Catalyst

Journal of the Amateur Yacht Research Society

Number 12 April 2003

Artist's impression of a fleet of Jasmin 120 bimarans (picture by cortesy of www.bimaran.com)
See news story page 3

Catalyst

Journal of the
Amateur Yacht Research Society

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There's many a slip . . .

This edition is late. I know. Although it was planned and started on schedule, illness and various other things got in the way of a successful completion. May is a busy month in the Fishwick household, and if *Catalyst* does not get out the door by the beginning of the month, it has to wait until the end.

Mea culpa. And I hope to pull back to schedule over the next two editions.

However, that does give me the opportunity to pick up on

Some later news

First the bad news. Sir Peter Johnson, the Chairman of the World Speed Sailing Records Committee, died on 24th May. We hope to publish an appreciation in the next edition of *Catalyst*.

Secondly some good news. Bob Downhill took the timing equipment used at Weymouth Speedweek to Leucate La Franqui (France) to time kites pulling sailboards. Mike Ellison drove him down, but when they arrived there was no wind. Bob stayed on however, and recorded a run of 38.3 knots by Malik Bouchenafa of Algeria, which is a new record for kite power. This record is being submitted for ratification by the WSSRC. Some of the kites were using sails of up to 20sqm which fits nicely into the existing sail area classes. We understand it is proposed to hold another event in the Canary Islands from 4th July.

Next edition we hope to include an article by Dave Culp on the development of kite power and its applications to yachts such as the America's Cup yacht *Oracle*.

In the meantime, AYRS wishes you a good summer (for those in the Northern hemisphere) and a reasonable winter (for those in the South).

Concept Boat Competition

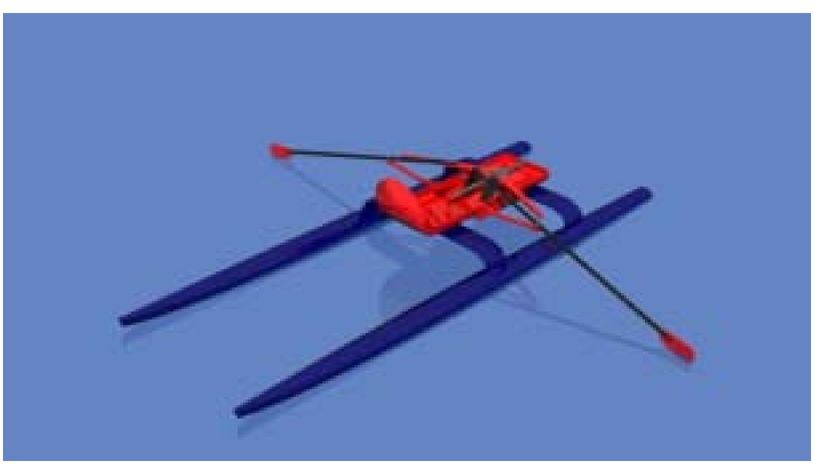
A sailing catamaran with berths for four which folds up for easy transportation is the winner of the UK's first Concept Boat competition, which challenged entrants to design a 'transportable boat of the future'.

Winner

The winning entry, Jasmin, was designed by Gray Treadwell, a New Zealander who works in the computer industry. The judges chose to award the £5,000 first prize to Mr Treadwell because they were impressed by several aspects of Jasmin's design, including her transportability, performance and sheer innovation.

A rigged scale model of Jasmin has been constructed by staff and students at the College of Falmouth in Cornwall, one of the UK's leading centres of boat building and boat design. It was on display at the London Boat Show 2003 on the Concept Boat stand.

Second prize



A second prize of £3,000 has been awarded for the ROCAT Rowing Catamaran. Frustrated at not being able to find a fast, stable boat to row on the sea, Cornish-based industrial designer Christopher Laughton was inspired to design one himself. The judges were impressed with the unusual rowing system, ease of transport and extreme stability which make it ideal for novice and skilled oarsmen. Visitors to the boat show could see a prototype of the ROCAT.

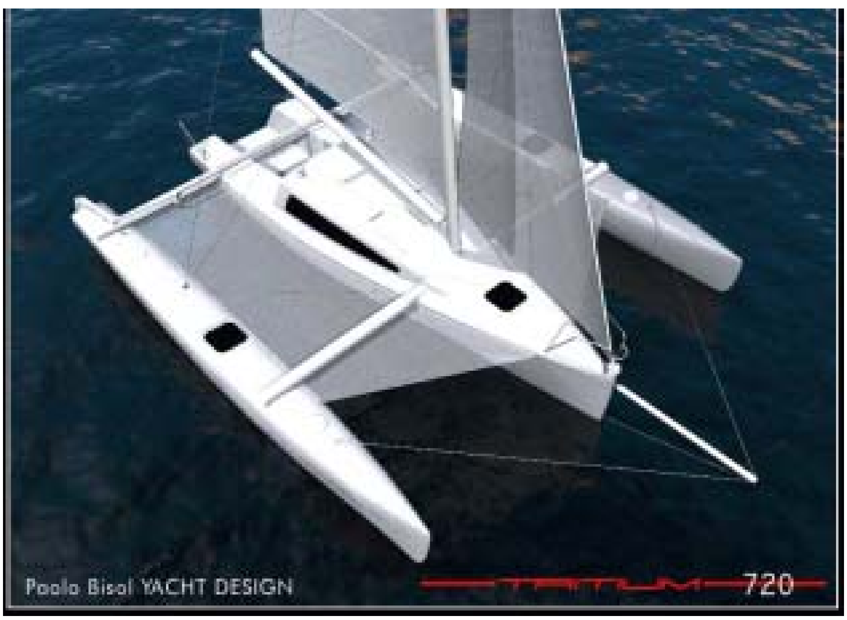
Third prize

Mike Munson, a naval architect from Plymouth, won the third prize of £2,000 for Boxcat, a transformable workboat that travels as a standard 20 ft container but converts quickly into a powered catamaran for flood relief use. The judges thought it was a clever idea and were impressed with its potential for both flood relief work and general work in any sheltered waters.

The Concept Boat 2002 competition was launched at the 2001 Southampton Boat Show as part of a drive by the British Marine Federation and the Royal Institution of Naval Architects to boost the global small craft industry by injecting new dynamism and innovation into boat design.

International Multihull Design Competition Result

Early last year, we ran a notice of a design competition issued by the Norwegian Multihull Association (Norske Flerskrog Sailklubb). Readers may remember the objective was to "promote the creation of a small or mid-sized sailing multihull which offers very high sailing performance and a little cruising comfort, on a modest budget. A new design to fill the gap between the classic beach-cat (i.e. Hobie 16, Tornado) and most current cruising designs, which for many sailors can be too expensive and complicated to build - or not sporty enough!" the winning design had to be: unusually fast-sailing and visually attractive, feature a minimal accommodation, enough to provide shelter, onboard vacationing and some privacy when in harbour for 2-4 people, and be possible to self-build for between US$10,000 and US$16,000 ready-to-sail. The results have now been published, and the winner was Paolo Bisol, an Italian designer living in France. The winning design, the Tritium 720, is a 7m (about 23ft) trimaran. Bisol describes it as follows.



"I found the design brief a very tough one: the boat had to be fast, but at the same time provide cruising accommodation - AND be very cheap. Accommodation requires volumes, volumes require size, and size costs. If we also want performance, than we need powerful rigs with large sail area, and the cost is bound to escalate.

To avoid getting into this vicious circle, I tried to stay clear of the 8 m limit, and fit the required accommodation in a boat of around 7 meters.

The general idea was to keep it as simple (and light) as possible, give it a bit more sail area than the average cruising boat, include some "modern" racing multihull features. Finally, I wanted a modern aggressive look, with plumb bows, raked mast, roached mainsail etc.

I drew a "tulip" shaped hull like in most cruising trimarans, where the flare provides width above seating level, and the floor sinks into the narrow, immersed part. The widest beam on deck is carried after so to have a nice large cockpit.

Each float has about 200% buoyancy, i.e. twice the displacement of the whole (loaded) boat. They have relatively small rocker, to get a long waterline length as soon as the boat starts sitting on them. The buoyancy is carried well forward to avoid tendency to diagonal capsize, at the same time keeping a fine entry to the bows.

The deck is round so that if the bow does get under, it can come up relatively easy without shipping a lot of water – a bit like in "wave piercing" designs. A round deck is also easier to build if the floats are made in two halves with a centreline joint.

Two options are proposed for the mast, a traditional fixed mast and a rotating wing-section mast. In both cases the spar is in aluminium and a single set of diamond spreaders is fitted for lateral rigidity. The spar length is 9.9 metres.

The mainsail is heavily roached to maximise sail area with a relatively short rig, and because the top could twist to de-power the boat in gusty conditions. The headsail has a small overlap. A Gennaker can be set on an articulated bowsprit.

The interiors are very simple. A "U" shaped platform goes from the bow to abaft the daggerboard well, splits in two leaving a small floor area and extends abaft the companionway and under the cockpit seats, up to the after crossbeam. The two main berths use the after part of this platform.

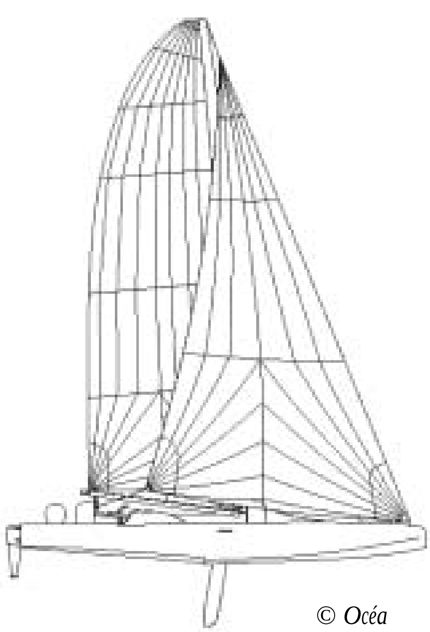
On the port side of the daggerboard case, a shelf integrates a simple galley, sink and a two-burner stove. On the starboard side, a hinged portion of the platform hides the chemical WC. The forward part of the platform provides two more, smaller, bunks."

Aquitaine – Like Team Phillips but better?

Yves Parlier has released details of his new catamaran, now under construction at the Larros yard at the Bassin d'Arcachon. Like Team Phillips, it is a big (60ft, 18.28m) beamy (50ft, 15.05m) open structure catamaran with a twin rig (2500-4000 sqft, 240-390 sqm). Unlike Team Phillips, the rig is stayed, and the masts are stepped some way inboard on the crossbeam. Like Team Phillips, there is (at least in the design studies) no forward crossbeam to tie the bows together, but it is to be hoped the design team have learned from their predecessors experience. Unlike Team Phillips, and indeed unlike every other big catamaran that we know of, Aquitaine has steps midway along its hulls, which suggests that someone has enough faith in the theory that catamarans can plane to try it out on a large scale.

In fact, the development builds on work by the French team of Morice and Eluére, who built several (comparatively) small-scale catamarans with stepped planing hulls in the late-1980s. The advantage of such hulls is that at high speed the centre of planing lift is located more or less at the midpoint of the hull, whereas with a "conventional" hull it moves towards the transom. The more forward location of CL has of course significant advantages in preventing pitchpole.

Realised by IBM for Yves Parlier & the Aquitaine Design Team



© Océa

The rig details in the publicity material are clearly not finalised. As drawn, the masts are mounted inboard, which has implications on the bending moment in the crossbeam, and are stayed inboard, and to each other by means of a strut between the mastheads. No outboard staying is shown, which if true would throw all the drive force of the windward mast onto that strut, and, as several experimenters have learned, it is very difficult to keep that strut from buckling.

Crew accommodation is in, or rather on, the hulls. There is a small working platform at the rear of each, with a cabin at its forward end. The daggerboards are canted, and are positioned just abaft the masts and forward of the steps. Sailing to windward, Aquitaine will not carry any foresails; downwind, she can add one or two gennakers to give 60% more sail area.

Launch is due by September of this year, with the aim to be ready for the Transat Jacques Vabre race from Le Havre to Salvador de Bahia on 2nd November.

A project to watch we feel.

National Maritime Museum, Cornwall.

The new NMMC opened last year on a trial basis with free entry, which Joddy and I were able to take advantage of shortly before entry charges started.

Sited on the Falmouth Docks waterfront the new building is architecturally distinguished in its own right, and along with the Eden Project up the road near St Austell adds brilliantly to Cornwall's visitor 'attractions'.

Only a proportion of the Museum's collection can be shown at one time, rotation is planned for March 2004. The present showing includes either models or actual craft exemplifying every sort of small craft from dug-out canoes to a 2001 Phil Morrison International 14, complete with variable-incidence T-foil rudder.

Among full-size distinguished boats are SUPER.. .DOCIOUS, THUNDER & LIGHTNING, and LADY HELMSMAN. The latter two are at floor level so that one can supplement the excellent interactive data display which has film and commentary by some of the people involved with a closer examination at one's leisure.

Multihulls have a special display explaining their merits, and nearby a survey of boat-building methods, from a partly hollowed-out log to carbon-reinforced resin ends with an explanation of Niels Haarbosch's flax fibre reinforced catamaran FLAXCAT, complete with a photo of her at Weymouth Speed Week 2001 - 15.34 knots over 500 metres.

A fleet of radio-controlled model sloops, each some 12" long, may be sailed in a comfortable scale Force 4 for 50p a go, for which you get long enough to accustom to the steering and sheeting controls and then overtake everyone else.

The 'wind' blows across rather than down the oblong pool, so DWFTTW experimenters should not bring their trial models.

Details of opening times etc are at www.nmmc.co.uk, phone +44 (1326) 313 388.

George Chapman.
<gc.chapman@rya-online.net>

Windmill/waterprop Boat

Members may be interested to know that Mr Brad Blackford of Halifax, Nova Scotia made himself a windmill/water screw - propelled boat some twenty years ago, using an eighteen foot Hobiecat hull and has been developing it ever since. He says that it has a VMG of 8.5 knots (byGPS) in any direction including to windward

This speed to windward is remarkable to me, being equivalent to a conventional boat speed of 12 knots close-hauled. I recall previous windmill boat speed claims of the order of 3.5 knots to windward - or am I out of date?

I learned of Mr Bradford's boat in Halifax but did not meet him. We spoke by telephone. He is a retired physicist. He once lectured about his boat at Southampton. His ambition is 10 knots VMG.

