,000. eg. A 25' boat with a disp. of 4 tons has a DLR of $4 / (25^3) \times 1{,}000{,}000 = 256$

Motto: *He who makes the most mistakes learns the fastest!*

CALLIOPE – CATAMARAN
WITH OVERDRIVE AND FLY BY WIRE

By George & Joddy Chapman

Calliope uses knowledge gained in the speed sailing quest to provide safe, quick, comfortable multihull sailing. She is a 16 ft cat, 9' 6" beam across the hulls, with flapped foils at the bottom of the daggerboards or struts. Unrestrained by the Road Traffic Acts, the beam is chosen to give a wide base for upright sailing whether displacement or flying one or two hulls. With the small sail area of 11.25m it helps to keep the mast near to vertical.



The main aim was to design and build a catamaran capable of sailing as fast as other cats of similar sail area on all points, and possibly faster off and downwind, by flying on foils when the wind permits. Once afloat, the transition from inactive to active foils was to be achieved by literally pulling a string, with no reduction in speed to do it: this is the overdrive facility. As with our previous boats, she has to be operated single–handed off a slipway and beach.

The hulls are 3mm ply with 3mm decks and 4mm bulkhead; round bilged and with transoms each end. Forward, detachable ply and foam grp–skinned bows carry the feelers and contain links to transmit feelermovement to deck level and to the the wires leading aft to the clutch mechanisms on the struts. These hulls are therefore optimum for displacement sailing, and replace the Bandersnatch hulls which, incidentally, are available for anyone who wants a very cheap cat to experiment with.

The lifting foils are fixed at the bottoms of the two daggerboards or struts. Each foil has a 32% flap actuated by its feeler via the links, a wire, the clutch mechanism fixed to the top of the strut, and a push rod inside the strut. An elastic cord is connected to pull the flap to DIVE if the boat flies too high.

On a third–beam, right at the lifting rack and foil rudders ex–*Bandersnatch* steer and keep the pitch attitude constant.

The wishboom rig was chosen since it develops full drive when sheeted right out. The fashionable low boom (or boomless) sail which twists as soon as the sheet is eased is useless for a flying foiler. Besides, visibility is improved, sheet loads are reduced and, taken from the centre line, do not distort the hull structure. When taken from the leeward end of a track, the sheet load inevitably twists the hulls in an undesirable way: here we save the cost and weight of the track. Boom versus head encounters are largely eliminated.

The initial concept called for L shaped foils, the actual lifting foil angled to minimise hydrodynamic load and strut hydrodynamic drag: but making such foils with flaps poses structural problems. So for 1992 the foils used were those from *Bandersnatch*. These are probably a bit oversize but, being horizontal, they have operational advantages; and they saved building time.

Because all the horizontal sideforce is carried on the struts which had only 6" chord, they ventilated when flying both hulls. By the end of the season we had tried, first fences some 4" up from the foils, and then increasing the strut chords to 8". With the latter, ventilation–free flight is possible from 130° off the true wind, but not closer. Sailing at 15 knots with 10 knots of wind over the deck in a true wind of 11—12 knots is a joy: this at 140° off the wind.

At the time of writing (November 1992) we are undecided on the next steps with the foils. One option is to fit fences to the existing struts, say 3" and 6" below the designed flying waterline. These could be on a sleeve so that the strut can be raised for coming ashore without wiping off the fences. The shoreside wheels permit about 4" of strut to show below the keels, and that amount is in any case useful when sailing off or onto the beach.

Another option is inclined inverted T foils which will be less difficult structurally than inclined Ls, operationally easier, but they may still need fences.

What is clear is that the basic concept is a sound one, the boat sails quickly, upright, you sit out of the spray, she tacks happily, and the transition to and from foiling is instant and almost effortless.

In light winds the feeler arms trail up against the hulls, and the flaps remain held in neutral. The wetted area of the foils will add drag compared with simple boards, but the hulls have truly semicircular sections.

As the wind rises and speed increases one pulls a green cord to clutch in the windward feeler and foil. The windward hull then flies at a height controlled by the feeler. Less skill will be required of the helmsman – and no trapezoidal acrobatics – to prevent overheel, since negative flap is applied if the hull rises too high. When the wind drops and the hull descends to the water, the flap goes to RISE, shown on an indicator; one then pulls a red cord to declutch the feeler and the flap reverts to neutral. Flying one hull the helmsman can concentrate on sailing the boat to best advantage, he does not have to worry about balancing on one hull and avoiding capsizing.

With stronger wind and more speed, a pull on the same green cord which lies across the boat engages the lee flap and feeler as well as the weather ones. Off the wind the boat accelerates smoothly and flies both hulls, upright, stable and quite quick since the sail will come back upright: the drag is reduced to that of the two main foils and the single rudder/foil combination.

On the strength of her performance so far, we believe Calliope shows that it is possible to use lifting foils to widen the 'sailing performance envelope' of what is otherwise a conventional catamaran, improving speed on some points in enough wind, as well as improving comfort and possibly safety. The wind needed to fly is around 11 knots, slightly less than Bandersnatch needed. Racing such craft round suitable courses would be fun and introduce a new element requiring new skills of the crew.

Initially, the clutch mechanism embodied a 'lost motion' feature to allow the feeler to rise against the hull after passing the 'FULL FLAP TO RISE' level – to reduce drag when clutched in but not flying. The device was prone to hangups, leaving the flap to RISE too long: hence the dramatic lift–off in the photograph. The device proved unnecessary anyway since one can readily declutch. The normal clearance between the hull and the sea surface is about 6" when flying – quite enough.

Sting

by Miles Handley

Miles Handley brought his boat, *Sting*, to Weymouth Speed Week '92.

Sting is a beautifully prepared craft on the tri–scaph principle. The crew are carried in a central pod which is normally clear of the water. The three floats, one forward and two abeam of the main pod, are connected to it by aluminium booms. The craft has an overall length of 20 ft and width 30 ft.

Foils are mounted on the floats, which are shells constructed from grp. The two front foils are fixed to the forward float and these are used to steer the boat.

The sail is a 10sq m windsurfer sail made by Mountfield to Miles' specification.

Miles writes of the current and future development of *Sting*......

"When I decided Wizard was a little anti–social, being a single seater, I started work on *Sting*, a two–seater project that had been in the back of my mind for some time, using knowledge gained in the development of Wizard and earlier boats.

