Catalyst

Journal of the Amateur Yacht Research Society

Number 52 November 2017

2018 ANNUAL GENERAL MEETING

The 54th Annual General Meeting of AYRS will be held on Sunday 21st January 2018 at the Village Hall, Thorpe, Surrey, starting at or after 4.00 pm (after the all-day AYRS meeting).

You are invited to attend.

The AGM is open to all paid-up members and their guests, but only members may vote.

AGENDA

1) Apologies for Absence.

2) Minutes of the 53rd Meeting held on 22nd January 2017 at the Village Hall, Thorpe, Surrey.

3) Chairman's Report.

4) Treasurer's Report and Accounts

5) Confirmation of President and Vice-Presidents, Election of Officers and Committee Members. See below

6) To appoint a Reporting Accountant for the year. (See below)

7) Any Other Business

8) Vote of thanks to the helpers of the society.

Previous Minutes: The draft minutes of the 53rd AGM are on the AYRS website.

Chairman & Treasurer's Reports and Accounts: These will also be found on the AYRS website.

Officers and Committee Elections: Under our rules, the Chairman (Graeme Ward), Treasurer (Slade Penoyre), and Committee Members John Perry and Robert Downhill have completed their current terms of office. The current Secretary (Kim Fisher) has also resigned, and a replacement is needed **URGENTLY**. Job descriptions will be posted on the AYRS website.

All nominations should be submitted to the Committee, preferably by email to committee@ayrs.org, as soon as possible.

Nominations received will be posted in the AYRS Discussion Forum in the Members section (https://www.ayrs.org/phpbb/viewforum.php?f=40)

Reporting Accountant: The Committee propose that Robin Fautley be re-appointed.

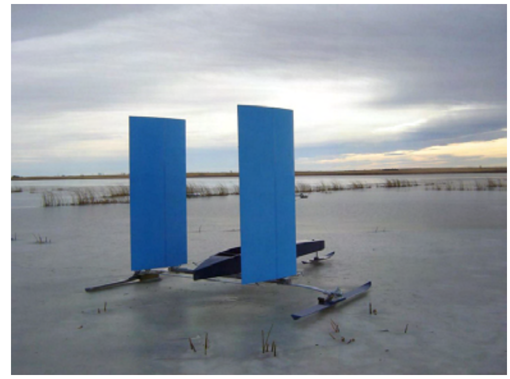
Any Other Business: Any items for formal consideration were to be submitted by 24th December 2017, but items for informal discussion may be notified to the Secretary up to two days before the meeting.

Note: Thorpe Village is close to Staines (and Thorpe Amusement Park), easily reached from the M25 Jn 11 or 13. The Hall is off Coldharbour Lane (follow signs to TASIS).

Note: The Annual Report and Accounts will, if time permits, be inserted into this edition of Catalyst. If time does not permit, you will have to have recourse to the website. - Editor.

Features

Regulars



Barney Kenney's SIL yacht on a frozen lake in Alberta, Canada

(Photo: Kenney)

Catalyst

Journal of the
Amateur Yacht Research Society

Catalyst is a journal of yacht research, design, and technology published by the Amateur Yacht Research Society, BCM AYRS, London WC1N 3XX, UK. Opinions expressed are the author's, and not those of AYRS. AYRS also publishes related booklets.

Contributions are welcome from all. Email them to **Catalyst@ayrs.org**, or send (at your risk) disks or typed copy with illustrations to the Society's office. AYRS can take no responsibility for loss or damage in the mail.

AYRS subscribers receive both *Catalyst* and the booklets. Subscription is UK£20/US$30/Eur15 per annum for paper copies, (£10/$15/€15 concession for the retired), £10/$15/€15 for download copies. Subscription requests and all other queries to be sent to the AYRS Office, BCM AYRS, London WC1N 3XX UK, email: **office@ayrs.org**

AYRS is a UK Registered Educational Charity (No 234081) for the furthering of yacht science.

Website: http://www.ayrs.org

ISSN 1469-6754

Part of AYRS' remit as an educational charity is the need to educate. We spend a certain amount of time each year at exhibitions, not only promoting membership but also talking to the public, answering their questions and generally explaining to them how and why things nautical work.