Michael Collis
7 Manor Farm Way, Sharnbrook, Bedford. UK

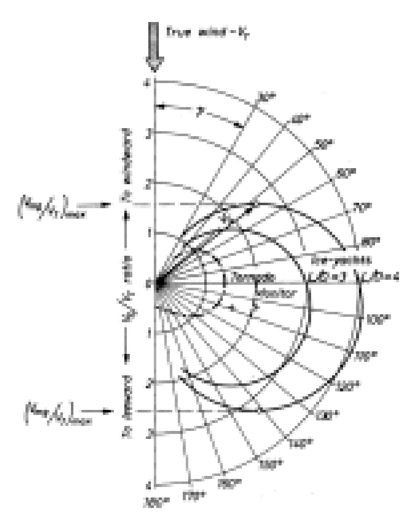
Polar Diagrams

In response to Fred Ball's appeal for polar diagrams of land and ice yachts (Catalyst 11, P.31), there is a diagram with polars of a Tornado and two typical ice yachts on P.138 of '*Aero-hydrodynamics of Sailing*' by C.A. Marchaj, 1979, ISBN 0 229 98652 8. Part 1, Section H 'Land and Hard Water sailing Craft' covers the fundamentals well.

The Wingeatt craft is an interesting design and I wish him luck. The price paid for the excellent performance is that the hull must be very light - it is about the same weight as my 20-foot Red Fox and is, presumably, bare inside.

His argument for his design making a good small cruiser falls down because speed under sail is a low priority today. There are few proper sailors left and the usual solution to any problem is to motor-sail or to motor. There are also few small boats that make passages of any length and even fewer that are taken 'outside' in anything over Force 4.

Michael Collis
Sharnbrook, Bedford. UK



Tornado & ice yacht polar diagrams after Marcaj's 'Aero-hydrodynamics of Sailing'

Exposing the Myth

"And have you concluded as to how you might dedicate yourself?."

Father and son were sitting between the castellations of Henry VIII's fort built on the promontory where Southsea meets Portsmouth. They were idly watching the remnants of Nelsons Fleet lugubriously fetching out to sea. The same spot that Henry last saw his Mary Rose. It was the year 1825, the boy was just fifteen years old and Trafalgar a memory of twenty.

"Yes father, I am mindful of becoming a Naval Architect."

The Father drew a deep breath, and a mysterious look came over his countenance

"A most wise choice William, and now you being of suffient age and wisdom for your years, I shall pass on to you the most sacred law of physics. Worship it, my son for it yields a great truth and is beyond the dispute of any man. It will be your comfort and companion. It is written - The square root of a displacement ships length in feet, multiplied by 1.4 defines the ultimate attainable speed of the ship in knots."

The father had a profound look of self importance, as though he had imparted some tremendous intellectual gift, and had spoken as a high priest giving some holy rite.

William felt very humbled, but very grateful to be the recipient of such profundity and trust as his father had bestowed.

"But father ..." said William hesitantly ..."why is that small mail packet able to overtake the Fleet?"

"Stupid boy, I said displacement ships".

"Yes father, but surely all ships big and small displace water... our teacher said that Archimedes said..."

"Don't be obdurate boy, that is the law and that's final."

He strode away leaving young William Froude feeling privileged and very confused.

And so, William Froude became a Naval Architect. He saw, one day the Cutty Sark that had just become the fastest sailing ship in the world. She was 224 feet long with a beam of 35 feet. She had made the fastest passage ever recorded - 2163 nautical miles in six days, an average speed of 15.09 knots, and carrying a full cargo.

William knew that Nelson's HMS Victory had not equalled this prodigious speed, but why, because they were both more or less the same length. So he decided to find out.

In 1868 he sat on a naval committee to study naval design. His work led to a grant for the construction of the first test tank in England. In it he conducted his experiments. He towed various planks - he called them friction planes - of differing shapes and sizes and weight at various speeds, to observe and record their different characteristics. He discovered the resistance to forward motion of a ship is Friction (wetted area) wave-making (shape/weight) and separation (suction of viscous fluids) also known as eddy-making.

He also observed that by using very thin sections sharply pointed at the ends, wave-making and eddy-making are eliminated.

He concluded that wave-making resistance is caused by transferring the kinetic energy in the ship to the surface or gravity wave system which accompanies it. Differing friction planes caused differing wave characteristics. The interference effects depended upon a relationship between the wave length and the ship's length.

He gave them numbers, as low as 0.6 for blunt planes, higher for narrow sharp ones. This ratio is the Froude number, where Froude Number = Velocity divided by the square-root of the product of acceleration due to gravity and the waterline length.

He had laid the ghost, ...or had he? He died in 1879.

The Institute of Naval Architects reprinted all his many published papers in 1955.

****

"Is that Captain David Watson Taylor?"

"Yes...."

"This is the President's office, Mr McKinley wishes to speak with you."

"Hello Dave, Bill here."

"Yes Sir Mr President" said Captain Taylor of the US Navy. Jumping to attention, his hand trembling on the telephone. He still marvelled at Mr Bell's invention, that had been around for thirty three years now.

"Dave there are some navy guys here arguing about the speed of ships. Our intelligence tell us that the Japanese have some very fast warships that can do 35 knots. British too!. Some of our people say its impossible, they mutter on and on about some 1.4 rule or something. Can you help, we know that you are doing some research?."

"Well Sir eh.. Yeah .. there's that English guy called Froude ..."

"Yes, Yes, But his work was to do with sailing ships? We are talking about ships with powerful engines. Check it out and let me know your findings, you will have full use of the new test tank we're building. OK, have a nice day..."

So it was in that in 1899 Captain D W Taylor of the US Navy began his work in a test tank voted by Congress - the first in the USA.

His own special interest was prismatics and hull sections. He wanted to eliminate the gun's recoil effect on narrow boats, which could knock them over.

In 1910, his book The Speed and Power of Ships was published. It is internationally known as Taylor's Standard and it is still the authoritative book used by naval architects to determine the actual effects on changing characteristics, which make it possible to estimate in advance the resistance to a ship of given properties.

He simplfied Froude's formula, to produce Taylor's Quotient. This speed/length quotient is defined as: velocity (knots) divided by the square-root of the length (feet).

It follows that a heavily-immersed ship will have a low number, whilst the extreme destroyer type craft will have a number as high as 2.0, even though L is constant.

Captain Taylor died in 1940, with the rank of Rear Admiral.

Was that an end at last to this 1.4 myth? And yet....it still persists. Metaphysical worship seems as strong as ever. Even Dennis Conner of America's Cup fame, in his book Sail like a Champion published in 1992, wisely explains to us on page 19 that 'The formula for a displacement boat, ie, one trapped in its own wave train, is hull speed = 1.34 square root of waterline.' Where did he get that figure?. Hadn't he grasped the fact that all boats displace water?

Sailing across the Atlantic in her 60 foot monohull, true a light displacement with a swing keel - Emma the skipper, speaking to the camera, glances at the speedo and casually remarks '22 knots, not bad'.

Was her boat 'Unrestricted by the square root waterline rule, and breaking a fundamental rule of Physics' as described in the January issue of Catalyst, or was it simply conforming to its own Froude/Taylor number?

Enough of this myth. Let common sense prevail.

Let us discard this fable to the annals of fiction.

Can we . . . will we . . . ?

Anyone wishing to acquire a greater in-depth knowledge, and better understanding of this subject, without referring to Froude's published papers or Taylor's Standard can consult the Encyclopaedia Britannica Vol 16, pp 121-136.

David Chinery
1b Brewery Hill Arundel W Sussex BN18 90Q

PS According to Britannica, Froude also experimented with planing hulls - some 30 years before there were engines light enough to propel them!

Conveyer Belt Foils;

(*Catalyst* No 9. 7/02, p 8).

"At Sea, everything should be designed not just for use, but for abuse and refuse as well.". While I'd like to think that was original, I suspect it was said long ago by someone better qualified than me.

In his article, Ken Upton seems to observed the first and third, but I suspect that even he must doubt that his foils would long escape abuse —getting fouled up while on deck for instance, or snapped off on grounding, protective keels notwithstanding.

However, the glory of AYRS and of Catalyst is that people can air their undeveloped ideas knowing, as I have found, that readers will not indulge in negative criticism, but rather find inspiration for related ideas. In my case, an article in an AYRS Publication 10 years ago (Hazelwood, 1993) led me to develop the assymmetric oar with which I have now stern-sculled my 20' boat along some 1000 miles of Britain's Waterways (Practical Boat Owner, September 1998). Ken's article has made me wonder if this oar, like his foils, could not also be used to generate power as well as transmit it? i.e. could a way be found to leave the oar over the stern when moored in a current so it auto-oscillated and, through some mechanism, produced storable energy?

More generally, it seems in fluid dynamics that oscillating motion often results from steady-state conditions; witness how a moored boat on a windless day and in apparently constant current will alternately approach and recede from its buoy. Does this suggest another approach to the problem?

Let's hope that these thoughts and Ken's will, sooner or later, lead to a practical boating device for producing green energy, even if not on the scale he now envisages.

Mike Bedwell
<michael_bedwell@hotmail.com>

Ref: Hazelwood, R. Flowtiller, AYRS Projects 1993, (AYRS Booklet #112) pp19-23.

Request for Information

I am researching amphibious vehicles, specifically a small support vehicle to get from beach to sea even through surf. I have several ideas, but before reinventing-the-wheel I would appreciate any information from the membership of any actual or planned vehicles.

Many thanks in advance.

Peter Westwood
<context@wight365.net>

Speedsailing on the Baltic?

After last years Weymouth Speedweek I gave some thought to the idea thats been on my mind for a couple of years, of organizing another speedsailing event. It would, of course, be planned not to compete in any way with Weymouth Speedweek, indeed, my current idea might even enhance Weymouth event.

Some may probably recall the freelance journalist from Kiel in Germany, Johnny Buerck. I had some long conversations with him both at Weymouth and since. The subject was another Speedsailing event in Germany. We initially thought of 'Kieler Woche' which is Germany's equivalent to Cowes Week but possibly larger. In fact it is so large that we realized that we would get lost in the spray which would not suit our aims, which are to create an interest in Speedsailing here on the continent.

I feel that the Baltic coast of Germany would make a fantastic summer venue. It has a flat landscape which means little disturbance to winds. It has a number of sheltered bays and some enclosed salt water lagoons. It has many campsites and is very tourist oriented which means, to my way of thinking, affordable summer accomodation right on site, and possibly a number of bored tourists looking for something to interest them. There is another very important factor; this coastline is the sailing area of not just Germans but Norwegian, Danes and Swedes, to say nothing of the Dutch , Poles and the Latvians.... I must confess that my ultimate dream may sound utopian from a speedsailing aspect but it is simply to create enough interest that would ultimately lead to something of a Speedsailing 'Grand Prix'. A Springtime event in France - say, Brest, and summer event on the Baltic coast, culminating in what else but Weymouth Speedweek.... I know I am jumping ahead here but do understand that I do realize the frailty of this 'dream' . Anyway, dreams are free!

So, to get into reality I plan to drive my camper North in April/May with the aim to seek out a suitable site which offers sheltered waters from as many directions as possible, together with a suitably sited campsite, hopefully with access to the water where a base camp can be set up.

I have in mind to organize this as a simple 'meeting' and I believe, with Johnny's help that we can get enough mentions in media and magazines to create some interest. I am aware that there are a number of Proa craft, for instance that are all ready to go but nowhere to go to. However, I do believe that it would be very important to set up a course as per Weymouth for a couple of reasons. Firstly for straight forward interest, but with that will come the realization that it is not so cut and dried as many people think, and here some people will hopefully realize that there is a skill factor that gets more complicated as one becomes deeper involved. There is also the fact of being able to accurately measure one's speed over a distance rather than watching a needle flick to the highest point somewhat briefly.

I have spoken to Joddy Chapman and he has shown some interest in coming along. So to has Bob Date of the Bristol Boys. Hopefully some of the other regulars to Weymouth will also be interested in due course. It will be arranged to coincide with school holidays so I hope others might also find the idea attractive.

For the crafts coming over from Britain the major single cost will be the Channel crossing and to this I wonder if you might be able through the title of AYRS, manage to obtain a rebate for AYRS members?

Whatever, please feel free to mention my hopes of arranging this 'Meeting' some time in August in *Catalyst*. It will be interesting to see if there is any feedback.

Chris Evans.
chris.evans@t-online.de

WaPRig

Anthony Warren

Introduction

My wife Maureen and I have sailed a Halcyon 27 for the last few years. We were finding the big genoa increasingly hard work with the passing years, and we planned to build something bigger and more comfortable, also easier to handle, especially in heavy weather. I spent a good deal of time thinking about the rig.

I read several of Marchaj's books, and articles about Junk rig, and Hasler and MacLeod's book "*Practical Junk Rig*". I enjoyed a short trip on a two-masted Junk-rigged boat through the auspices of the Junk Rig Association. I was impressed with how easy Junk is to manage, especially when we were hit by a squall and reefing was accomplished very quickly by simply easing off a couple of halyards.

Equally impressive was the efficiency and performance of the Sail Wing reported by Marchaj (Aero-Hydrodynamics of Sailing, p606). This wing has a D section leading edge canted into the airflow, with stretched double skin cloth abaft. Marchaj also made some very positive statements about parabolic leading edges in a similar role (Sail Performance, page 190).

How then, to combine the ease of handling of Junk rig with real aerodynamic efficiency? Answer: **Snowshoes**! Well, that's what we ended up calling the shaping foils that are the key feature of the Warren Parabolic Rig.

What is *WaPRig*?

The key features are: (see photos)

· Aerodynamically shaped foils (the snowshoes) with circular cutouts slightly ahead of mid-length through which passes the mast. There are a number of these spaced along the length of the leading edge.

· A sail – this passes right round the snowshoe and comes together at the downwind end of the snowshoe. Behind this is conventional single thickness cloth. So we have a thick foil part of which is ahead of the mast, tapering down into a conventional sail.

· Battens pivoting about the aft end of the snowshoe extending aft to the trailing edge of the sail, and forward into the frame of the snowshoe.

The forward extension ensures that the snowshoe cannot over-articulate, and that the lee side of the thick foil merges smoothly with the single layer cloth abaft.