My original design parameters were to select an optimum foil shape and to design a boat around them that could be sailed very fast by disabled or elderly people. It was not necessary to do any further research on the foils (ã1,000 a day at the water tank cannot be repeated too often) but I am currently making them larger to increase manoeuvrability at very low speeds.

The boat I brought along to Weymouth in October 1992 consisted of a hull which can seat two people and which I originally constructed by gluing together planks of polystyrene and then carving inside and outside the resulting block to obtain a shape rather like a dodgem car. This was then coated with glass fibre and resin. Once at sea with the foils down it is possible to sail without moving from the seat, as the tiller and sheet are to hand. The polystyrene got waterlogged at Weymouth and all you good souls who helped Jill and me lift it out of the water will be interested to learn that it was carrying approximately 70 lb water in its foam!

I have just finished (November 1992) making new moulds for the hull, using the existing hull as a pattern, and am now ready to go ahead with making a grp shell.

With a new hull and new foils, I hope to be a little more seaworthy next year."

SAILING CRAFT HAGEDOORN

by Roger Glencross

The idea for this craft came from "Ultimate Sailing", the book by the Dutch Professor Hagedoorn (available on private loan from AYRS). The rig consists of a conventional unmodified parafoil, the directional parachute that is used in the sport akin to hanggliding.

The clever bit is an underwater kite which is pulled by the parafoil. This underwater kite is called a 'hapa' or in French 'chien de mer' or 'seadog'. It is this hapa which provides the side thrust that in sailing boats is obtained from the centreboard. The hapa is connected to the parafoil by a line and the only control is through the parafoil by the pilot as per normal parafoiling procedure. The hapa follows passively and automatically and has no moving parts. The extreme efficiency of the hapa and the absence of hull drag should result in a fast craft.

Many years of work have gone into developing hapas and only the inventor Didier Costes has succeeded in developing a satisfactory one. The breakthrough was the solution to the problem of the vibrating lower bridle which, at speed, was so bad that all efficiency was destroyed. Didier has succeeded wonderfully in producing a hapa without a lower bridle. This hapa is being used for the first time with the parafoil at Speedweek so we cannot predict results. But tests with the parafoil indicate that a launch from the land is preferred. There was not enough room on board a boat for successful sea launches. Probably the pilot will walk slowly backwards into the sea against a minimum of 15 knots true wind speed after first having launched the parafoil and maintaining it flying above his head.

The main problem is expected to be control, especially during launch. The only way to find out how to do it is to try it, and that is what Speedweek is all about. Once the parafoil gets wet its performance becomes sluggish and we expect a great many dunkings. The hapa is a one–tack machine so the support boat will have to take us back home after every trip. The hapa line incorporates a quick release catch so that the pilot can glide away and land if things get too hairy. This method of sailing has never been tried before so we have no guidance how to do it. The present project is at 'proof of concept' stage and we do not mind how slow we sail as long as we can learn to control the machine and fly with the pilot just above the waves. But mathematical models indicate that this is the fastest method of sailing so far invented and speeds of 100 to 200 knots in 20 to 40 knots of wind should eventually be possible.

This was written by Roger prior to Speedweek '92, in the event the offshore winds he wanted did not materialise and Roger remained firmly rooted to the ground. However, he has now completed a parafoiling course and Didier produced the improved hapa with which he succesfully sailed a catamaran (with foils removed) at Speedweek. Things are looking good for 1993. (Ed.)

***Free Energy V** – an Exercise in Empirical Fluid Dynamics*

Background. In 1970 I joined a design consultancy practice which took on the modelling of fluid dynamic experiments. One undertaking was to asses the practicality of a low drag hull for use in conjunction with a Plainsail type rig. Several models were prepared which utilised aerodynamic and hydrodynamic principles. The final design was never tested under sail but it performed admirably in tank and open reservoir tests under tow. it utilised hydrodynamic and aerodynamic lift to effect maximum hull efficiency.

From 1976 – 1987 I constructed several trimaran configuration sailing vessels of sixteen to twenty feet in length for the purpose of river and estuary sailing. The brief for these designs was to achieve maximum speed from displacement hulls (16–20 knots being the performance objective) while throughout construction all aspects were studied in order to quantify environmental impact through construction. This has remained an a priority in all subsequent work.

I had read a great deal about foil bound vessels and had discussed, perhaps, constructing one in the mid eighties though my decision to enter this area of research at full scale was forced by the destruction of my displacement trimaran (*Free Energy IV*) in the severe October gale of 1987.

Free Energy IV was constructed by a system of monocoque units, bulkheaded and butted together, constructed of WEST system fabrication. After the gale I had a choice which was to reconstruct, or starting with a "clean sheet of paper" make a radical design which would provide a long term platform for rig developments and enable me to compete favourably in "boat" speed sailing regattas.

Design. Once the decision had been made to produce a design the main criterion of which was speed, I then spent the period between November 1987 – March 1988 establishing design criteria. I set up a database computer record on a "MAC II" preparing my own "draw" programme.

Initially I abstracted all known design criteria for successful high speed sailing boats with established records at the time; Crossbow II, Jacob's Ladder and Icarus. There were other designs of note which showed similarities with these which were also evaluated. The main source of information being the book "Hydrofoil Sailing" published by Juanita Kalerghi in which the experiments of D J Nigg are summarised along with other research undertaken in the USA. Other valuable reference was obtained from 'The Science of Flight', Sutton; "Hovercraft and Hydrofoils", McLeary, and "Icarus, The Boat That Flies', Grogono, particularly Chapter V, 'innovators'. Of even greater importance to my initial survey were the National Maritime Museum library at Greenwich and Imperial College Library in Kensington.

Added to this was a range of design criteria and general information derived from board sailing. It became clear that displacement hulls with foil assistance would ultimately be limited by disadvantages of known foil performance, which at the time, indicated that a full blown foil vessel might not achieve speeds above about 30–35 knots in favourable conditions. I then looked closely at factors relating to the fastest boards. In 1986 Pascal Maka had achieved 38.9 knots in the 8 Square Metre class.

Through the use of video film I had managed to make frame by frame analysis of Free Energy IV while moving at speeds of 18–20 knots. Free Energy IV had a very desirable design feature which was a design hull speed specific bow form which would function well up to 25 knots while providing pitch recovery. This enabled the rig to remain stable and relatively free from fore and aft pitching moment in surface conditions of 2–3 foot waves.