This past year for example, we had stands at the London Dinghy Show (picture below), Beale Park Boat Show, and the Northern (Liverpool) Boat Show. We used to be regulars at the London Boat Show, but it's become very expensive for us, and we also had difficulty keeping the stand staffed over the 10 days, so we stopped going.

There's some doubt about Liverpool in 2018, but we'll be going back to both the Dinghy Show, and to Beale Park. We need display material, let us have details and photos of your projects and we can then mount them on suitable display panels

Before that though is the AYRS Annual General Meeting at the end of the London meeting on 21st January. We desperately need new members on the Committee. Only two of us are under 60, and several are pushing 80 and want to retire! So if you can please step forward and volunteer your help to keep your Society going. You don't have to live near London – we've held meetings using video conferencing before now and will do again – the key words are "willing and able to help". How about it?

Robin Blain, RIP

It is with great and personal regret that I have to tell you that the founder of the Junk Rig Association, Robin Blain, has died.

The JRA was conceived at the 1979 Southampton Boat Show, where Robin had a stand for his Sunbird 32. He found that there were many more people interested in junk rig, than could afford to buy his boats and, typically, he discussed with them the idea of forming an association, where ideas could be aired and swapped. I say typically, because Robin also ran a business to provide junk rigs for people wanting to convert their existing boats and the fact that people would be exchanging ideas for their own, DIY version, was not going to bring him more customers. However, Robin was always more interested in promoting the rig than in promoting himself.

I was one of those who visited his stand. Robin had a wonderful little working model, and after two minutes of playing with it, I was converted. It was the start of a long friendship, renewed at rallies and AGMs and through correspondence.

For many years, Robin, in essence, *was* the Junk Rig Association. Ably assisted by his wife Mandy, amongst other things, he kept track of the membership, wrote and photocopied letters and fact sheets, helped with the Newsletter (as it then was), accepted subscriptions, dealt with enquiries from all over the world (few of which brought him any income), organised rallies, sold JRA regalia and collected and ran our wonderful library. This was all in the days before computers (with which Robin never had the happiest of relationships) and involved much more time and energy than would be the case today. Particularly he had to cope with foreign cheques, and occasionally cash, and trying to post magazines to far flung corners of the globe.

I think it's fair to say that everyone who had anything to do with Robin became a friend. Generous, convivial, unassuming and always ready to go well out of his way to help people, he was a gift to people struggling with understanding their new rigs, or wanting to 'have a go.' His presence at numerous rallies, often towing his little *Gigi*, enabled people to see a junk rigged boat and to get the opportunity to sail one. Patiently he answered the same questions he had been asked times without number, booked marina places, arranged for somewhere to eat, to stay and to sail. Surrounded by like-minded people, and wearing his blue denim cap, his JRA sweatshirt, with a pint in his hand, he was in his element, offering suggestions, giving advice, making introductions and chatting about all things junk.

The Junk Rig Association recently presented Robin with the Hasler/McLeod Award; it was the best we could do to thank him for all he has contributed. In the words of our Constitution, he did an astonishing amount "to promote and encourage discussion of junk rig (JR), including its traditional use, its design, and developments of it, and of the building and use of vessels with such rigs and their derivatives, and to facilitate contact and communication between members of the Association."

The Junk Rig Association will not be the same, without Robin. He will be missed by all who knew him.