· A boom, with what is called a topping lift in Junk Rig parlance, or adjustable lazy jacks. This serves the double purpose of holding up the boom and catching the sail as it is lowered.
· A boom downhaul
· A yard, from which the top of the sail is hung
· A halyard for hauling up the yard, and a sheet, to haul in the sail.

There are many, many open questions about what might be best to do within this overall design framework. Below I list some of the questions and some of the considerations that might suggest the answers.

Prototype Development – Details, and questions and answers

We bought a second-hand YW Dayboat (14ft centreboard dinghy, heavily built and stable by modern standards), and built a prototype. I fitted some additional woodwork to support the new unstayed mast. The mast was keel-stepped and about 9 inches abaft the original deck-stepped mast for the Bermudian rig for which the boat was designed.

The Mast and its support

We elected to use an unstayed mast in line with Junk Rig practice. It might be possible to attach shrouds and forestay at or near the masthead, but there might be interference with the yard and foils.

The mast cross section can be relatively large, because most of it is within the sail and does not create drag.

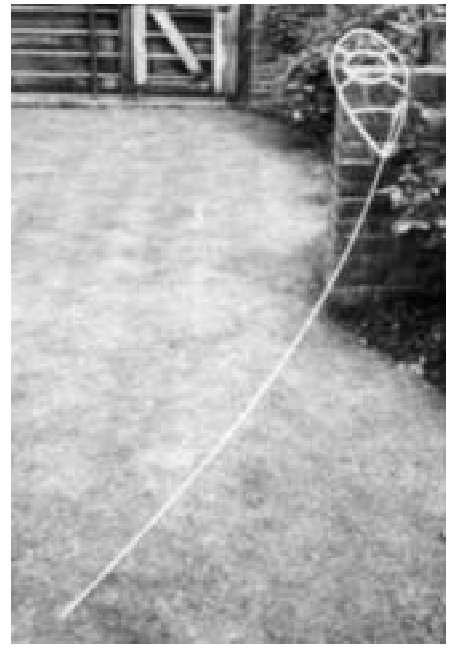
There is the possibility of fitting a freely rotating streamlined fairing to the upper part of the mast to further reduce drag, and a similar fairing could be downhauled from the base of that upper fairing as the yard is lowered.

We built the mast out of standard aluminium tubing.

The Snow Shoes

The precise shape of the leading edge, the aspect ratio, and the chord are all open to experimentation and development. We opted for as near to a parabolic leading edge as my woodworking skills allowed. From about 6 inches aft the leading edge the entire curve was drawn by eye simply to look fair.

The ring in the centre of the snowshoes is a very loose fit over the mast. This ensures there is no binding, either in rotation or vertically during the process of raising and lowering sail.



We made the snowshoes by casting glass matting and polyester resin into a mould made from several layers of MDF board.

A very crude arrangement made from rectangular pultruded fibreglass section stuck to the aft point of the snowshoe allows the battens to pivot from side to side. Movement of the leading end of the batten is restricted by another piece of pultruded fibreglass screwed to the end of the batten. As the batten pivots, the batten stop comes up against the inner rim of the snowshoe.

We stuck heavy duty Velcro all round the outer rim of the snowshoes to attach the sail.

The Sail

What planform should the sail have? Somewhere or anywhere between a square and a triangle seems to be possible.

We opted for a basically rectangular shape with a fairly low aspect ratio (see picture). The aim was to more or less match the sail area of the original Bermudan rig.

We opted to angle the yard upwards toward the aft end, giving a triangular head above the top horizontal batten. I have no idea if this was a good thing to do or not, but it looked pretty. The sail was tied out to the ends of the yard, but not attached along the length of the yard.

We made the sail in two parts. Both parts were made from PE cloth (incredibly cheap) and were cut completely flat.

The first part goes round the snowshoes. It has horizontal Velcro strips on what is to be the inside for attaching the sail to the snow shows. Both trailing edges have Velcro stitched along the entire length, on the inside, for attaching the second part of the sail.

The second part of the sail is effectively a big flat sheet, with batten pockets along the whole depth. Velcro is sewn the whole length of the leading edge on both sides, and attaches to the other part of the sail.

How should the upper and lower ends of the tube formed by the snowshoes and surrounding sail be shaped? I don't know. We left them open to the air, and tied the leading edges of the upper and lower snow shoes to the end of the yard and boom respectively. This seemed to work OK, and may contribute to keeping pressure high within the tubular space: that would help resist collapse of the shape between snowshoes.

The battens all run horizontally, and the line of the top batten extended forward meets the yard ahead of the mast.

The bottom batten is a couple of inches above the foot of the sail. Clew and tack are tied to the boom, but the rest is loose.

The Battens

These are full length, and have a stop fitting on the forward end to prevent over-articulation within the snowshoe.

They are made of pultruded fibreglass.

The Boom

The boom is mainly there to hold up the sail when lowered. The bottom batten can fulfil all the aerodynamic requirements, bearing in mind the sheeting arrangements described below.

The boom should be symmetrical and form a wishbone round the mast. No gooseneck fitting is required as the boom is free to slide up and down the mast. However we made a crude wooden rectangular box, which fitted round the mast, and screwed the boom to it on one (arbitrary) side.

We made the boom out of pultruded glassfibre section.

The boom uphaul (lazy jacks) runs from the masthead, under the boom, back to the masthead and down to a cleat. This enables the rig to be held up out of the cockpit when the sail is lowered. When the boat is to be covered up the whole rig can be dropped down to deck level.

The boom downhaul enables the luff tension to be adjusted. For reefing, it might be necessary to attach further downhauls to some of the snowshoes, one for each reef. We have not experimented that far.

The Yard

All the same remarks apply as for the boom, except the yard, obviously enough, is to hold the sail UP. The sail with its snowshoes, battens and boom all hang from the yard when under sail, exactly as with Junk rig.

Halyard and Sheet

The halyard is led from the cockpit to the masthead and down to the yard. The point of attachment to the yard needs to be made such that the yard is more or less in balance as the sail is hauled up and down.

From the masthead the halyard is passed down inside the frames of the snowshoes but not through the ring through which the mast passes. The same route is used for the boom uphaul and flag hoist.

The sheeting arrangements are typically Junk. Sheeting lines are attached to the sail at the point where each and every batten emerges from the trailing edge. We played with a variety of spans and euphroes. What we ended up with is (I think) a six point euphroe span. We used alloy Inglefield clips as euphroe blocks and they work well. The net purchase on the mainsheet in hand is 3:1.

In order to obtain a sheeting point far enough aft, we built a wood frame extending about 18 inches behind the transom, and attached to it.

Does it work?

I've done a lot of dinghy sailing in the past. It was a wonderful and entirely new experience to be sailing downwind onto a marina pontoon and be able to stop! You just drop the sail, anywhere, anytime, any point of sailing. And it doesn't fall on your head.

We've only sailed the rig twice, and both times in light winds. We had no similar boats against which to measure performance, and the strong tide running made it difficult to estimate just how close to the wind we could sail.

What we do know is that the sail sets fair, with the lee side forming a smooth join between the foil-supported section and the aft part. There was minimal caving in of the leading edge between foils. The rig handled as we had hoped.

The boat remained well balanced, in spite of our new mast being well abaft the designed position, and our having only the one sail set on it, no jib. This could be some indication the foil is generating real lift near the leading edge.

Plus Points:

- Very easy to handle
- Low stress in sail and rig
- Boat can be left rigged
- Performance? Maybe

Minus points

- Getting rigged: all that Velcro!

Further Developments

I have seen enough to convince myself the rig will work on a yacht. We need to develop a snowshoe design where the snowshoes can be fitted round the mast at deck level, rather than being dropped over the top. This means a two-piece snowshoe that can be taken apart.

Apart from that there is endless opportunity for further experimentation with foil shapes, aspect ratios, etc, etc. I am leaving that to others.

We are rebuilding a 40 foot Cornish Lugger. This type of boat could have been designed for our rig. The mizzen lugsail of old was sheeted onto an outrigger (projecting on the stern), and so will ours be. The mainmast was, and will be, right forward in the boat.

Don't hold your breath for further news. The project will take several years at least.

Anthony Warren <amwarren@freeuk.com>

FOR SALE

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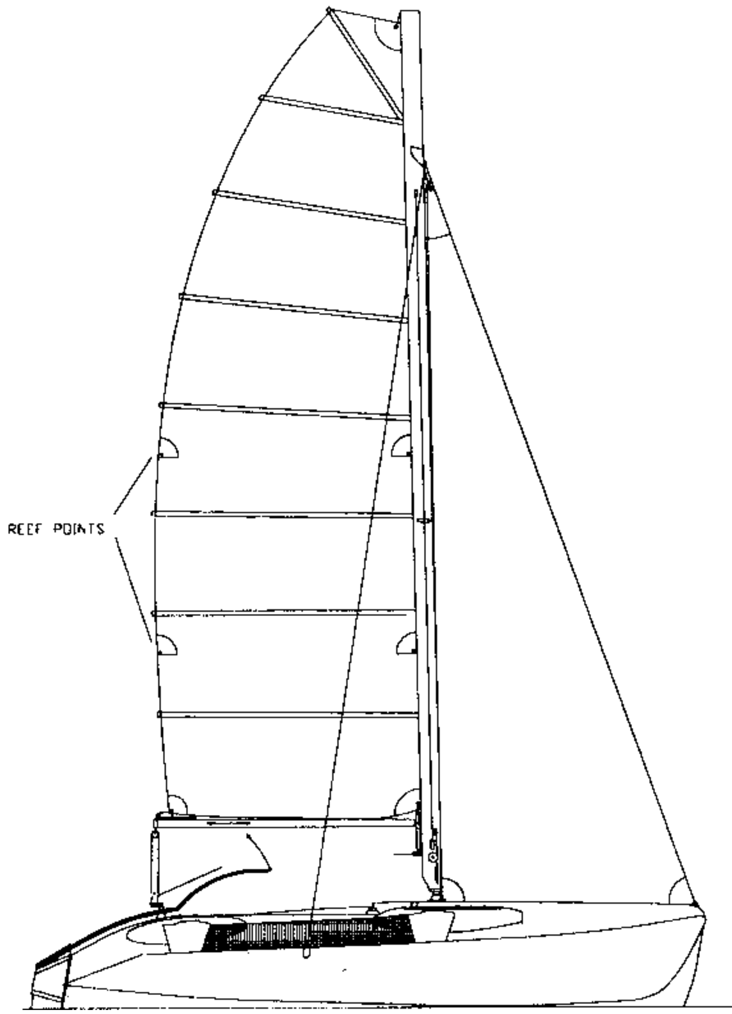
General info about YW Dayboats is at http://www.ywdb.co.uk/index.htm

Anthony Warren <amwarren@freeuk.com>

Design Philosophy — 7 Metre Trimaran

Charles Magnan



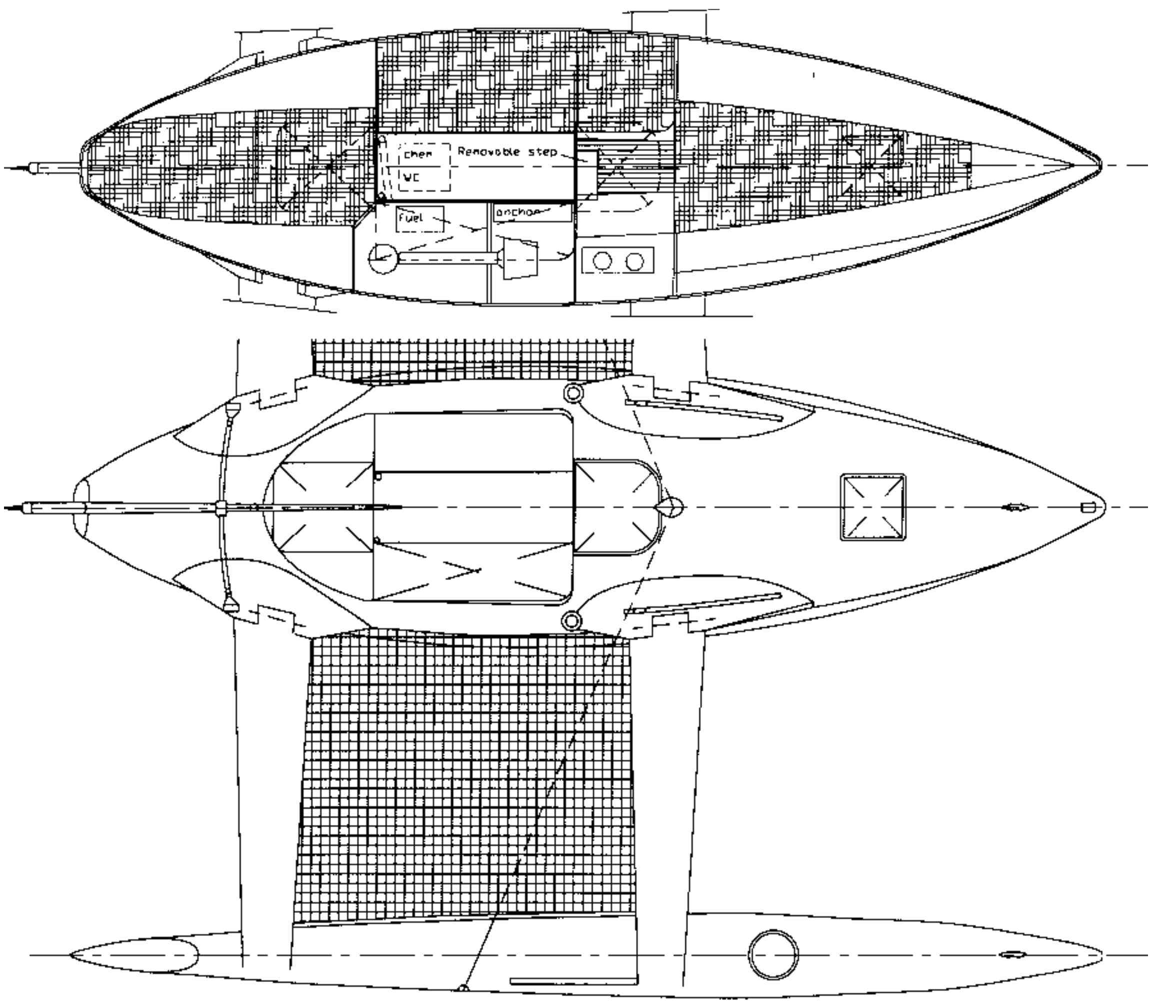
A trailer sailer trimaran designed to be sailed by a one to two person crew. but with weekend accommodation for three.