In analysing video film of Maka at speed, I found the pitching frequency and the trim control through body position, to be similar to that of Free Energy IV. It thus became obvious good pitch stability combined with excellent lateral polar moment stability were essential for fast controlled sailing. I decided to model a design study which incorporated as many extreme radical features as possible while ultimately remaining constructionally practical. The model I have worked with throughout the past five years of development is an accurate quarter scale study.

The first test version incorporated a single lee outrigger float, a vee configuration bow hydrofoil to counter pitching moment, a windward canted unirig and a windward aerofoil to effect low drag lateral polar moment stability. I tested this design extensively on the model tank at Southwold in Suffolk, and with very little trim tuning, it performed faultlessly. I then resolved to commence work on a full scale version which possessed all the features of the quarter scale model with one addition which was to use the main hull as a tuned venturi, ducting air, under partial ram pressure through the hull, venting under the rear planing surface with the intention of reducing skin drag through 'ground effect'. This is an area of aerodynamics I am particularly familiar with as I had designed and supervised construction of the first negative lift ground effect racing vehicle for Ecurie Mototrike in 1971. Lotus were eventually to copy this idea in their F1 designs of the mid 80's

Construction. Free Energy V is constructed of foam sandwich, combining glass reinforced resin with kevlar and carbon in high stress and load bearing areas. At present all cross beam and spar assemblies are of aluminium though many of these components are to be replaced during 1993 with carbon composite structures.

Throughout the construction and development of Free Energy V. I received constant advice and material support from my sponsors Strand, Scott Bader. They provided the most up to date advice on newly available high density foam core materials, resins and woven sheet glass, kevlar, and carbon fibre.

Having completed the drawings for my project by March 1988, and having collected the materials from Brentford, I constructed a formidable datum jig using 2" x 2" seasoned soft wood, built up from a 1" HDF base gusseted with Dexion and exterior quality 3/8" plywood. The high density green Tamanto foam was erected into this jig in slab construction using thixotropic resin and hard wood pins to hold the structure in place while curing. The main hull monocoque is basically a double cavity sealed box of rectangular section. The entire structure is sleeved with two layers of woven glass bonded with H series resin. The main hull incorporates a dorsal pylon of glass, kevlar and carbon composite construction.

This pylon is an area of critical loading as a triangle of forces from the cross beam to the upper mast, via the shrouds, is transmitted, which in turn is stabilised by two sets of underigging below the cross beam, rooted in a massive compression tube which is secured through the full width of the main hull. The entire fixing is of aluminium (HE30) with plastic sleeved high tensile stainless steel studding providing the compression via nuts and large diameter washer plates, the assembly being glued in place with epoxy. The bow foil conforms to NACA 4412 profile with slight modification, and is constructed of moulded kevlar, glass, carbon composite. Its geometry is of 90° V configuration supported by a vertical foil constructed of kevlar, glass and carbon on a Tamanto former. The upper tips of the foil are supported by a cross foil of 10° give section set at a constant angle of 6° to the normal attitude angle of the V foil when flying, which is an attack angle of 10° to the true perpendicular. The cross foil performs the dual function of providing triangulated rigidity to the main foil tips, also pitch recovery. During the first season of testing, the bow foil angle was variable by a vernier screw, pivot and lever, though once the best take off angle had been achieved the foil angle was fixed in a sealed boxsleeve. The first tests were carried out using a single windward outrigger float with the rig canted to windward at an angle of 20°. At this time the main hull had large ducting fences running two thirds of its length. These provided colossal lateral resistance and caused excessive weather helm to be required.

Testing. The first tests were made on Alton reservoir near Ipswich in August 1988. In high winds Free Energy V quickly assumed the predicted hull position though with no lee float and the very powerful fully battened main sail, canted to windward and behaving exactly as hoped for, like a wing, the sudden moments of lateral instability with no chance of recovery were very unnerving. It was like attempting to balance on a knife edge. In these initial tests certain factors became clear. Firstly the one way boat concept was not very practical as great dependence on support boats and crews is unavoidable, but also I wanted better control which was eventually achieved by setting the rig in the vertical position and utilising a second outrigger float. The two cross beam trampolines were 5ft (1.5m) in width giving a beam of 10ft (3m). Listed below are the modifications made during 1988.

1.Progressive cutting back of main hull fences to reduce lateral resistance.
2.Employment of an articulated outrigger (see Adrenalin F40 1987–88) with buoyancy bag, windward side.
3.Use of a small jib to encourage the bow to pay off from the wind and overcome lateral resistance of the bow foil

Modifications 1989.

1.Use of second outrigger float and crossbeam. Outriggers included foil boxes to utilise rear mounted foils.
2.Further reduction of main hull fences.
3.Experimentation with mast position with the incorporation of a jib.

Modifications 1990

1.Use of lightweight Z90 mast. (This failed at speed during the first day of testing).

2.Further experiments with rig balance for and aft utilising a range of high performance battened jibs.
3.Setting up canard steering. (This worked very well but was abandoned because the increased length of the steering foil induced too much lateral resistance which prevented ease of tacking.
4.Construction of a single elliptical blade rudder, stern mounted.
5.Test of a submerged stern mounted foil, (this modification was plagued by biplane effect and was abandoned).

Modifications 1991

1. Boom vang track to assist in maintaining better main sail shape.
2. Lengthening bow foil central support to lift the main hull clear of water.
3. Experiments with mast position to achieve fine feel and low rudder drag.

Modifications 1992

1. After model tests using outrigger floats with flat bottom profiles, Simon Sanderson constructed two new outriggers conforming to the general specification of the model. These outriggers are of foam core glass epoxy construction.

By early 1992 Free Energy V had demonstrated the basic soundness of the design and had indicated that ducted ram air is a viable solution to increase hull efficiency. In wind speeds of 15–20 knots Free Energy has regularly sailed at speeds in excess of 25 knots and promises to continue on an improvement curve which it is hoped will yield impressive results at Weymouth and Brancaster in 1993.

At Weymouth '92 (Free Energy V first visit) though conditions on the water were the worst I have sailed this design in, all performed well. However, due to an injury which kept me away from my workshop for several weeks prior to Weymouth, I did not crack test all highly stressed metal welds. At Weymouth the rudder pintels failed which prevented any further activity on the last and only day of my participation. Making components strong enough for the function they perform is a matter of high priority, as many experimenters, including myself, tend to construct components (which are under high stress) too lightly, which in short can result in breakages and consequently less time is spent on the water, the ramifications being obvious.

Observations. Much has been written about foil performance of a theoretical nature and much has subsequently been put into practice.