Annie Hill
Chairman JRA

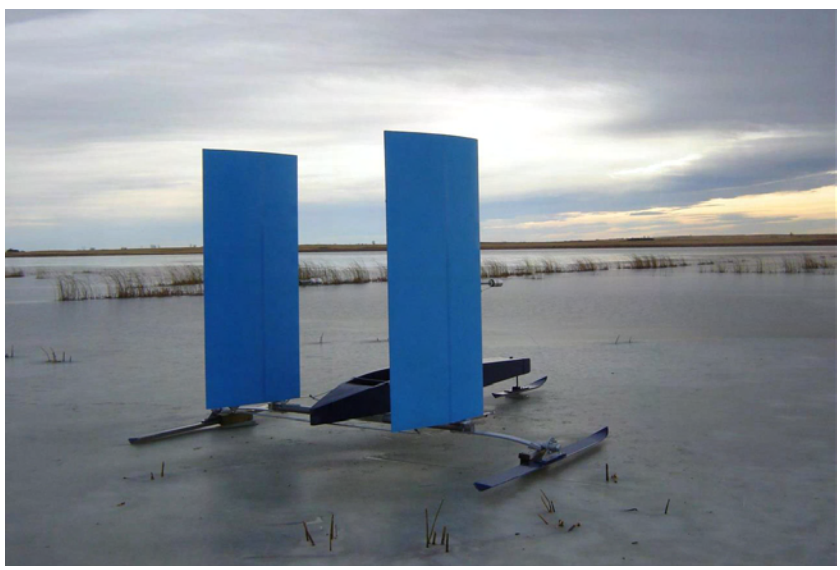
Robin's Bay Cruiser, Gigi

HYPERWIND SAILING on SNOW, ICE, LAND and WATER

Barney Kenney, Ph.D

1: Introduction

This treatise is directed towards dynamic constraints on hyperwind sailing, viz., sailing faster than the wind (Kenney, 2001a). The speed of sailboats on the water is usually limited by wave and viscous drag to less than the wind speed. Sailboats with planing hulls or hydrofoils can exceed the wind speed but require large sails and/or high winds to get over the hump speed (Froude number = 1). The lower drag of wheels requires much less wind for hyperwind sailing on land but the lack of venues suitable for landsailing has limited the global popularity to a few wide ocean beaches, dry salt lakes and desert playas.



Iceboating, a winter alternative to landsailing, has no shortage of potential venues but is weather dependent. It is popular in cold arid regions of the world with lots of clear ice or in slightly warmer latitudes where snow melts rapidly following a snowfall. Even in the melt zones iceboating can be occasionally snowed out for an entire season, negatively impacting its appeal. The ability to sail on all types of snow and ice would increase the number of global venues suitable for sailing by orders of magnitude but to date has only been exploited by windskiers and snowkiters. Attempts to sail boats on snow have not enjoyed much success largely due to weaknesses in both boat and ski design.

In this treatise, key aspects of hyperwind sailing on snow, ice, land and water are presented based on simplified steady-state performance prediction models and field measurements. Because the models are mathematical balances of forces and moments, the results depend critically upon the accuracy of calibration data or the algorithms used for lift and drag estimates when no data are available. The problem of rationalizing the results of steady-state models with data collected in an unsteady world is also addressed. Requisite theory of differential equations, linear algebra, aerodynamic, hydrodynamic, sailing physics and vehicle dynamics are all well established and have been widely available from many sources for decades. The present work draws from Abbott & von Doenhoff, 1959; Bethwaite, 1991; Davidson, 1958; Hoerner, 1965; Lanchester, 1907; Marchaj, 1980; Milliken & Milliken, 1995; Perkins & Hage, 1949; and Taylor, 1974. The numerical models were written in MATLAB© and evolved from a numerical model of a hyperwind sailboard by Kenney, 2001a.

The SILboat (snow, ice and land) used for field measurements is shown above with twin wings and skis with integral blades (Kenney, 2001b). The skis are mounted on composite springs for smooth running over snowdrifts. The boat has a high design wind speed to cope with the local Chinook winds. The two short 2.2 m^2 wings increase capsize resistance and facilitate transport. Although the span loading is high, induced drag is small because the wings operate at a small lift coefficient, C_L, at the design wind speed. Induced drag increases proportional to C_L^2, however, so that wing performance is poor in light winds (because C_L tends to be high). A variety of windsurfer and conventional sails between 4.0 and 8.8 m^2 are used when the winds are light. A bi-directional sheet is used to backwind the wings (or sail) for aerodynamic braking.

The main focus of the paper is the impact on coupling of pitch, roll and yaw on the design of hyperwind boats and the stability constraints of trike versus quad configurations. A case study of the design of three and four wheel International 5.6 mini-landyachts and iceboats is also presented.