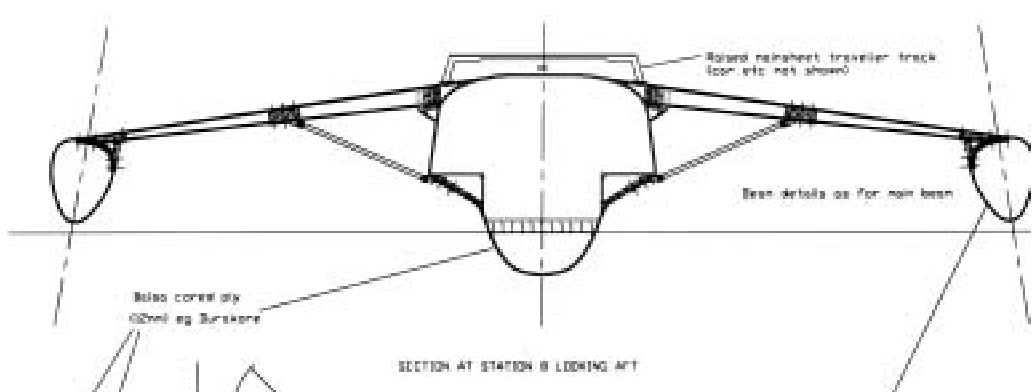
The main design criteria are:

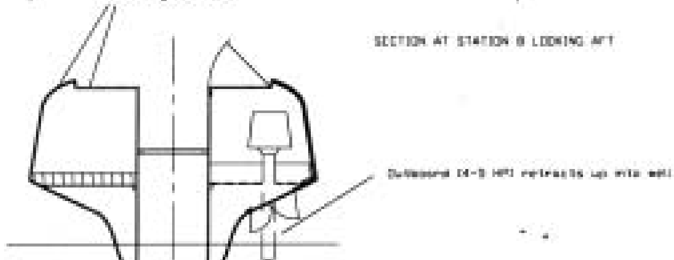
1. Lightweight construction which leads to a boat that is easy to trail behind a fairly small car.
2. Simple construction suitable for home building.
3. Easy to sail, vet with sufficient performance to be competitive in racing.
4. Stable for storage ashore and launching from a slipway with a minimum of setting up time prior to launching.
5. Sleeping accommodation for three people.

In view of the above, a Durakore® plywood/balsa sandwich layup has been chosen although the design could easily be modified for foam sandwich construction. The crossbeams are designed to fold for trailering or to allow storage in a boat compound ashore so that the boat does not have a larger footprint than a comparable monohull.

An enclosed outboard compartment allows the use of a smaller motor than is usually the case as it is located near the LCF and hence allows the outboard to work efficiently without ventilating the propeller in a seaway. The motor can also run more reliably as it is protected from breaking waves and is less likely to be lost overboard due to a securing lanyard not being as well tied on as may have been believed to be the case.







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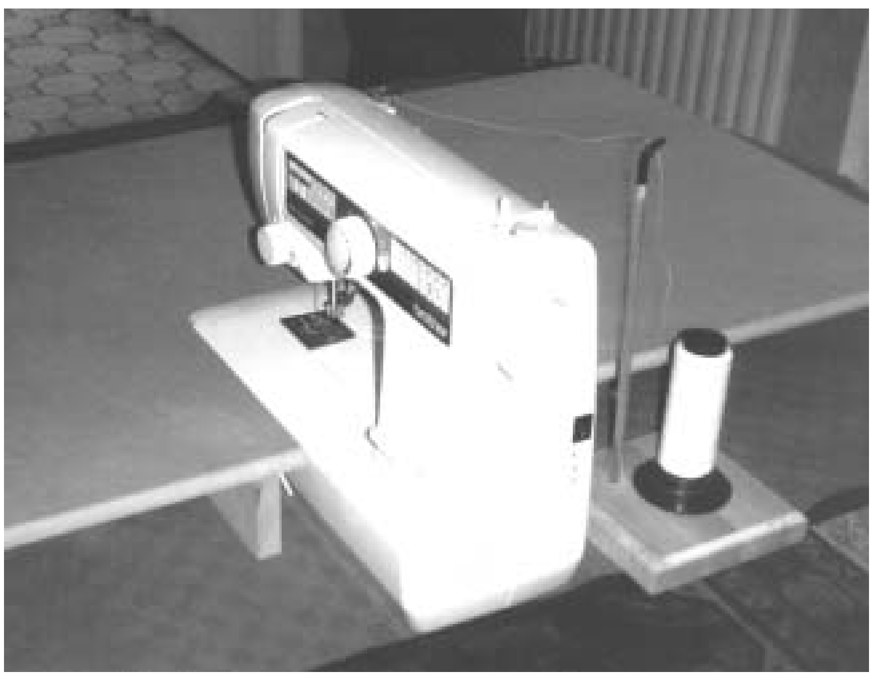
Amateur Sailmaking

Charles Sutherland

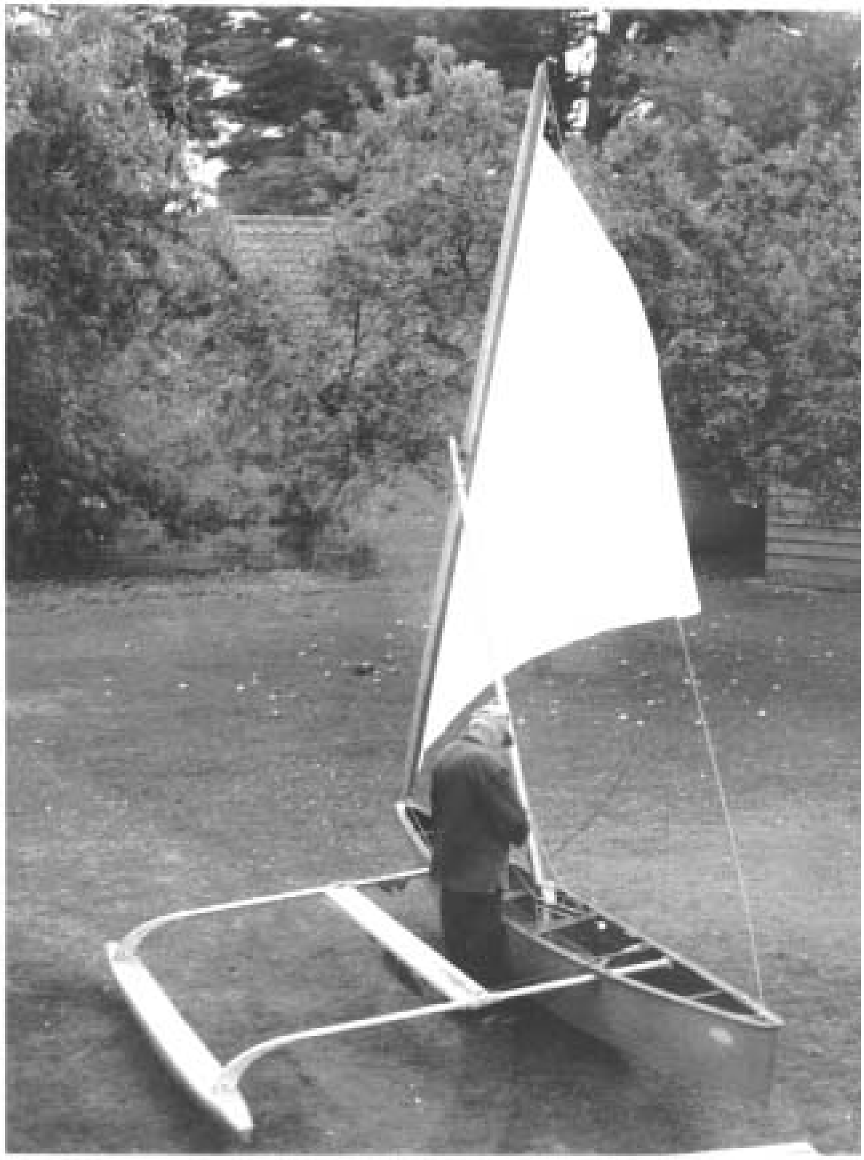
Wanting a small but unusual sail for my boat, I decided to make it myself rather than trying to explain it to a sailmaker. I asked the local sewing-machine shop for the cheapest domestic machine which could do zigzag stitching on sailcloth and bought it, with the advice to use the largest needle. In retrospect, the shop and the general public think 'sailcloth' is the lightweight canvas still used for bags and leisure clothing.



I showed the needle to a sailmaker who provided me with 5 ounce heat-set polyester cloth and a 5 km reel of thread, which is of course too big to sit on the machine. Instead, the stationary reel sits on a vertical peg beside the machine, and the thread is drawn up off it, passing through a fishing rod ring at the height required by the machine. (You can see this at a shoe-mender or tailoring shop). I found that the paper-like stiffness of the sailcloth made the task quite different from sewing e.g. a large curtain. The main body of the cloth cannot be draped over a table while part of a seam is sewn on the small raised working surface of the machine. Pins cannot be used to position the cloth, and the whole sail has to be moved stitch by stitch as it is sewn.

I made a false table top the same height as the machine's working surface, two feet wide and four feet long (8 feet would have been better) with a cut-out for the sewing machine in the middle of the right-hand long side. This sat on our dining table, and the tops of the chairs provided moveable support at about the same height.

I slowly reached a method of working: The whole of one edge of the e.g. inch wide seam was located with masking tape, until the other edge had been sewn. All the rest of the material was rolled up parallel to the seam and secured with strong adhesive tape. The roll needs to be tight enough to be self-supporting, or could have been stiffened with a garden cane or light plastic pipe. It may also need to



be small enough to must pass through the arch of the machine. One can then guide the one or two rolls straight along the false table, while sewing the seam, perhaps stopping now and then to reposition the chairs. The edge of the table provides a useful guide to the direction of the stitching.

I found the slippery sailcloth easy to move on the smoothly sanded table. Considerable force was needed for the machine to puncture the cloth, so I changed from the coarse needle to a finer one. I had bought plenty of cloth, anticipating wastage. In fact I wasted hardly any cloth, but a lot of time in ripping out bad seams and remaking them. The tension setting for zigzag stitching caused a lot of trouble, and I finally reverted to straight stitching. I understand that zigzag seaming was preferred because the seam can stretch with the cloth. I wonder if it is still necessary with modern low-stretch cloth.

Professional-looking circular corner patches are not worth the trouble. One difficult seam was stabilized before sewing by interleaving it with the web-like hot melt tape sold for ‘instant’ seaming. This involves a risk of overheating the cloth. I made a temporary luff seam with strong parcel tape and altered it three times before getting a tolerable shape when hoisting the sail on a nearby tree.

Is amateur sailmaking worthwhile? Only if the sail is small and of unusual design, and you have ample time and patience.

Charles Sutherland

Monofoil — Progress and intellectual property

Jonathan Howes

Many members will have been somewhat surprised, as I was, by the startling similarities between the Monofoil concept and the vessel described by Stephen Bourn in his John Hogg prize paper as printed in Catalyst Number 7 (January 2002).

As a result of the actions of Mr Bourn in applying for world patents on this concept we (Monofoil) have been obliged to take steps to protect the concept, initially by filing observations on the Bourn application and also by initiating Patent activity of our own.

Some members may recall that I presented the broad details of the Monofoil concept during the AYRS Speedweek evening meeting at Weymouth on the 7th of October 1998. Mr Bourn's patent carries a priority date of 2nd November 1998, barely a month after this public meeting. We are therefore objecting to this application on the grounds of lack of novelty.

The actual timeline for Monofoil starts in 1995 when I tired of fighting with the impracticalities of kite rigs. My final kite concept was to pull a sailboard with one, silly idea…! And, as shown in the excerpt from the AYRS Digest for 8th October 1998, I threw the string away and replaced it with a rigid foil:

Fig 1 - The early model

"It became obvious to me that the way ahead was to fly with the rig and keep the bare minimum in the water to react the rig loads. This was achieved by replacing the kite line with a rigid foil, a wing rig at one end replaces the kite (cambered since it is free to feather like a kite), the body (fuselage?) hangs from the supporting foil and is freely pivoted in yaw and at the other end of the foil is a ventilated hydrofoil (also cambered but very hard to describe without a picture!) which dips into the water. The whole rig can rotate around the fuselage and the hydrofoil is constrained to point in the same direction as the fuselage. The wing rig is canted and hauls the fuselage clear of the water when running and pitch stability comes from an aerodynamic fin/tail at the rear of the fuselage. The vessel is capable of equal performance on both tacks and can also be tacked and gybed."

Mr Bourn has used a description of this vessel written by a third party (John Perry) to claim that my use of a foil is different to his use of a "Rigid Strut", the relevant quote being;

"To keep the fuselage from flying too high, the pilot uses the fuselage elevator to set a negative angle of attack on the long streamlined strut which links keel to sail, thus

Figs 2 & 3 - Model trials

producing an aerodynamic downforce to counteract excessive sail lift"

Mr Bourn's contention is based on a highly selective reading of John Perry's article as earlier in the same article as the action of the rig in lifting the fuselage clear of the water surface via the streamlined beam is well explained.

Development

My earliest attempt with the first model took place on the River Thames at Henley when my employer had seen fit to send me on a management course, the Management College at Henley backs onto the river and they own a rowing boat, very thoughtful! I had mistakenly applied dihedral to the free feathering rig but, due to the geometry of a restrained rig this was destabilising and was quickly replaced by an anhedral rig. This allowed the first flights of this variant to occur over the winter of 1996-1997 at Hove Lagoon (not my favourite test location, all the charisma of a building site). This model was shown at Weymouth and is illustrated in Fig 1 in its successful format.

Note that the cross beam is of small chord. It also has an elliptical cross section and is only capable of generating a very small downforce. This was not its reason for existence.

This model hit its designed performance in this configuration (flight in 8 knots of wind measured at rig height with a cruising speed of 20kts).

As an aeronautical engineer I have little faith in analysis without test or test without analysis, I had therefore preceded the build of this first model with a detailed mathematical model of the vessel. Two pictures of the model in flight are shown in Fig 2 & 3.