However, observations of the foil sailing machine 'Longshot' indicate that the phenomenon of foil planing occurs at high speed. The bow foil of Free Energy V also behaves in this way; the balanced orientation of the entire vessel on relatively flat water within the dynamic of its upper performance envelope presents behaviour which as yet has not been adequately explained using classical fluid dynamic theory.

Over a five year development period with more than one hundred sailing hours, many changes have been made, too numerous to list here, though throughout the entire development programme an accurate log of all detail has been assembled both in hard copy and on computer disc. It is envisaged that at a later stage a detailed analysis, including design calculations and formulae, will be published.

Developed Specification – January 1993

Weight 150 lbs Length 15ft OA Beam 16ft

Configuration Trimaran: Vented ram air main hull (planing) with forward mounted V foil and planing outriggers. Rig. A class, fully battened high performance main sail. Battened (Glazer Keef) high performance Jib. Steering conventional. Elliptical blade, stern mounted.

TRIFLY and SPEEDWING

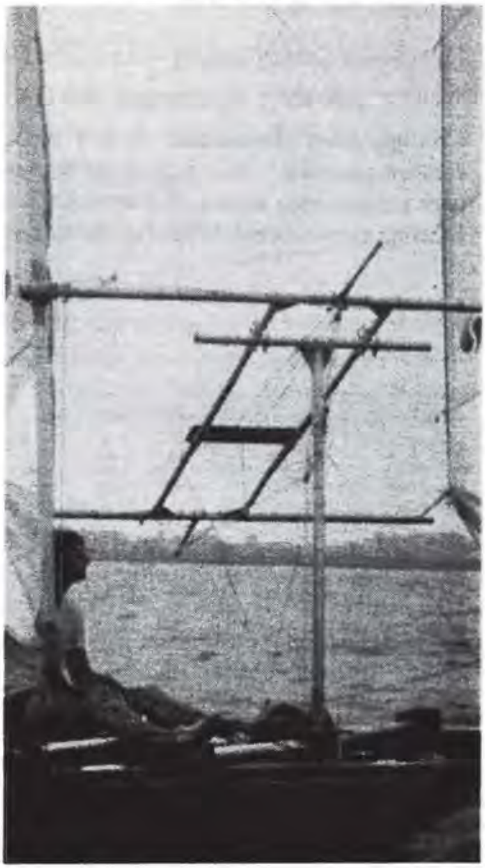
AN EVOLUTION IN SPEED SAILING

by Tony Blofeld

Being a Naval Architect who works in the offshore oil industry. Tony Blofeld is currently working in Oslo, Norway on the design and installation of a tethered leg platform for the North Sea. He is an experienced sailor on everything from dinghies to deep sea yachts and has competed in transatlantic races.

Tony's interest in hydrofoils started after a trip on *Icarus II* when he skippered it in an attempt to show how to sail a high performance boat.

Bob Downhill reports that he did not entirely succeed and they were nearly shipwrecked in the middle of the Solent after attempting to imitate a submarine (Wil Gillison take note). On his return from that trip he never set foot on Icarus II again, but the bug had bitten.



His first design, *TriFly*, was intended to be sailed as a windsurfer, standing. It was a trimaran with what looked like a television aerial to hold two wind-surfer sails, Picture 1. The television aerial rotated on a stub mast to point into wind. This rig was never successful, attempts were made to improve it by reconfiguring in various ways, but all failed. After one season it was abandoned.

The failure of this rig was never fully understood, it was finally concluded that the hydrodynamics of the hulls, with standard surface piercing foils, caused so much drag that the speed was insufficient to achieve suitable air flow pattern over the sails. The hulls also had insufficient buoyancy and the effect of waves caused additional drag.

This was the first lesson in high speed sailing, the craft must be seaworthy, only then can you learn how to get the best from it and attempt to sail fast.

The second *TriFly* variant was a much bigger vessel, it used the same floats but with increased buoyancy and they were connected by a rigid tubular aluminium frame and braced with wires to provide torsional rigidity, Picture 2. The hulls were constructed from ply, sealed with glassfibre. The pilot was supported on a mesh trampoline strung from the aluminium frame. Overall the craft was about 14' wide and 12' long.

The foils rotated on pins on the outer floats behind a stepped hull, they swung back and up for ease of launching and recovery. The original foils were made

from glassfibre with ojival section. Later Tony experimented with solid aluminium foils with a control surface which was actuated by a surface sensing trailing arm via linkage and torque rod. This proved quite success

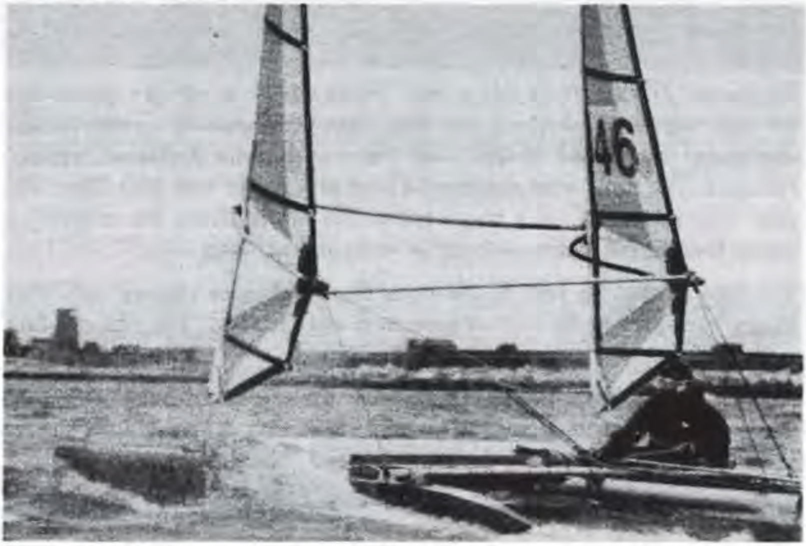
The rudder was a T–foil made of wood with a very thick section, but was later replaced by a welded aluminium

The two windsurfer sails were replaced by a single, centrally mounted mast with a Moth sail. This policy was adopted to reduce the number of unknown factors. With this configuration Tony sailed TriFly for a season and was able to try out many new ideas and modifications

The second lesson is one often forgotten in the design of a fast boat, if the boat takes much time to construct on the beach, that is time lost from sailing. In order to bring any new boat, particularly an experimental one, to maximum performance much time must be spent sailing.

Eventually Tony refitted the twin sails, but this time they were stepped on the two outer hulls, rather than the television aerial. They were modern, induced camber 8.2 sqm windsurfer sails.