2: Steady-State Models

A Simple Performance Prediction Model of an Iceboat

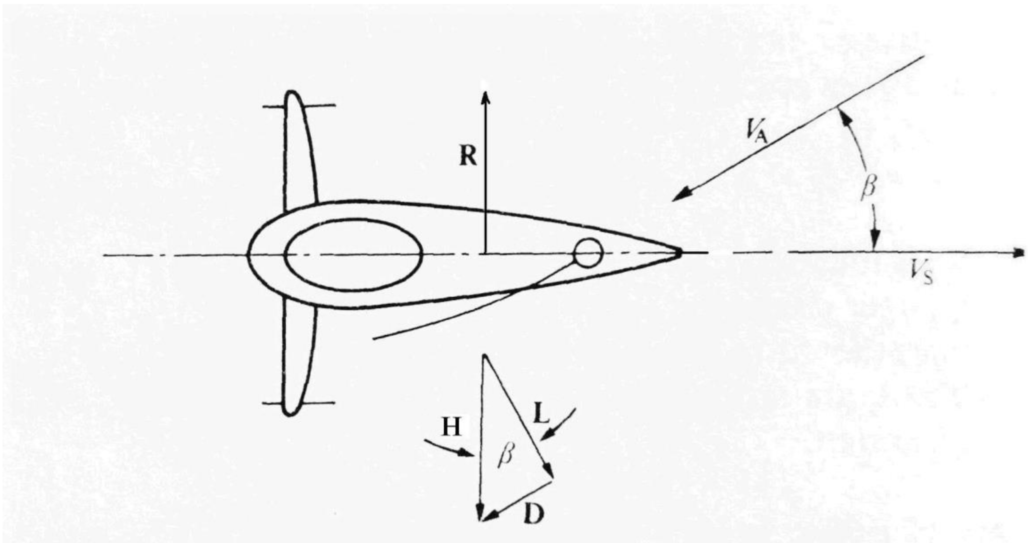
Three key aspects of any type of vehicle design are performance, stability and control (Perkins and Hage, 1949). Although attention is often focused on maximum speed performance, a design will not be successful if it is unstable or uncontrollable. With no other constraints, the maximum speed of an iceboat is a function of power available versus the power required. Power available from a sail depends upon the strength of the wind and the forces produced by the wind flowing across the sail. The power required also depends on the wind strength producing pressure and skin friction drag on the iceboat as well as drag produced by blades contacting the surface.

In terms of steady-state forces, an iceboat on a level surface that is unconstrained by stability will accelerate as long as the thrust available exceeds the drag of the blades and the aerodynamic drag on the body and appendages. At steady state, thrust equals drag. The maximum steady state speed can be increased by increasing the maximum thrust (e.g. higher wind or higher lift sail) or by decreasing drag with better streamlining. When stability constraints are imposed, the maximum speed may not be reached and the speed achieved may be well below the drag limit. There are also important differences in the stability constraints for trikes and quads sailing on ice, snow or land that will be considered later.

Firstly, it is important to recognize that a sail must have a surface to push (or pull) against in order to generate airflow over the sail and thrust. On a hypothetical frictionless surface with no lateral or axial resistance, the only motion possible is drifting directly downwind - much like the motion of a hot air balloon near the ground. The shape of a sail (or balloon) is irrelevant when drifting with the wind because there is essentially no airflow relative to the sail. While the lack of wind can be an eerie memory of one's first hot-air balloon ride, it can also be observed in other settings. For example, qualitative observations of downwind drifting of three different types of sailing craft with little lateral resistance or surface drag were made by the author at different times and locations. The three craft were: an iceboat with rounded off blades on smooth hard ice, an experimental shallow-draft trimaran with no centreboard and little lateral resistance, and a novice windsurfer on a board with no fin. In all three cases, the sailing craft could not generate enough relative wind for any forward motion across the wind and drifted straight downwind towards the lee shore. (Note that an experienced windsurfer with a broken fin will usually tilt the board on its side to generate sufficient lateral resistance to go across the wind but often not enough to go upwind.) Although anecdotal, these observations are not unique and can be easily repeated by anyone sceptical of the simple theory.

In the following section, Taylor's (1974) iceboat model with frictionless blades is recast to emphasize the importance of the lateral forces generated by the blades pushing on the ice surface. Taylor's simple model shown in the next figure only considers aerodynamic lift, L, and aerodynamic drag, D, of the sail and iceboat. The component of lift in the direction of travel (i.e. the thrust) is balanced by the equal and opposite component of D parallel to the longitudinal axis of the boat. There is no blade drag in Taylor's model and the lateral force balance was ignored. The vector, R, representing the total lateral force generated by all blades, was added to Taylor's figure here to facilitate the following discussion.