This model tended to slow if too much heel to windward was allowed to occur so I came up with the bright idea of increasing the chord of the cross beam to allow some negative incidence, applied via the fuselage, to generate some downforce. Not a big drag penalty due to the presence of the rig and the water surface and it seemed too good to miss. This resulted in the second model, a pseudo 1:8 scale model of a potential full scale machine, illustrated by the picture in Fig 4.

Fig 4

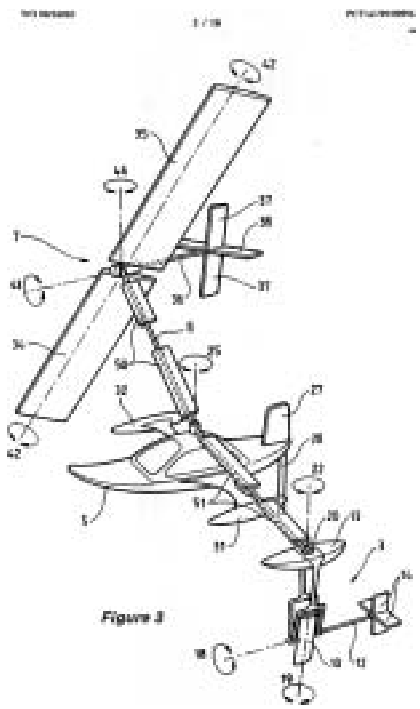


Fig 5 - Drawing from Stephen Bourn's patent

This model was also displayed at the Weymouth meeting and attracted much interest, unfortunately, it was a complete dog, due mostly, to the increased chord cross beam. This tended (with hindsight predictably) to cause the model to flip in turbulent conditions and I have not used this concept since. The two models that have been built since then have both returned to the narrower chord design and I have two other far more elegant methods of controlling weather heel, neither of which I can discuss at present as they may end up in as elements in our defending patent application. The photograph makes a very interesting comparison with Mr Bourn's patent drawing (as originally published in Catalyst);

I was unable to attend the 2000 AYRS meeting at Weymouth, Nick Povey, who is largely to blame for getting me into this activity, showed some video of my third model in action at the meeting and this caught the attention of James Macnaghten who then got in touch, he wanted to build it! After the usual "is he firing on all cylinders" questions it became clear that he was (or at least missing on the same cylinders as me). He also has staff and a serious workshop in addition to a highly inventive turn of mind of his own. As a result we now have a boat taking shape in his workshops with the intention of testing in spring 2004. To whet the appetite, and without giving anything away, Fig 6 is a picture of the fuselage half plug.

I have one further model which incorporates all elements of a well behaved Monofoil and James has been introduced to the "joys" of model testing, great for patience but very frustrating given that winds about two feet from the water surface are rarely strong enough and virtually never coincide with a favourable tide.

I now have film evidence of Models Three and Four in action, none of which can be released at present due to the ongoing intellectual property problems. My first instinct was not to patent as this only tends to inhibit progress, but, given the actions of Mr Bourn, we may have no choice but to proceed with protection of the key elements that have not yet been disclosed.

The latest iteration of the Bourn patent is that he is now claiming that his vessel comprises only a hydrofoil assembly, an aerofoil assembly, a rigid beam and a hull connected to the rigid beam (ref: claim 1 of his revised European patent application). He has also contended that Monofoil has more elements than this and that therefore "Howes' craft neither infringes nor invalidates any of my claims". This does not excuse that Mr Bourn's key inventive step is identical to the replacement of a kite string with a rigid foil as referred to in the AYRS excerpt above. Further, without additional stabilizing elements I strongly doubt that a vessel comprising just these elements, in the configuration described in Mr Bourn's primary claim, can be made to sail at all. I invite him to demonstrate otherwise and refer him to his own subsidiary claims, many of which directly coincide with essential elements of Monofoil.

It is going to be an interesting year!

Jonathan Howes
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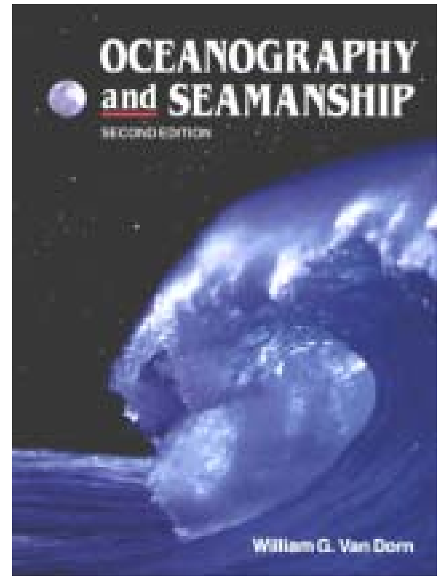
Reading Matters - a page of reviews

Oceanography and Seamanship



William G Van Dorn

Cornell Maritime Press; ; 2nd edition (February 1993) ISBN: 0870334344

Hardback 453 pages Dimensions (in inches): 1.53 x 11.32 x 8.89; many graphs, line drawings and photographs.

Price: Approximately £40

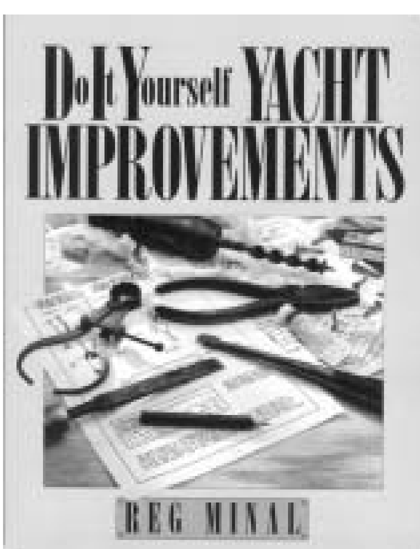
The author is both a working oceanographer and an active sailor. As such his academic knowledge of the sea environment underlies implicitly his approach to seamanship.

A good grounding in the science of oceanography appears within the book, but always with a view to the knowledge required by the seaman.

To take just a couple of references: A powerful section on anchoring in limiting conditions denies the myth that all you need is more chain; his suggestion that the best clothing to wear at sea is a wet suit has a strong reasonance with me, as a dinghy sailor - it seems strange to me to wear clothing on board that will not work if you fall overboard!

His writing style will appeal to the casual as well as the serious reader. There is plenty of maths if you want to follow them, but often the author resolves the maths into straightforward parameters that are easily accessible and memorable in times of difficulty at sea.

His analysis of the fully-developed-sea, some interesting comments on chain-plate fastenings he has seen, make this book readable. A love of his subject and the detail he provides make this a solid reference book for all who may set out on the sea - even armchair sailors.



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Down Wind Faster Than The Wind

Contributions from many members

1. Theo Schmidt

The letters and articles in Catalyst 10 and 11 on the subject "Downwind faster than the wind" (DWFTTW) still havn't reached a common conclusion. In 1999 we had an intensive discussion on the subject on the AYRS email mailing list - now unfortunately defunct. I can send interested people copies of these digests by email. Most of us concluded that DWFTTW was theoretically possible but practically doubtful.

Frank Bailey requested opinions presented without using much math. This is a laudable sentiment, as the papers we have had on the subject so far, including Joeseph Norwood's treatise in AYRS 120, rely so heavily on mathematics that most people are not able to follow everything and find any errors there may be. I think I can show here that DWFTTW is possible without resorting to more than a few simple calculations, but will need a lot of text to do so. However I'll try to break this down into managable units and write clearly enough to convince most people.

One reason DWFTTW is so elusive lies in the following geometrical problem:

4-quadrant operation: A propeller or turbine utilises twisted blades with certain blade profiles, usually a completely asymetrical one like the Clark Y shown, which has camber and also a rounded nose/ sharp tail. As shown in the figure there are however four directions from which the fluid flow can approach, and as we will see, a "practical" DWFTTW craft needs to utilise each of these four quadrants on both the air-screw and the water-screw. Most people are familiar with the "normal" and "normal reverse" quadrants when using a motor boat. "Normal reverse" is clearly the very worst quadrant and this is borne out by the poor performance of propellers in reverse, although this is often not noticed because modern engines are ridiculously powerful and "ordinary" motor-boat propellers have pretty poor profiles anyway.

The "inverse" quadrant is what happens when you use what is normally a propeller as a turbine, or vice-versa. The "inverse reverse" quadrant is what you get if you use this "wrong" device the "wrong" way around as well. Now there are three things we can do to against this problem:

1) Uncambered profile. If we use a blade profile like the NACA 20012 suggested by Mario Rosato, the performance as propeller or as turbine is identical, however such blades will stall more quickly than a cambered blade used in its preferred quadrant. The efficiency and the useful operating range will be smaller. However as "normal" and "inverse" are identical, the performance is better than a cambered blade used in "inverse".

2) Ogival profile. If we use ogival blades, as is done with many traditional marine propellers, the quadrants "normal" and "inverse reverse" are identical. In conjuction with 3) below we can use ogival blades for both propellers and turbines. However ogival blades like 1) have neither the peak efficiency nor the operating range of asymetrical blades used in the preferred quadrant.

3) "Swivelling" drive. If the device is free to swivel 360° as with the "Schottle" drive" or the common small electric outboards, or indeed most wind turbines on boats, we can turn the device 180° in order to get the "normal" operation in "reverse" (or "inverse" instead of "inverse reverse").

If this all sounds confusing, just take a real propeller into your hands and you will see what is meant.

By combining 1) and 3), or 2) and 3), we can cover three of the four quadrants, but one will always be bad. For the ultimate in efficiency it is required to have two separate air screws and water screws, or indeed two separate boats, one for going upwind, and the other for going downwind (I will not complicate matters by reflecting on the autogyro mode or on any courses other than straight downwind.) This is one reason why "practical" DWFTTW boats may remain very few even when the principle has been proven.

Efficiency and Power Factor: As has been shown in various articles in AYRS publications [e.g. Catalyst 11] all fluid propulsion devices including turbines are subject to the disc-actuator theory which follows from simple fluid dynamics. Real devices can actually come very near to this ideal. Mario Rosato describes Betz's theorem, which states that the maximum power which can be removed from a fluid stream is 16/27 of the total power. It is then suggested that this means that DWFTTW is theoretically impossible. I think this must be reformulated to say that DWFTTW may be impossible if an ideal turbine is used, an ideal turbine being defined as one working near the Betz limit and hence using its swept area (i.e. area of the disc which the blades sweep out) as efficiently as possible. This means that DWFTTW may be possible if the turbine *isn't* operated near the Betz limit, which means that it will be larger than an ideal Betz turbine.

Betz's theorem is important when it is desired to get the highest power possible from the smallest swept area. It tells us how much power we may at most expect from a windmill of a certain size in a certain wind speed.

For the user of a mobile wind turbine on a vehicle, another property is more important: the prime interest is to get the maximum ratio of generated (shaft) power relative to the (impeding) force developed by the turbine, as the craft's propeller must produce oppose exactly this force plus the hull's drag. The actual fraction of generated (shaft) power extracted from the total power contained in the wind is only of secondary interest. We do *not* need to optimise this "size effectiveness", indeed in order to get a good *power efficiency* we must use only a small fraction of the power available and hence our devices will be larger than those working at the "Betz limit". It is only practical considerations which limit the size, including strength and cost of materials or geometrical considerations like heeling moment. For a thought experiment we can of course make the device as large as we like.

Actuator disc theory tells us that the smaller the load on the propeller or turbine disc, the higher the efficiency can get, approaching 100% as the size approaches infinity. Practical efficiencies of over 90% are achievable in practice for real devices at the best operating point. This is near enough to 100% to consider the DWFTTW question partly assuming ideal devices. In this case it is easy to prove that DWFTTW is possible with various thought experiments or mechanical models, e.g. Topher Dawson's thread spool experiment described in Catalyst 11. A similar device was described in AYRS publication Number 100.

An Imaginary Voyage

The question is not whether DWFTTW is theoretically possible, but rather whether such devices could be built in practice, and how low the drag of the boat hull would have to be. Keeping these things in mind, let us follow the progress of a hypothetical turbine yacht as it starts from rest and slowly accelerates to DWFTTW. We'll pause along the way and make several "snapshots" of its progress. The true wind VT will be considered the same for all stages. Unless stated otherwise, we'll assume ideal turbines and propellers, no resistances from the hull, no mechanical friction (or electrical losses) in the drive train, and a continuously variable transmission or electrical equivalent between the air-screw and water-screw. We'll use some simple equations and leave away the signs (minus and plus) to make it really easy. This means that you must keep track mentally in which direction a speed or force is acting.

Before we start on our trip I must mention that we will have to change the modes of our screw devices several times. An "ordinary" wind turbine boat uses a wind turbine and a water propeller. A DWFTTW-boat requires a air propeller and a water turbine. This is because the turbine must be in the medium with the faster flow, relative to the craft, because the turbine must produce more shaft power than the propeller consumes.

1) ***Leaving the mooring*** We start our trip from a mooring, say a buoy or anchor. We want to be able to release the mooring gently and stay at the same spot without immediately drifting downwind, which means being able to just go exactly upwind. The apparent wind V_A equals V_T, the boat speed V_B is zero. The power input to the air turbine is $P_A = F_A \times V_T$. The wind will try to push the boat downwind with aerodynamic drag force D_A (windage of hull and superstructure), so in order to keep the craft stationary when slipping the mooring, $D_A + F_A$ must be opposed by an equally large force F_W from the water propeller. To make things simple until further notice, let's neglect the windage D_A and take $F_A = F_W = F$. At that moment P_A also equals P_W so we call both P.

Now a propeller in a stationary fluid by definition has efficiency zero, but this does not mean it cannot produce a force. It does this by generating a local fluid stream or jet, i.e. accelerating a mass of water in the opposite direction. If a power P produces a static thrust or “bollard pull” F, the value F/P is a figure of merit which can be easily measured and is indeed often available for commercial outboard motors. We’ll call this T_S.

As $F = P/V_T$, $T_S = F/P = (P/V_T)/P = 1/V_T$. This means that if T_S can be greater than $1/V_T$, the system can move to windward. Values for T_S of 1-2 N/W (Newtons per Watt) have been measured for propellers used on human-powered boats. Thus such propellers can be used with V_T as low as 0.5m/s. If V_T is 10m/s, a T_S of only F/P = 0.1 N/W is required. This means that for most windspeeds, the wind turbine produces several times the power required by the propeller, so there is plenty left over to overcome the boat drag and do some useful work as well. If our transmission is electric, we can make tea or charge batteries and at the same time hold the craft absolutely stationary in the wind, a useful feature for staying very near the starting line in a race!