On the last outing at Weymouth in October 1991 Tony disappeared in spray extending higher than his masts. His progress across Portland Harbour was observed, from the Weymouth Sailing Centre clubhouse, as a fast moving cloud of spray. The actual speed was not recorded but was reported by onlookers as most impressive. If the bug had bitten on Icarus2, the fever had now reached its peak on TriFly. Tony left Weymouth with the warm glow of the confidence that he could now build and sail the fastest sailing boat in the world.




46

The new boat, Speedwing, Picture 3, is a catamaran and emdodies the lessons learnt so far, it is a most seaworthy craft and much quicker to assemble than Trifly. It is an interesting design and beautifully made.

The hulls and crossbeam were constructed by a boatbuilder in Windsor. They are wooden constructions of frames and stringers, covered with ply. The whole assembly is sealed in epoxy reinforced fibreglass, an average of two layers of very thin, high grade cloth.

The craft is designed to be fast in the water in displacement mode, to allow enjoyable sailing in light winds, thus overcoming one of the vices of Trifly. It is also intended that the hulls will plane at higher speeds, before finally rising onto the foils. This should result in a smooth transition up to the foil borne state.

The hulls are 16' long and the craft has an 18' beam. The foils, ex Trifly, are slotted through foil boxes angled at 45° to the vertical and the foils are kept in place by an ingenious key arrangement when installed. The two hulls fold approximately 45° inwards, under the crossbeam, to allow the foils to clear the ground during launch and recovery. When afloat they are swung out and secured by retaining bolts. A launching trolley is centrally located and lifts the boat clear of the ground with the hulls retracted inwards and the foils fitted.

The crossbeam forms a torsion box and is an airfoil section. The rear 30% is formed by a narrow trampoline on which the helmsman can lie at full length to reduce windage. The rudder is mounted on a 6" diameter aluminium tube extending aft from the crossbeam.

Speedwing is fitted with the double windsurfer rig from *Trifly*. The masts are stepped on the hulls, just forward of the leading edge of the crossbeam/ wing. The standard, Lord type, mast feet are somewhat stressed carrying the vertical load from the masts and in consequence it is difficult to obtain sufficient tension in the standing rigging.

Speedwing was completed in the early Summer of 1992 and Tony conducted a few trial sails in light winds, but the first time the craft was really tested was at Weymouth Speed Week in October, 1992. Then Tony was plagued with the irritating failures which all new boats seem to suffer. The rigging, when under load, showed up all the weak points and time and again Tony came back under tow to be repaired. Reg Bratt proved to be a life saver with his Alladin's cave of materials.

By the end of Weymouth Speed Week, with the wind picking up again after a couple of days lull, Tony was satisfied with the boat, disappointed with his speeds but eagerly looking forward to May 1993 when he will be out again for the Weymouth weekend. There he hopes to induce Speedwing to reach its peak in preparation for Speed Week 1993

Bob Downhill after commandeering a sail during Speed Week comments; "Speedwing is a delightful boat to sail as it rises on foils without the violent acceleration that was apparent with TriFly. This shows that the hull drag characteristics are appreciably better than those of TriFly. Controlling the sails still has some way to go as the sheeting arrangement seems to have yards of rope to contend with. The sails are linked with a pole attached to the rear end of the wishbone which does not allow for trimming of one sail in relation to the other."

Ed. My thanks to Bob Downhill for providing much of the material for this report including his two 'lessons in high speed sailing'.

ARE YOU REALLY SERIOUS?

by Tony Kitson

Are You Really Serious? is intended as an introduction to speed sailing. The purpose is to teach me both how to build and how to sail such a craft. Hence the name, when I explained these aims to my friends they all said, Are You.........! (I am still undecided whether they said it with a question mark or exclamation mark.)

I had long been toying with the idea of building a planing boat and as long been failing to make a start. I had read about Speed Week for a number of years but was convinced that I had neither the design nor construction skills to build a suitable boat. It was Bob Downhill who persuaded me that there was much fun to be had in participating even if your boat was not a Longshot. (In retrospect, we were both right, I did not have the skills but it was great fun anyway.)

Eventually, in the spring of 1992, I acquired Rebel Yell from Bob Downhill. This was a boat built by Greg Harris and entered in the 1988 Speed Week at Portland, achieving 17.63 knots.

This was not a planing boat but it did have the advantage that I would need only to make some small modifications and it would be ready to sail. The other advantage was that I would have Bob to bully me into actually doing it. Of the two, the latter turned out to be the biggest advantage.

Rebel Yell was a trimaran, based upon an AYRS hull, with a faired cross beam (wing) bearing two small floats with canted foils. The side foils were low aspect ratio of triangular shape with a depth and maximum chord of about 2'. There was also a diamond shaped bow foil mounted on a bowsprit, and a small inverted T foil rudder. The configuration was such that, at rest, the bow and stern foils were deeply immersed whilst the side foils barely touched the water.

I decided that this proliferation of foils was one too many (maybe I was too conservative, see Dave Culp's contribution) and that the bow foil should be removed. I also wanted to obtain the benefit of the large side foils as early as possible and so the floats had to be lowered relative to the hull.

The removal of the bow foil and bowsprit was easy, the subsequent repair to the bow was less so.

I decided that the floats could be lowered by reducing the height of the wing above the hull and simultaneously increasing its height above the floats. Uncertainty about the waterline of the hull was removed with the kind provision, by Michael Ellison, of a copy of the lines drawing of the AYRS hull.

The hull to wing distance was decreased by removing Greg's 'gun turret' and, since the foredeck sloped sharply upward towards the front of the cockpit, moving the wing forward. I reasoned that this forward movement of the main foils would also compensate for the loss of the bow foil, assuming that Greg had done his original sums properly. I moulded a sheet of grp onto the deck and another to the underside of the wing and glued them together, remembering to do the gluing with hull and wing attached, to avoid distortion of the new panels.

The float to wing connection was made via two vertical tubes attached to each wing tip which fit into two sleeves on each float. This allows for some vertical adjustment if my calculations are wrong.

The rig was provided by Tony Blofeld. It is a Moth mast and mainsail with added jib, ex TriFly.

The 'small modifications' somehow took weeks to complete. The fitting of standing and running rigging added more weeks. How anybody can find the time to build a boat from scratch I shall never understand.

The only 'theory' incorporated in this craft was the theory that one reason boardsailors go so fast is that they practice often. I would not turn up to Speed Week with an untested craft, Really Serious would be finished in good time, be easy to launch and be sailed often before October.