I have seen this demonstrated in practice, so there is no question that it is not both possible and practical.

Now we turn the craft so that it points downwind. Both the wind-turbine and the water-propeller should be swivelled around, so that their blades operate in the “normal” quadrant as described earlier. There is no difference to before except that there will may be slightly more aerodynamic drag from the boat so that we have slightly less free power available for frivolous purposes, or we start …

2) ***Drifting***: Going downwind at $V_B = 0.1\ V_T$, V_A is now 0.9 V_T, P_A has reduced to $0.9 \times V_T \times F_A$. However the power needed to keep the craft from accelerating downwind is less than before. In order to go faster downwind, we slow down the speed of the water-propeller, which is still pushing in upwind direction. Eventually it will be completely stopped, with just the static drag of the blades sufficient. Now is time to switch the mode of the water-screw from propeller to turbine mode. If we have ogival blades, it is sufficient to let the water-screw begin to auto-rotate in the water stream. If we have symetrical blades, we should swivel the drive around, and if we have asymetrical blades, we should swivel the drive around and replace the “propeller blades” with “turbine blades”, which have opposite camber. As the boat speed increases, so does the flow through the water-screw, and we can begin to extract power from this. We accelerate to:

3) ***$V_B = 0.25\ V_T$***: V_A is now 0.75 V_T. P_A has reduced to $0.75 \times V_T \times F$, however we are getting some power from $P_W = V_B \times F = 0.25 \times V_T \times F$ and so can continue to make tea and recharge batteries. $P_A = 3\ P_W$. Both the air-screw and the water-screw are acting as turbines and producing useful power, the air-turbine acting like a sail and the water-turbine acting like a brake. In order to go faster, we can decrease the pitch of the air-turbine or increase the pitch of the water-turbine. The total boat drag which we have neglected is likely to be very small - the water drag of the hull D_W probably just about cancelling the air resistance D_A from the superstructure. We eventually reach:

4) ***$V_B = 0.5\ V_T$***: V_A is now $0.5\ V_T = V_B$. This is an interesting situation, as $P_A = P_W = 0.5 \times V_T \times F$, i.e. both the wind and the water turbine are producing the same amount of power. Of course, in reality, the (opposing) hydrodynamic drag of the boat hull D_W is getting larger and the (helping) aerodynamic drag D_A is getting smaller. Therefore F_A and F_W are not really equal, as $F_A = F_W + (D_W - D_A)$, and as we speed up, D_W becomes greater and D_A smaller. Therefore we must reduce F_W, which is can be done e.g. by making less tea, i.e. reducing the load on the generator connected to the water turbine. We move along to:

5) ***$V_B = 0.75\ V_T$:*** V_A is now 0.25 V_T, P_A has reduced to $0.25 \times V_T \times F_A$, P_W has increased to $0.75 \times V_T \times F_W$. As the hydrodynamic hull drag D_W is becoming larger and the windage D_A smaller, $F_A = F_W + (D_W - D_A)$ is becoming considerably greater than F_W. Now this is fine when we still assume both turbines to have 100% or at least very high efficiencies, but in the case of the wind turbine the efficiency must eventually decrease, as we are increasing the loading of the actuator disc. Indeed we may be approaching the Betz limit, so that the efficiency must be below about 60%. However, what does this mean? As we are only using the wind turbine’s power to boil tea, it doesn’t matter that the efficiency is decreasing, all we want is to get the maximum force F_A possible. We can do this to some extent by increasing the load on the wind generator (more tea!) and by decreasing the pitch of its blades, causing it to rotate faster. Eventually we will however stall the blades and will have to take load away from the generator (less tea!). The wind turbine will then be turning fast, producing much force and little power. We are getting into autogyro mode.

Eventually however we will have too little force when V_A gets too samll. We will have to switch the air-screw from autogyro (turbine) to propeller mode.

If our air-screw has symetrical blades this involves swivelling it around 180° and applying mechanical power in order to change the direction of rotation. This is a drastic manoeuvre akin to gybing the mainsail of a Marconi rig. However, it won't be too bad, as V_A is small. In the unlikely case that we have ogival blades, we don't have to swivel around. If we have asymetrical blades, we will have to climb up on deck and replace the set of turbine blades with our set of propeller blades. In practice - if we contemplate such a crazy manoeuvre at all - during this time we want to keep the boat speed up during this operation and therefore momentarily use the water turbine as a propeller, using a supply of stored energy (e.g. batteries). Of course, the water screw will be in the wrong quadrant for this and therefore will be running at a poor efficiency. Having completed the switch, we begin to apply power to the air propeller. Now, using a propeller against the flow is not a nice thing to do. Its efficiency is negative and this is clumsy, just like an automobile which still uses petrol when going downhill. However with an air-propeller it is not as horrible as the common practise of ferry boats which brake forward movement by reversing their engines, the water-propellers rumbling and the whole ship shaking. In contrast, I have used an air-propeller in a following wind on a human-powered boat and it is quite nice: only a little power is required to go downwind approaching wind speed, or even overtaking the wind, which is what we are attempting with DWFTTW. Now we are approaching:

6) ***$V_B = 0.9\ V_T$:*** V_A is now only 0.1 V_T. We have switched the air-screw to propeller mode and are using it with a negative efficiency, therefore the value of $P_A = 0.1 \times V_T \times F_A$ is of no interest now. P_W has increased to $0.9 \times V_T \times F_W$ and the hull drag D_W has risen again, while D_A has nearly disappeared. What we now need to do is with the air propeller produce a force equal to $D_W + P_W/(0.9 \times V_T)$. This is really the same situation as in 1), except that the modes of the air-screw and the water-screw are exchanged, and that we have the hull's water drag D_W rather than its air drag D_A to contend with. We can probably produce a thrust T_S of at least 1 N/W with the air propeller. At a true wind speed of $V_T = 8$ m/s, we would be getting $P_W/F_W = 0.9 \times 8$ W/N = 7.2 W/N from the water turbine, so we are getting over 7 times enough power from the turbine to power the propeller. In other words, from a certain quantity of thrust, the water turbine can produce 7 times the power the air propeller needs to produce this quantity of thrust (at $V_T = 8$ m/s), still assuming an ideal water turbine and a real air propeller. Thus the hull's drag D_W can be up to 6 F_W (at $V_T = 8$ m/s). The water turbine is a handy small device compared to the hull and the air propeller, and the question really becomes whether a hull with the required drag can support a wind propeller large enough to produce the required force. The answer to this question must await more figures from calculations and measurements. If we do have a really low-drag hull, perhaps an optimised hydofoil, we might still be able to divert some power for making tea at this point. Having gotten this far, there is no difference in principle in reaching:

7) ***$V_B = V_T$:*** Now we come to the crunch: $V_A = 0$! The craft is now running at exactly wind speed in absolutely still air, other than the flow created by its own air propeller. There is no difference in principle or change of mode compared to case 6). There will also be no in principle change when the craft exceeds true wind speed. If we got to 6) and were still able to make tea, it is now no problem at all to stop drinking and accelerate smoothly through "the eye of the wind". Indeed, the air propeller will start to become more efficient. The only question is the mechanical one: Can our hull support a large enough air propeller? This is rather the same answer which Joe Norwood arrived at with much calculation. Clearly a heavy tub with a small air propeller will not be able to go DWFTTW, whereas a state-of-the-art multihull or hydrofoil boat 'might'. All that is required is that the air propeller is large enough so that it can drive the hull at V_B in a static thrust condition. If this is the case, the system will work, as the extra drag of a water turbine required to produce an equal extra force in the air propeller is *less* by a large factor which I believe is proportional to V_T. This is *not* perpetual motion, we are at all times extracting power from the difference between the air and water speeds. In theory it makes no matter which is which. In practice we have a problem with making large air screws and with extraordinary hull drag forces (wave and spray making). In contrast to the "upwind against the wind" case, where both problems are minimised, with DWFTTW, both problems are maximised.

8) ***$V_B > V_T$:*** How does it continue? Well, with increasing speed the air propeller becomes more efficient but its required power input also increases. Also, the drag of the hull increases with at least the square of V_B. Therefore there is a limiting speed for each set of conditions. Now it is interesting that the case $V_B = 1.5\ V_T$ is very similar to the case when the boat goes *upwind* at 0.5 V_T, which is about what *real* windturbine boats have been shown to do.

If we look at the wind velocity arrows for these two cases we see that they are identical if V_A and V_B are switched. As V_A contributes to the air forces and V_B to the water forces, we have an identical situation if we switch the water components and the air components. To see what this means we come to:

A General principle of turbine boats

Upwind air-turbine / water propeller boats work in theory and practice and DWFTTW air-propeller / water-turbine boats work in theory but we do not know yet whether they can work in practice. Even if they can, a further question is whether the *same* boat can go both upwind and DWFTTW. A boat which has a symetrical relationship between the components operating in air and water could do this. Let us therefore formulate the general principle of actuator-type sailing boats.

We have two pairs of components each acting in one of the two fluids. These fluids do not necessary have to be water and air, but could also be two different layers of water or air moving relative to each other.

1) ***Actuator pair*** One of these is a turbine and one is a propeller. Each is in a different fluid. For these to be considered symetrical and thus interchangable, the following criteria must be fulfilled: a) The Reynold's numbers are similar (in practice quite a large variation is possible). b) Secondary effects like cavitation, ventilation, and compressibility are negligible (usually not a problem). c) The quadrants should be the same (see discussion early in this article). d) The thrust coefficients should be similar. e) The ratio of the swept areas should be the inverse of the ratio of the fluid densities.

What this means is that the diameter of an air-screw should be 33 times the diameter of the water screw, as the ratio of the densities is about 1000.

2) ***Drag pair*** The craft has parts in each of the two fluids, e.g. the hull below the waterline and the superstructure above the waterline. In our simplified model we consider only drag components which are proportional to the square of the fluid speeds, which corresponds closely to reality if we neglect improvements like hydrofoils, ice-blades or wheels, and additional drag due to wave or spray-making on the interface. In practice our model is usable for long slim hulls, e.g. rowing shells or multihulls. The two components can be considered symetrical and interchangable if the ratio of the respective drag areas (C_D*A) is the inverse of the ratio of fluid densities.

A boat conforming to 1) and 2) would travel upwind and DWFTTW equally well, i.e. if it could go upwind just a little, it could also go DWFTTW just a little, and if it could go upwind at V_T, it could go downwind at 2 V_T. Can we thus say that because real boats can go upwind at 0.5 V_T, they could go downwind at 1.5 V_T? Unfortunately no, because they are far from symetrical, indeed they are optimised for the upwind case. The ratio of air-screw to water-screw diameter is only 4.75 to 8 for some real boats, reflecting the high apparent wind V_A and low boat speed V_B. To go DWFTTW we have a low V_A and a high V_B. If this means switching the diameter ratios, we would get air-screws of up to 200 times the diameter of the water screws. As this is just about impossible, we will need to optimise less or find ways around this. We have the same problem with the drag areas. A rowing shell's water drag area is only about 100 times less than the rower's air drag area. Multiplied by the density ratio, the water drag is ten times more. For a symetrical craft the drags would have to be similar, and for a optimised DWFTTW craft they would have to be reversed, e.g. by reducing the water drag one hundred times.

What does this all mean? Although we havn't done any proper calculations yet, we can safely say going DWFTTW is marginal and will require great efforts in making especially large wind propellers and especially low-drag hulls, a task comparable to building human-powered helicopters, which is equally marginal. It is unlikely that anybody will be motivated enough to do this unless there is a large cash prize. Actually Robert Hobbs pledged £500 for demonstrating DWFTTW in August 1999, but I havn't heard anybody take it up yet.

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2. Jon Howes

Reference the latest Catalyst, Mario Rosato has his model wrong - the aerodynamic bit should be a propellor, not a turbine. Now refer to the sketch.

Notation:

V_W = Belt or wind speed

v = increment by which the belt or wind speed is exceeded

F = drag on wheel

T = thrust from propellor

n = efficieny of drive and propellor

P = power in or out of the system

This will only fall over if n is a function of ($v + V_W$), i.e. if the wheel is braked. If the braking losses are very much smaller than the drive + aerodynamic losses it works just fine!

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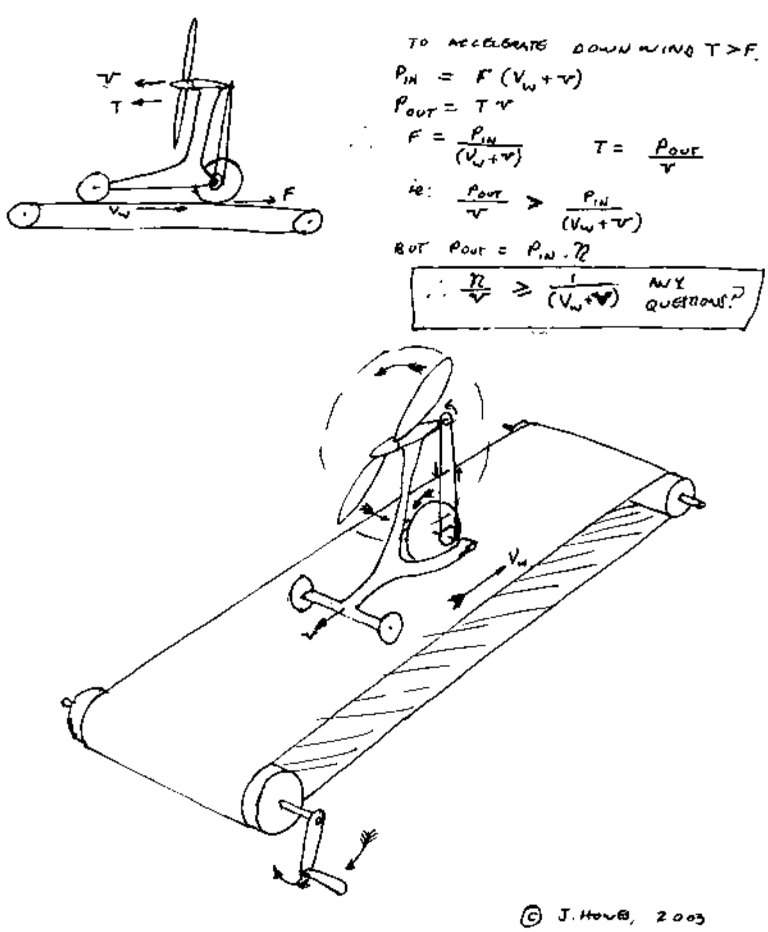

3. John Perry

I must say that I had assumed that if a DWFTTW boat is ever built it would be built as a one off stunt just to show that it can be done. In that case both screws could be perfectly optimised for a direct downwind course and for just one particular wind speed. The boat would be towed out of harbour by a motor boat, released to make one timed run over a measured distance and thereafter mothballed as a curiosity in some minor maritime museum.

If one starts to think in terms of a ‘practical’ DWFTTW boat then, as Theo says, you run into a whole lot more problems that I had not even dreamt of, I suspect that making the tea would not be the greatest of these problems!

If you want to think about a DWFTTW boat that can also go upwind perhaps it would be best to just reverse the direction of travel of the boat, i.e. the same end of the boat always points downwind. If you do that I think you can have asymmetrical cambered rotor blades always turning in the same direction, you just need a mechanism to revolve the blades about 90 degrees about a radial axis to change from a coarse pitch turbine to a fine pitch propeller. That should not be too difficult since reversible pitch motor boat propellers change pitch though a similar range of angle. Another point is that travelling upwind you probably want the centre of gravity forward since you have an elevated drag vector from the airscrew and a low down thrust vector from the water screw. For DWFTTW the thrust and drag are reversed so you want the centre of gravity aft. If you just reverse the direction of the whole boat the centre of gravity is always at the right end. My guess is that this could well be a hydrofoil boat so for the main lifting hydrofoil(s) you could either have an ogival foil section and tilt it one way or the other, or an asymmetric section and spin it 180 degrees about a vertical axis. Or perhaps since this boat is almost inevitably going to go faster downwind than upwind you operate as a hydrofoil downwind and as a displacement catamaran upwind.

At a recent meeting of AYRS organised by Fred Ball and held near Chertsey I did present some figures which showed that a DWFTTW rotor system could produce a modest forward propulsive force to balance against hull drag. These calculations could certainly be improved but unless I have made some mistake (which is certainly possible) I think they are adequate to count as an initial feasibility study.

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4. Jim Champ

Some interesting thoughts in the last issue. We must remember that sailcraft derive their energy from the differing velocities between wind and water, so the more of that we can exploit the better. As Slieve McGalliard points out from Bethwaite's figures a VMG faster than the wind is very achievable, and these days there are some thousands of craft in existence that can do it.

Mario Rosato's well prepared and far-too-mathematical-for-me paper appears to demonstrate that dead downwind at windspeed or more is impossible, and I'm not going to dispute that given his model... But, If we imagine two skiffs, both travelling on opposite gybes at a VMG in excess of windspeed, and and imagine that they are linked together with a piece of "perfect" elastic, and gybing regularly and simultaneously, then the centre of that elastic is clearly travelling downwind at a VMG in excess of windspeed, and because this model is indefinitely sustainable presumably one could consider it a single craft - imagine a water skier being towed at this point!

OK, but is this exploitable by a single craft? Here's where Mario could tell you and I can't. I can imagine two rigs on a single hull, both running on a perfect low friction track so that they can only move at 90 degrees to the hull. These rigs are set up so that they "Reach" off on opposite gybes and gybe back simultaneously. The craft doesn't need a centreboard because the two rigs interact to serve the purpose. What worries me is that I'm then not clear where the other half of the interface in the water is acting against, but it's quite clear that this theoretical craft is extracting energy from a huge volume of air, using highly efficient aerodynamics. There's certainly no free lunch or perpetual motion here, because the amount of wind slowed down by such a craft is vastly in excess of what a parachute of the same sail area would achieve. Of course to a good extent this effect is exactly what the kite surfer, flying his kite in figures of 8 to go fast dowmnwind, is achieving.

The key thing here is that the apparent wind on these rigs must be ahead of the beam, otherwise you won't get enough power to work.

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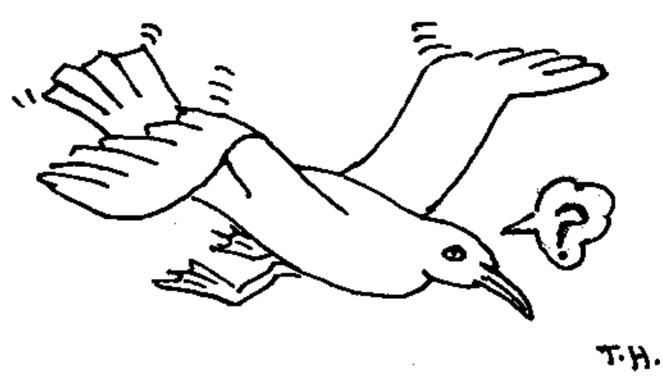

Look at me! I'm going downwind faster than the wind!

Errors Re. Sailing Directly Downwind; Plus Examples of PAS Craft

Peter A. Sharp

In Catalyst, No. 10, (Oct. 2002.) on page 12, Slieve McGalliard discusses the Bauer air propeller land yacht that can go downwind faster than the wind. He states, "I am convinced that the wheels are not feeding mechanical energy to the rotor..." He believes the rotor remains a windmill. That is incorrect. As I described in my article, "Power Alternating Sailing (PAS)", Catalyst, No. 3 (Jan. 2001), Bauer demonstrated a model of his vehicle operating on a moving conveyor belt in a windless room. The model used a wheel geared to a fixed-pitch air propeller. There was no windmill involved at any time. There was no wind energy at any time. The principle of operation of the model was the same as the full scale version outdoors in a wind. The model went against the direction of the belt, faster than the belt. That is directly analogous to going directly downwind faster than the wind because, from the frame of reference of the model, it does not matter to the model which medium (the air or the supporting surface) is actually moving. The model can "see" no difference (as long as the relative motion is in the correct direction).

Clearly, the wheel-mill had to be powering the model's air propeller since the moving conveyor belt was the only source of energy. An outdoor Bauer vehicle derives energy ultimately from the wind, but it takes that energy directly from the ground, since it does not matter to the vehicle which medium is actually moving, as long as there is a relative motion between the two media, in the right direction. It can "see" no difference in terms of its mechanical operation. Its wheel functions as a wheel-mill to power the air propeller regardless of whether it is moving against a conveyor belt or outrunning the wind outdoors. From the frame of reference of the vehicle, and in terms of its principle of operation, the two situations are identical.

Of course, the conventional mathematical explanations, which use the stationary ground of the observer as the frame of reference in both cases, must explain the two cases differently, and then describe the two cases as only analogous to each other. But from the frame of reference of the vehicle, the two cases are identical to each other, not merely analogous to each other.

The following brief introduction to my purely logical explanation (the "mill-prop paradigm", to be discussed in an upcoming article*) may be of some help to readers of Catalyst.

The key to understanding the Bauer air propeller vehicle (when going downwind faster than the wind) is to see it as operating like an upside down windmill vehicle (when going upwind) with its parts appropriately modified to match the media (air and ground). At a higher level of abstraction, both vehicles operate in the same fundamental manner. They are based on the same basic principle of operation. They are like two sides of the same coin.

Windmill land yachts and Bauer land yachts are representatives of 2 of the 9 possible basic mill-prop device combinations that can operate in 12 media contexts, and 24 basic context/device/mode combinations. Each of the 9 device combinations may be utilized by many craft that differ according to how they are supported against gravity, so there are a great many potential mill-prop craft. Understanding them leads to a radically new understanding of sailing itself. The full explanation is called the "mill-prop paradigm". It is a higher order explanation that includes the various mathematical explanations of windmill land yachts, windmill boats, Bauer land yachts, Bauer boats, etc. as subordinate, special cases.

In Catalyst 10, on page 30-31, Frank Bailey proposes a test apparatus for a model Bauer boat to find out if it could actually sail downwind faster than the wind. I appreciate Mr. Bailey's call for a non mathematical explanation. However, Mr. Bailey mistakenly believes that a Bauer boat uses a windmill when going downwind faster than the wind. Actually, a Bauer boat uses a water-mill and an air propeller, not a windmill and a water propeller. A Bauer boat is, essentially, the symmetrical opposite of a windmill boat. It is like a windmill boat turned upside down and going downwind instead of upwind. Its mill interacts with the water rather than

**Held over to allow this to be published first - Ed* with the wind. So Mr. Bailey's proposed test boat, a windmill boat, would not be able to sail downwind faster than the wind. That is because a windmill land yacht going directly downwind can typically attain a speed of roughly 0.7 times the speed of the wind, depending upon the magnitudes of all the variables, and an equivalent windmill boat would be relatively slower due to its water drag. A conventional windmill cannot exceed the speed of the wind under its own power.

Recall that Bauer used his land yacht's rotor as a windmill only to get his vehicle started downwind. He could have used a drag sail instead, or a push from another vehicle, etc. The specific use of a windmill was not necessary at all.

Even a Bauer boat would have great difficulty going downwind faster than the wind, due mainly to the considerable water drag of its hull or hydrofoils (as compared to the lower rolling friction of a Bauer land yacht). Also, a water-mill is inherently less efficient than a wheel-mill. Nevertheless, it would be easy to sail downwind faster than the wind over water using the Bauer technique.

The key is to use a Bauer dirigible (or the equivalent) rather than a Bauer boat. A Bauer dirigible would immerse its water-mill to spin its air propeller. The two devices would be mounted on the opposite ends of a common shaft, similar to what Mr. Bailey shows in his drawing. The Bauer dirigible would not need a push to get it started since, to begin with, it could simply drift downwind as fast as the wind; and it would have no hull or hydrofoil drag to overcome.

In Catalyst 10, on page 11, Mario Rosato discusses sailing directly downwind. He states, "So no matter what's the shape of the sail, the maximum theoretical speed one can sail downwind is about 2/3 of the wind speed." That is incorrect. (Nor does it follow from his premise — the Betz limit.) The actual speed limit for a conventional drag sail is almost exactly 1.0 times the speed of the wind. I will offer a simple explanation in the hope of avoiding further confusion.

A dirigible (blimp, balloon) can drift downwind at the speed of the wind. When doing so, it functions as a sail with perfect efficiency (because there is no retarding drag from water drag). If anything is lowered to contact the water, such as a toy boat, so as to create a minuscule amount of retarding drag, then by definition the dirigible is "sailing" downwind. That is, the propulsive drag of the dirigible is overcoming the retarding drag of the toy boat. So the toy boat is sailing downwind by using the dirigible as an inflatable traction kite. The dirigible will be slowed, but only by an immeasurable amount. So we can say that, in principle, it is possible to sail downwind at almost exactly 1.0 times the speed of the wind. The practical limit depends upon the balance between the propulsive drag of the wind versus the retarding drag of the water.

Mr. Rosato states, "Suppose that, to be absurd, you were sailing at the same speed of the wind." But sailing downwind as fast as the wind is not absurd at all. It is quite easy to do and is done all the time by balloons. Every time a child's helium balloon floats downwind while dragging the tip of its string along the ground, or water, it is sailing downwind at almost exactly the speed of the wind. That is true sailing. To understand it, merely think of the balloon as an inflatable traction kite, which it is, and think of the tip of the string pulled along the ground, or water, as representing the minuscule drag of an almost perfect model sailing craft.

While Mr. Rosato understands the Betz limit, he unfortunately applies it incorrectly. The Betz limit is concerned with the fundamental limit on a windmill's ability to convert wind energy into power, whereas Mr. Rosato misinterprets it to imply a limit on the speed of drag sails. The Betz limit is a mathematical statement about the maximum proportion of the wind's kinetic energy that a perfect windmill can extract from the wind and turn into power. Expressed as a percentage, the Betz limit is 59.3%. (Due to friction losses, even well designed wind turbines convert only about 45% of the wind's energy into mechanical power.) In other words, the kinetic energy in the air passing through the rotor disc area of a mechanically perfect windmill cannot all be extracted from the air. Only 59.3% of the kinetic energy can be extracted, even if the windmill is, within itself, mechanically and aerodynamically ideal (perfect), with no friction losses from bearings or air turbulence or aerodynamic blade drag.

The reason for the Betz limit is that much of the energy in the wind must be used just to remove (sweep away) the slowed-down air behind the windmill from which some energy has already been extracted. If all of the energy in the wind could be converted into power by the windmill, the air behind the windmill would come to a complete stop. But that would block any more air from passing through the windmill, thus stopping the windmill until the dead air could be gradually dragged away by the wind passing around the windmill. So the Betz limit is, in effect, the best possible compromise that an ideal (conventional, horizontal axis) windmill can achieve during continuous rotation. It is possible to extract most of the kinetic energy from a volume of air if the air is brought to a complete stop (like braking a drifting hot air balloon to a complete stop), but so far that not proven to be a workable technique for practical windmills. The Betz limit is worth remembering because the future of sailing may include a great many more windmills, as on PAS craft.

When it comes to PAS craft, then everything changes. In principle, PAS craft could use windmills, drag sails, and lift sails to go downwind, and upwind, faster than the wind. (Plus, in an article I am currently writing, I attempt to show that, in principle, PAS craft can sail across the wind faster than is possible for "ultimate" sailing craft.) My upcoming article will explain Bauer craft, and windmill craft, as mill-prop craft. It will show that windmill craft and Bauer craft operate using the same fundamental principle. Therefor, the basic wind sailing principles that have been invented over the previous 10,000 years of sailing may be reduced to only four. The principles are 1) drag or lift sails that redirect the airflow, 2) mill-sails, such as cylinder-like rotors or autogiros, that continuously rotate to redirect the airflow such that the devices function like a sail, 3) mill-prop sailing wherein wind energy is converted into power such that the craft can advance directly against its mill medium, and 4) PAS (not yet demonstrated), wherein a stationary or slowed "on" mill produces power to advance an "off" mill at high speed (so as to avoid the high drag upwind, or the lowered power downwind, of a conventional mill — as on a windmill boat).

Here is a description of a practical PAS land yacht with a wingsail that should be able to achieve a downwind Vmg faster than the wind, and therefor faster than existing land yachts. It would be an energy storage type of PAS craft. The energy would be stored in a very large rubber band extending between the widely spaced rear wheels of the land yacht. (A rubber band is an efficient energy storage devices in terms of energy-in and energy-out, although its energy storage capacity is relatively small. Dr. Paul B. MacCready has calculated that a one pound rubber band could store enough energy to accelerate an average cyclist up to 20 mph.) One rear wheel would be used to wind the rubber band. The rubber band would then power the opposite rear wheel. Each end of the rubber band would require appropriate control mechanisms, such as a clutch and a ratchet.