I managed only three test sails before Speed Week, all in winds ranging from light to non–existent. I arrived at Speed Week two days late, because, even in these conditions, several necessary modifications had become apparent. Speed Week itself was a series of breakages and repairs, culminating in a fairly major demolition of the port chain plate mounting and a goodly portion of the wing beam.

Was Speed Week a disaster? Not at all. As Bob had promised I certainly had much fun and as a learning experience it was unbeatable. Even my final breakage had its bright side. I was offered help with my repairs by veteran speed sailor, Reg Bratt, and from Reg learnt more in two days about design and construction than I would in two years on my own.

Have I learnt anything about Speed Sailing? I think so. There are the obvious things like learning how to put resin on the moulding instead of myself, and beginning to get the hang of driving the craft. But the main lesson is learning that to go fast you must also go slow. The testing and development cycle allows no short cuts.

Am I really serious? Yes certainly. I am really serious about having as much fun next year as I did this year. I am fairly serious about trying to go a little bit faster.

Dimensions of *Are You Really Serious?*
Hull: Length – 447cm Width – 60cm, Wt.– 30kg (CG 240cm from bow)
Crossbeam (Wing) L – 484cm, Chord – Centre, 70cm, tip, 28cm
Wt. – 21kg (CG 21cm from wing LE at centre)
Floats L – 135cm Width – 32cm Wt. – 9kg each (CG 93cm from bow of float) (NB this is same point as CG of beam)
Main Foils Length – 66cm Depth – 58cm, Maximum thickness – 4cm
Area – 3828cm^2 (equivalent horizontal plane – 2706cm^2)
(tip is 48cm aft of LE at root), Weight – (included in floats)
Rudder ,Depth – 88cm, Chord – 15cm, Max thickness - 2.7cm Weight – 5kg (including tiller, stock and foil)
Aft Foil Width – 60cm Chord – 10cm Maximum thickness – 1.6cm Weight – (included with rudder)
Mast, Length – 210cm, Wt. – 6kg, (CG 178cm aft of bow)
Boom, Height – 580cm, Wt. – 1kg (CG 105cm aft of mast)
Pilot, Weight – 65kg (CG 300cm aft of bow)

Fifteen Foot Proa "Nimanoa"

Designed by S Fishwick

Purpose – Primarily to investigate problems of proa handling, secondarily to provide a larger, stable, family boat! Speed was not a consideration.

Restrictions – To be low cost – the hull for preference to be made from two sheets of plywood.

Description – The hull is of hard chine form, of fairly conventional glued clinker ply, with a slightly curved bottom, built over sawn softwood frames. The outrigger float, which is only eight foot long, is of stitch & glued ply. Connecting beams were aluminium scaffold poles (cheap, but thick and heavy, so now replaced with timber) arranged in a triangular planform to minimise torsional stresses on the main hull. Due to the low cost limit, *Nimanoa* has insufficient freeboard to be used on the sea without either a deck or washboards fitted.

Originally, she was rigged with a mast and 80 sq. ft. sail off my Solo class dinghy. Eventually, she will be re-rigged with a 100 sq. ft. Pacific Lateen set on a swinging mast stepped amidships, with the yard tacked down to the current "bow". Staying is to the apexes of the outrigger booms. Lateral resistance and steering are provided by two linked side rudders mounted on cross beams about a foot from each end of the hull. The rudder blades are arranged to trail a little to avoid overbalancing the helm. In shallow water, when the rudder blades are partially or completely lifted, the tiller links must be disconnected as rudder movement is otherwise restricted.

Performance – With the Solo rig, and once under way, the boat is well mannered, light on the helm, although neither especially fast nor close winded. The biggest problem is spray from under the main hull chines, although the outrigger seems to have too much wavemaking drag. At times, it seems to be "bow–down" in the wave from the main hull.

Stopped, the boat rapidly turns beam to wind (outrigger to windward) and lies quietly. The rate of drift can be readily controlled by the angle of the side rudders. In fact she is too stable in this position, as it is very difficult to move off again without lifting the "bow" rudder. Any attempt at sheeting in merely changes the angle of the boat to the wind as the main hull pivots around the outrigger. We have never yet completed a shunt without resorting to a paddle. This is undoubtedly due in part to the aft C of E of the rig, and it is hoped this will improve when the lateen is fitted.

Update – That was the position in September of 1990. Things have moved a little since then, but not as much as I had then hoped. The lateen sail still has not been made, but instead I am using a 6.4 sq. m sailboard sail that is suspended from the masthead by a halyard at about $^2/_3$ of its height. The tack is hauled down to the lee gunwale at the current bow. The mast, which is off a Mirror, is stepped on the weather gunwale, and stayed to the float, and the current stern. It leans forward, and when I "shunt" moves to lean the other way. The rig is sheeted to the current stern with a twin sheet to the current bow. (I'm too lazy to do it standing up.) In this way the Centre of Effort of the rig has been moved forward, and is about $^1/_3$ of the boat's length from the bow when the sheets are slacked.

Handling has improved. The boat will now bear way from beam to wind quite happily and shunting is no longer a problem. It still would not point very well, and it became clear that the forward rudder/leeboard was stalling. This will not have been helped by the foil section which was a simple ogive with sharp leading and trailing edges.

After some experiments I now use a leeboard fixed amidships, and raise the forward rudder. There has been a marked improvement in pointing and manoeuvrability, and I can now pivot the rudder at its leading edge so improving feel. (Previously the rudder was pivoted in its centre, for symmetry.) I have yet to try it in a really strong wind as I am a little concerned about the strength of the leeboard which bends alarmingly!

The next generation boat will have a lighter hull, a bilgeboard instead of a leeboard, a lighter and longer outrigger, the rudders mounted on the stems, retractable upwards, with locks to fix the idle one, and a larger sail area!

Lessons Learned.

1.A boat may be balanced dynamically, but not be manageable when at rest. Rudders are no good then, turning has to be achieved by changing the relation of Centres of Effort and Lateral Resistance.

2.Bow rudders are not a good idea. Though they can be very effective under normal conditions, when they stall they are useless. A stern rudder, when stalled, still has some use as the drag acts in the right direction. For directional stability, the forward foil needs to be more heavily loaded then the after. This increases the tendency of a bow rudder to stall.

3.Weight is only needed in a proa outrigger if there is enough sail to pull it out of the water in the first place!