When winding the rubber band, the land yacht would use its wingsail to head downwind at an optimum angle to the wind in order to best balance energy storage and its Vmg downwind. When using the energy stored in the rubber band, the land yacht would head directly downwind, with the wingsail feathered for minimum drag. Variable gearing would increase the average speed downwind. In addition to sailing downwind, or upwind, faster than the wind, extremely high reaching speeds could be achieved by using both the wingsail and the stored rubber band energy simultaneously.

Or, the land yacht could use a very large drag sail and head directly downwind while winding the rubber band, and then fold or collapse the drag sail for minimum air resistance when using the rubber band for propulsion.

Or, a windmill could be used instead of a drag sail, and the windmill could wind a rubber band (in line with the horizontal shaft of the windmill) while the land yacht was stationary, or moving downwind. While accelerating downwind after winding the rubber band, both the windmill and the rubber band could power the wheels. When exceeding the speed of the wind, the windmill blades would be feathered. Once the land yacht slowed down to wind speed, the wheels could be engaged, along with the windmill, to start winding the rubber band again immediately. Alternatively, the feathered windmill could be employed as a Bauer propeller after the rubber band was exhausted, and while the land yacht was still traveling faster than the wind.I hope these comments help to clarify some of the issues around sailing directly downwind and upwind.

The Feb. 2003 issue of Popular Science contains a photograph of a partially completed (no main wing yet attached) rubber band airplane, with a very large propeller, that is intended to carry two people at an elevation of 100 feet for a distance of 1 mile. If that airplane were to use its propeller as a windmill to wind the rubber band, it would be a PAS airplane. Including the time for energy storage, it could, in principle, fly downwind faster than the wind. However, its speed upwind would be higher if it stayed on the ground and used a wheel for propulsion rather than a propeller.

I hope these comments help to clarify some of the issues around sailing directly downwind and upwind.

Peter Sharp
<sharpencil@pipeline.com>

Lists

Frank Bailey

Let it be known at the start that I am not qualified to write this article. I am sure some of our members are much better qualified. On the other hand, that has not stopped me before this. Also, the following might not qualify as "research" or even be relevant in a journal such as this but if we can save some time and perhaps add to the safety of our operations, all may not be lost. Mostly, I would just like to get this article out of my system. Some newcomers to this madness might find the material useful. Perhaps they or someone else could add something more relevant.

Perhaps you have experiences similar to the following that I have gone through: A. Forgot the tiller on the daysailer. You find it missing 30 miles from homebase. Stop in a lumberyard and pick up a piece of 2x2 for temporary replacement. B. Do not have a tool, on board, to take the fuel filter off the inboard diesel. It must be removed because of water in the lube oil. Change course for nearest marina and adequate wrench. C. The forestay broke. We had on board spare shackles and the like such that with a file, we were able to get under way again shortly.

The subject of this article is "Lists" or "Checklists". In the area of which we have interest, I posit that there are two types of lists. The might be generally described very briefly as follows:

Spare Parts Lists
Rigging
Engine
Plumbing
Electrical
Hull
Electronic

Equipment Lists
Navigating tools
Tools
Fuels
Foul Weather Gear
Personal maintenance

Depending on the extent of the cruise involved, be it an hour, day, weeks, or years, the completeness of the list of course varies tremendously. The dashed lines indicate each list has many more items than shown. I opine that the art of cruising/sailing is in taking along with you the minimum but still adequate amount of "stuff".

Let us present a few such lists not necessarily split into the two headings above. Here is the equipment list for boats on the inland waters of Pennsylvania, U.S.A.:

Personal Flotation Devices (life jackets),
running lights,
anchor lights,
fire extinguishers,
backfire flame arrester on inboard engines,
sound producing devices (a whistle, or horn),
visual distress signals,
engine muffling devices on inboards,
holding tanks if sanitation devices are included.

That is all!

The State also recommends but does not require the following:

Oars or paddles,

anchor and line,
marine radio,
charts,
sunscreen,
flashlight,
compass,
throwable float,

extra fuel can,
first aid kit,
fenders,
tool kit,
spare spark plugs,
propeller pins,
spare propeller,
light bulbs,
fuses.
and last but not least –
a cell phone (Lists evolve!),

Trailer sailors could also have a list for trailering which might start out looking like this:
Spare tire,
jack,
light bulbs,
spare bearings,
specific tools for eventual tasks,
reflectors,
flares, etc.

Here is a list of inboard spares courtesy of an old timer who at one time painted communication towers above the clouds:
1 qt. engine oil,
water pump or impeller,
hose clamps,
belts,
grease,
ignition coil,
distributor cap +rotor,
fuses,
bulbs,
feeler gage,
ignition points + file,
condenser,
one set of plugs,
O-rings,
hoses,
propeller key,
shear pins,
cotter pins,
prop puller,
gasket material +scissors,
extra fuel pump or spare parts for same,
silicone sealer,
fuel filter,
glass bowl if required,
miscellaneous small wire
and tape.

Spare parts need not be new. (This list is vintage 1975. Engine technology has changed a bit so some items may be obsolete but the list just changes a bit.)

I have included here in another place two more lists. The first is a consolidation, for purposes of space, of items I have found useful for daysailing and on to perhaps a three or four day inland cruise. It was consolidated from four separate lists, which I have developed over a period of time and consolidated alphabetically on a spreadsheet program. So there may be a bit of duplication. A useful exercise may be splitting this list into the two before-mentioned categories, that is Spares and Equipment. Off-hand there appears to be a dearth of spares. The boats ranged from a 9 foot racer to a 17 foot English Channel type cruiser. The second list was taken from a U.S. periodical named “Marine Engineering”. I did not keep a record of the date of the issue or the publisher. I think it should be include here if for no other reason than “history”. An interesting item listed is: two hatchets. I recently made a list of everything aboard a 32 footer on Lake Huron but will not include it here since I feel many of you have a better handle on that sort of thing who get their boats wet with salt water.

The literature also offers excellent lists. Small Boat Magazine, before it went glossy, had an issue with an excellent tool list. I will mention only three other books here. No doubt there are many others

Tinkerbelle, Robert Manry, Harper and Row. You may remember he sailed across the Atlantic in a 12 footer.

A Shoal of Stars, Hugh Downs, Doubleday, 1976. Across the Atlantic I believe.

Suhaili, Robin Knox Johnson, W. W. Norton & Co. No introduction necessary for this famous volume

Robin also included a book list. It has 53 names on it. If you read all of these books, you would have I suggest almost a college education. How many boats have room for 53 books? I will mail the list to anyone upon request.

The bottom line to all of this I suppose is how formal should list making become. Could or should the A.Y.R.S. be a repository of existing and future lists prepared by our members for various situations, to illumine the future for our followers? How about having on hand at Speed Week a vehicle with all kinds of spare parts and tools to keep the boats moving? Any lists here printed should be understood to be definitely incomplete. If safety and saving time can be accomplished then perhaps at some time we should all consider making lists.

Lifeboat Equipment

Oars for everybody
1 ½ sets rowlocks
1 steering oar
1 rudder
boathook
2 life preservers (extra?)
2 hatchets
1 galvanized iron bucket
1 bailer
1 compass (2” card)
oil, lantern
1 gal. Illumination Oil
box matches
2 cups
wooden breaker
2# provisions for each person
sailmaker’s bag
sea anchor
sea oil, one gallon
mast with sail gear
flashlight
rope each side of boat, full length
first aid kit
canvass hood
massage oil, one gallon
jib sail + 30 fathoms of 15 thread line
biscuits, 14 oz. per person
pemmican, 14 oz. per person
choc. tab., 14 oz. per person
milk tab. 14 oz. per person
yellow or orange flag
tiller
25 soft wood plugs
12 reds lights in metal case, w.t

Composite List

anchor
Aspirin
bags, cargo
bags, garbage
bags, plastic
bags, sleeping
bailer, large and small
ballast
battens
binoculars
board, clip
boards, floor
bolts, misc.
books, recreational
boots
bulbs, spare
burgees
camera, plus film
candles
carbide lamp
caulking
centerboard
charts
clothes, dry
coat, rain
comb
cups, plastic
dishes, plastic
fittings rigging, misc..
flags
flares
flashlight,
floatation vest
glasses, sun
gloves
glues, various
hammer, sledge
handkerchief
hat
jack, wrench, & handle
kit, first aid
kit, toilet
knife, hunting
knife, pocket
lantern, Coleman
line, lead
lines, extra
matches
mattress, air
mess kit
microscope, small, portable
mirror, normal
mirror, signaling
nuts, wing
oars
oil
ointment, burn
opener, can
paper, note
paper, toilet
pencil
pins, cotter
pins, safety
pliers
poncho
pot, cook
pulleys, blocks, misc.
radio, portable
radio, weather
repellent, insect
rudder
sails
screwdriver, regular
screwdriver, Phillips head
shoelaces
shovel, small
snaps, sail
sponge
spoon
sneakers, dry
stick, hiking
stone, sharpening
stove, portable, small
strip, skid
sweater, wool
tape, duct
tape, masking
tell tales
thermometer
towel
towels, paper
vang, boom
vest, life
wallet
windbreaker
wire
wrench, bicycle type

AYRS John Hogg Memorial Prize - Rules for 2003.

The AYRS announces the third award of a Prize in memory of John Hogg, the distinguished amateur yachting researcher, who died on July 24th 2000.

The prize of £1000 has been donated by his family to commemorate John's life and work.

The aim of this international award is to encourage and recognise important amateur contributions to the understanding and development of sailing performance, safety and endurance. Preference will be given to current work where the prize money is likely to benefit further development.

Nominations, whether of oneself or another, should be submitted to the Amateur Yacht Research Society, BCM AYRS, London WC1N 3XX, UK, to arrive by 15th October 2003. Nominations may be made by or for anyone, whether or not a member of AYRS. Those nominating another must obtain the written agreement of the nominee and forward it with the entry.

Submissions must be made in English, in hard copy sent by post, to arrive by the due date. FOUR COPIES are required– one for each of the three judges and Secretary. Electronic transmission, the use of web site pages and direct extracts from patent applications (which are written by and for lawyers and can generally be shortened) have resulted in unsatisfactory presentation, hence the need for hard copy of a dedicated paper conforming to the details given below. The vagaries of reproduction from disks are such that hard copy for the entries is essential.

'Amateur' in this context means work done as a pastime and largely self-funded. Details should be given of any grants or other funding or assistance received. Work carried out as part of normal employment is not eligible, but subsequent commercial exploitation of research need not debar work carried out originally as a pastime. Those with ongoing projects are as eligible to apply as those whose work is completed.

The submission should cover the following:-

• A summary, of not more than one page, identifying the nominee and the work submitted, and including a short statement of its merits to justify its submission.

• The description of the work itself, its novelty, its practicality, its degree of success to date, and (briefly) hopes for the future. The work will be judged on the final result achieved to date. Please spare us a complete history of your researches except to the extent that they are truly relevant. The use of your already published material, whether or not peer reviewed, incorporated in an entry, is welcome. Diagrams, graphs and photographs may be used, video material on VHS PAL system can be helpful. Programs on disk may be entered as part of a submission (accompanied by explanatory text etc). Appendices may be used, e.g. for mathematical workings. Direct reproduction of pages from an author's web site has generally proved unacceptable (due for example to captions appearing on the page preceding the image) and is not welcome.

Entries should be printed on A4/letter paper in a legible font. Successful short-listed entries to date have ranged from a maximum of 22 sides with 6 of photos, to one winner with 5 sides, 3 of photos and one A3 drawing. Clarity, legibility and brevity pays!

• Separately, a brief biography of the nominee(s) may be included, and their amateur status and qualifications should be explained.

• Nominees may care to say how they will use the prize should they win.

• AYRS will wish to publish brief summary accounts of entries, and may also seek further articles from entrants. To this end it will be helpful if entries can (if necessary) readily be abridged for publication in *Catalyst*. Grant of permission to publish such articles is a condition of entry. However any information received as part of a submission will be treated 'In Confidence' if so marked.

The winner and runners-up will be announced at the London Boat Show in January 2004. All short-listed entrants will receive one year's free membership of AYRS and a certificate.

The Judges, whose decision shall be final, will co-opt experts as required. Submission of an entry will be taken as signifying the entrant's acceptance of these rules.

Requests for copies of the definitive set of rules, and queries concerning possible entries may be made by phone or e-mail to the AYRS Honorary Secretary on tel/fax +44 (1727) 862 268; e-mail ayrs@fishwick.demon.co.uk.

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

May 2003

12th - 16th Sailing Meeting
Mainly for speedsailing boats, but all are welcome, Castle Cove Sailing Club, Weymouth, UK. Contact: Bob Downhill; tel: +44 (1323) 644 879; email: icaruswsr@tiscali.co.uk

October

4th - 11th Weymouth Speedweek
Weymouth & Portland Sailing Academy, Portland, UK, Contact: Nick Povey, tel: +44 (7713) 401 292; email: nick@speedsailing.com

8th AYRS Weymouth meeting
Speedsailing. 19.30 for 20.00hrs at the Royal Dorset Yacht Club, Upper Mall, Weymouth. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

November

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

December

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

January 2004

8th - 18th London International Boat Show (dates subject to change!)
New venue – EXCEL Exhibition Centre, Docklands. Those who can give a day or two, from 15th December onwards, to help build/staff the AYRS stand (reward - free entry!) should contact Sheila Fishwick tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

17th AYRS Annual General Meeting
Venue to be announced!
Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

February

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

March

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

April

7th AYRS London meeting on
Subject to be announced 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

AYRS London Meetings

Please note that the AYRS London meetings at the London Corinthian Sailing Club will be on the FIRST WEDNESDAY of every winter month (Nov-April).

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

On the Horizon . . .

High speed sailing craft - Giles Whittaker
Kitesail power for the America's Cup - Dave Culp
Autonomous Wingsailed catamaran - Gabriel Elkaim
Paddle wheels - Ambus Janko
Mill-Prop Paradigm - Peter Sharp
Flying Proa - Roberto Rampinelli
More sources and resources: reviews, publications and Internet sites

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

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