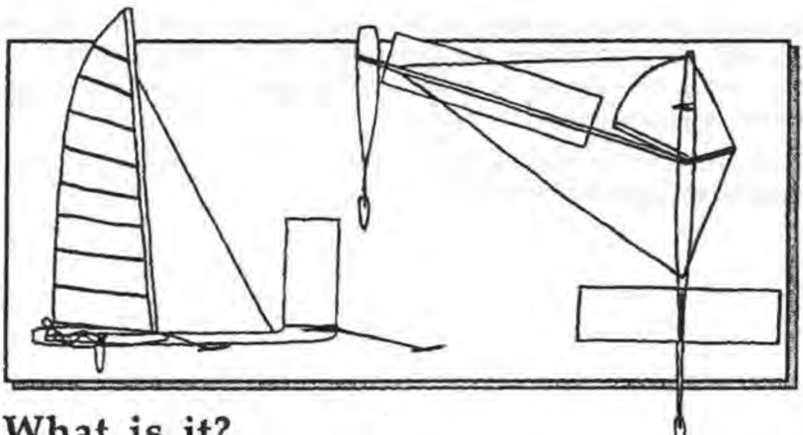
4.I still do not know if a hydrofoil proa could be made to fly on a canted leeboard. At least, by separating lateral resistance and steering functions I have neatly side–stepped the problems of interacting lift and directional control that I expected to have to face.

Help – Anybody know of a good (UK) source of the fine mesh net used for commercial catamaran trampolines?

ONE OAR IN THE WATER

by Dave Culp

I've built a new boat, "Sheerspeed". It is an aerodynamically balanced hydrofoil with automatic two axis control via surface sensors. It flies on a single hydrofoil, and uses aerodynamic elements to supply three axis control to overcome both heeling and pitchpoling moments from the conventional catamaran rig. The basic boat was designed by Greg Ketterman, designer/builder of Longshot and Trifoiler III. My input was to do the construction design, subsystem design and actual construction The hydrofoil and some substructures were built by Larry Tuttle of Santa Cruz, California. Larry built the foils for Longshot and all Trifoiler prototypes.



What is it?

The new boat is powered by conventional soft sails (no kites this time). It is innovative in that it uses only one hydrofoil; an inverted "J" foil similar to Longshot's. The boat gains three axis stability, when flying, through the use of aerofoil elements. Pitch, roll and heave are auto-controlled via surface sensors and yaw control is pilot induced via a bow mounted air rudder.

The boat is a "one way" proa. Though it sails quite happily on the "off" tack, it can do so only when hull-borne. The pilot sits in the windward ama, fully 24 ft. to windward of the main hull and rig. The main hull is 22 ft. long (plus an 8 ft. sensor arm) and the boat is 26 ft. wide (plus 8 ft. overhang at the canard wing) overall. The mast is 26 ft above the deck and the mainsail (a stock Prindle 16 catamaran main, but set on a beefier cut-down Prindle 19 mast) is 170 ft^2. The boat carries an additional 32 ft^2 in the air rudder (jib?), and 128 sf. in horizontally mounted airfoil elements. All aerofoils are symmetrical rigid wings.

Here's how the auto-controls work:

First roll control: There is a 4 ft. by 16 ft. wing element, mounted on and free to rotate around, the cross beam. Its centre of effort is 15 ft. to windward of the main hull. This wing is actuated by a leading edge mounted surface sensor on an 8 ft. arm. This sensor gives the wing a nose up attitude when hullborne and a nose down attitude when the windward ama rises too high.

At low speeds, the upward lift from the wing helps ama lift-off. At higher speeds, downward lift from the wing counteracts heeling due to sail forces. Greg's VPP program indicates that best speed (at highest efficiency) will be achieved when this wing is nominally not loaded, either positively or negatively. The aerofoil elements aren't meant to carry significant load at speed (too much induced drag). Their main function is to auto-control heeling (and pitch), allowing the pilot to keep sail power "full on" and concentrate on course keeping. Greg credits this auto-control for his successes with Longshot. We designed the rest of the boat's dimensions and weights around this parameter. The wing does see both positive and negative transient loads, of course, as the boat and pilot respond to wind and wave. The net design goal, however, is no lift.

Second, pitch: Greg has come up with a rather clever approach here. The main (only) hydrofoil is positioned well aft on the main hull, under the sail's centre of effort. It is aft of the main hull's centre of gravity, but coincides with the boat's overall C of G when the ama is flying. The foil actually carries 98-100% of the boat's weight at speed. There is a canard wing at the bow of the main hull (actually two wings – one on either bow - but cross linked to move as one). The canard's centre of lift is 16 ft forward of the hydrofoil. This wing is actuated by a second surface sensor, also on an 8 ft. arm. (Both sensor arms are somewhat flexible, to attenuate the sensors being buffeted by small waves.)

The hydrofoil is permanently set at a slight positive angle of attack (it is also asymmetrical, using a NACA 63 series low-drag section), but at hullborne speeds, its lift is insufficient to raise the boat; also drag is fairly low. The aerofoil canard has a pre-set positive angle of attack, set by the sensor. When boatspeed, and thus apparent wind, is sufficient for the canard to lift the hull's bow (we want about 12 kts boatspeed and 18 kts.

apparent windspeed at this point), the bow-up hull pitch angle adds to the hydrofoil's angle of attack and the hull lifts out. If the bow rises too high, the sensor calls for a negative attack angle on the canard and the bow comes back down. The sensor thus controls the canard's attitude, the canard controls the bow's altitude (and thus the hull pitch angle), and the hydrofoil "slaves" along after, doing all the real work.

The advantages here are several:

1) The highly loaded main foil doesn't need to be actuated and is rigidly bolted to the hull.

2) The main strut is vertical and thus resists ventilation.

3) Only one surface piercing strut minimizes spray loss and ventilation sites.

4) Wetted surface is minimized, in this case, exclusive of the sensors' "footprints", wetted area is about 3.73 ft^2.

Third, yaw: Greg has specified an air rudder in order to reduce wetted surface and induced hydrodynamic drag. His VPP shows that aero drag at speed will be less than hydro drag of an equivalent water rudder.

Expected results of Greg's VPP in 15 kts of true wind are as follows:

?????? Thrust= lbs.	Strut lift (horiz)=721.74 lbs
Vb = 46.8 kts	Strut drag(horiz)=54.83 lbs
Total drag (all sources) = 99.4 lbs.	Strut Cl=0.12
Va = 46.5 kts	Strut Cd=0.01
Total sideforce = 721.7 lbs.	Strut L/D=13.16
Vb/Vt=3.1 True course=100	Strut area=1.31 ft^2
Sail Area = 150 (dif. from as-built)	
Sail Aspect ratio=3.5	Beam aerofoil lift= -16.17 lbs
Sail L/D = 5.8	Beam aerofoil drag=3.15 lbs
Wt hull=200 lbs (dif. from as-built)	Beam area=64 ft^2.
Weight of ama w/crew = 280 lbs	Canard aerofoil lift=1.55 lbs
Righting arm of ama = 24 ft	Canard aerofoil drag=2.49 lbs
	Canard area=64 ft^2.
Foil lift (vert) = 494.6 lbs	
Foil drag (vert) = 28.55 lbs	Rudder lift=0.00 lbs
Foil Cl = 0.19	Rudder drag=1.25 lbs
Foil Cd = 0.01	Rudder area=32 ft^2.
Foil L/D = 17.32	Sensor drag (both)=9.14 lbs
Foil area = 0.58 ft^2	Sensor area=0.20 ft^2.

It is significant to note that all aerofoil elements are providing minimal lift and drag at top overall boat efficiency. The sensors are contributing less than 10% of the total drag, and that boatspeed is 3.1 times true wind speed (46.8 kts boatspeed in 15 kts true windspeed). Lest one suppose these predictions are too extreme, I should note that Greg degraded efficiency figures from those used for Longshot. Foil L/D suppositions are from empirical data taken from in-the-water boats using very similar foils. A similar VPP run on Longshot predicted 2.3 times windspeed at 15 kts true and the boat has been measured at 2.5. Greg actually thinks that these figures are conservative.

Results to date: First, the boat is heavy. The VPP supposes the all-up weight with pilot to be 480 lbs, of which 280 lbs is in the ama. Actual all-up weight is about 555 lbs, with 290 lbs in the ama. This will surely increase take-off speed and lower top speed, but very little.

Construction went well. The ama is built of foam sandwich with 3/8 inch Kleegicell, plus one 8 oz. layer E-glass/polyester inside and two layers outside. It weighs less than 45 lbs empty. (Greg Ketterman has developed a very "quick and dirty" one-off method for getting out foam sandwich hulls, and I've simplified it again. The ama is 11 ft long, by about 24 inches in cross section. I built it for about $125 in materials and not 50 hours of work. I'll try to write a future article about the technique.) The main hull is the weight culprit at 150 lbs. It is 3mm plywood over 12 x 40mm softwood stringers. It is covered with 2 layers of 4 oz E-glass/epoxy. The after third of this hull has an additional 3 layers of 8 oz glass set at + or – 45o, to resist torsion loads between the foil and mast socket. In addition, this hull has an interior strut and jackstay consisting of a 40mm x 75mm wooden compression strut 16 ft long under the deck and a doubled 5mm stainless jackstay from the forestay chainplate, under the mast socket, up to the main sheet chainplate. All this is to resist excessive bending of the hull due to mast compression. We anticipate sheet tensions of about 900 lbs and mast compression of over twice that in 50 kts of apparent wind.

The aerofoil elements were semi-mass produced, all 5 identical. They are 8 ft long and 4 ft in chord and use a 10% thickness/chord ratio NACA 00 series section. There are two elements coupled together in the cross beam wing, two in the canard, and one is the rudder. They are built of aircraft Dacron heat-shrinked over wood frames and finished with butyrate dope. Torsional rigidity is through Kevlar tows laid on diagonally under the fabric skins. They weigh just 16 lbs each. The supporting aluminum framework and spars account for the remainder of the all-up weight.

If I were to do it again, I'd make two changes. I'd build the main hull of foam sandwich also, eliminating the strut and jackstay in favor of additional glass thickness. We thought the plywood hull would be quick and cheap; it was neither, and heavy. Second, I would skin the aerofoils with 2mm foam and 'glass them. I had anticipated doing this on the second generation aerofoils (after expected destruction of the first set), but I wish I had done it originally. They would be heavier, but tougher.

The boat is complete and in the water, but we've only managed about 11/2 hours of sailing time this year, and all in winds under 12 kts. The boat is going through expected teething problems. The over square (wider than long) and asymmetrical geometry create helm balance challenges. The helm changes quite significantly from port to starboard tacks and also from hullborne to foilborne attitude. The boat has not yet flown and I expect it will need another season's tweaking before we get it right. Time and money considerations have limited sailing time this year. Nothing has broken yet and the boat sets up rather easily in about $1^1/_2$ hours with 3 people.

Postscript

Since writing the introduction to this issue and editing the contents I have thought some more about AYRS projects. It occurs to me that we have a rich fund of knowledge, skills and experience within AYRS. The problem often is that no one person has all the knowledge, skills and experience to complete his project. What we need is a way to put these individual abilities together and to apply them to projects.

You have a speed sailing project designed but not the constructional skills to carry it through? Someone else is looking for a boat to build for Weymouth next year. The only problem is that you do not know each other.

You have a new concept in sail design but no boat on which to try it, someone else has a boat needing new sails. The same problem.

I have been thinking about a 'computer dating' agency for AYRS projects. If you let me know what you want to do and what help you require to do it, I will check whether anyone else has registered with complementary needs and resources.

There is no such thing as a free lunch. The price of this service is that I will know who is working on a project and will pester you for progress reports.

The strength of AYRS is in the variety of knowledge and skills possessed by members. Let's get those harnessed into more projects and then I can edit two issues a year on 'members projects'.

Final Thoughts

After reading the contributions for this publication (on achievements rather than dreams) I now have a dream. I see a 50 ft cruising catamaran powered by Giusseppe's rotor, but with Dick's self aligning foils (aero and hydro), running on Josef's roller skating track. The hulls are clear of the water, courtesy of Wil's submarine, and the whole is self-steered by Henry's steering centreboard controlled by Captain Uller's windvane. We are fully automated.

I am lounging on the deck with nothing to do but sort through the mountain of contributions for the next issue of 'Member's Projects' (this really is a dream!). Could someone please design me a wind/water/sun (yes, it is sunny in my dream) powered generator to run the computer for the next editing session?

Tony Kitson

AYRS Projects – 1993

Captain Uller
Henry Gilfillan
Dick Hazelwood
Josef Dusek
Giusseppe Gigliobianco
Wil Gillison
George Chapman
Miles Handley
Roger Glencross
Adrian Nutbeem
Tony Blofeld
Tony Kitson
Simon Fishwick
Dave Culp