The wind drag force on the iceboat and sail, D, is parallel to the wind relative to the moving boat, called the apparent wind, V_A. For hyperwind boats that can go 5 or 6 times faster than the true wind, the



boat speed is the largest component of the apparent wind. Because there is no vertical shear in the boat speed component the optimum sail twist is much less than for slower boats. Although the term "apparent wind" is widely accepted it can be misleading because it is the real wind in the face of a sailor on the boat and the wind actually flowing over the sail producing lift and drag. The drag force varies as the square of the apparent wind speed and can be parameterised by $D = \frac{1}{2} \rho C_{Do} A V_A^2$, where C_{Do} is the overall drag coefficient and A is a scaling area such as the frontal area or wetted area. Both C_{Do} and A are functions of the apparent wind angle, β. For hyperwind iceboats and landyachts, where β can be less than 14 degrees, the drag area C_{Do} A can be modelled as a constant with only a slight loss in accuracy. In this study the drag area was measured in coastdown tests and taken as constant.

The lift force, L, acts at a right angle to the apparent wind through the centre of effort of the sail. In the simplest model with zero blade drag, the lateral heeling force, H, is the (vector) sum of the sail forces, L and D. The net axial component of sail force is necessarily zero because the axial component of lift is balanced by the axial component of drag. Although it can't happen in Taylor's hypothetical steady-state model, any momentary imbalance in the net axial force in the real world would result in an axial acceleration (or deceleration) that persists until the imbalance and the inertial force goes to zero. Time dependent terms and inertial forces due to gustiness or changing winds are not included in this simplified steady-state model. H is always at right angles to the centreline.

With these simplifications, Taylor found that the maximum boat speed, Vs, to wind speed, Ws, ratio is a function only of the lift to drag ratio, L/D, in the air and does not include R,

$$Vs_{max}/Ws = \sqrt{[1+(L/D)^2]}.$$

Increasing the lift or decreasing the drag (or both) will increase the speed.

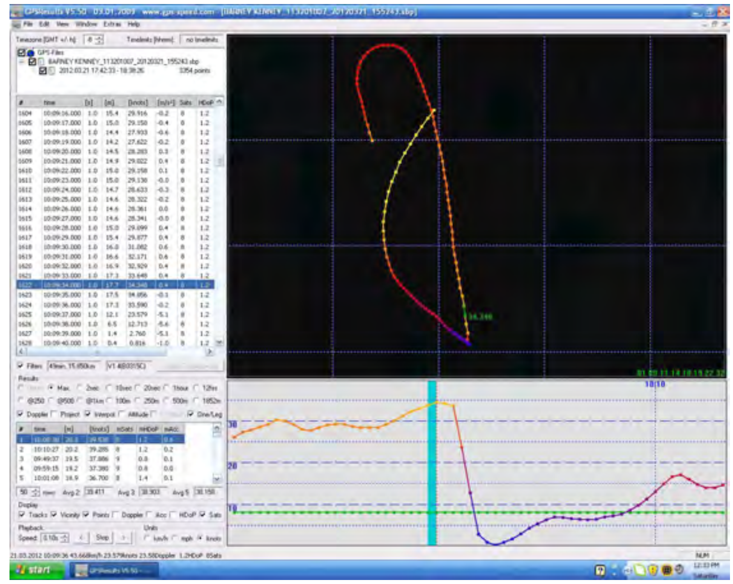
Applying Newton's 3rd law, H is resisted by a total lateral resistance, R, of equal magnitude produced by all the blades pushing against the ice in this simple model. R is not constant but is a reaction force equal and opposite to H that varies directly as H varies on different headings. The maximum possible R is infinite in the model that assumes no sideslip. In the real world, however, R has a maximum value and the iceboat skids when $H > R_{max}$.

This lateral resistance is crucial to sailing because it is this reaction between the boat and the ice that generates the apparent wind that allows the boat to sail several times faster than the wind speed as well as across the wind and at some angle into the true wind.

An example of what happens when the lateral resistance of the twin wing iceboat at speed suddenly drops near zero is shown in data recorded at one second intervals on Ghost Lake, Alberta (see GPSResults© plot next page, top; Fuchs, 2009). After completing a U-turn from a northerly to southerly heading, the iceboat did a spontaneous snap yaw ~90 degrees to starboard when it encountered a small patch of shell ice too weak to support the stress imposed by the wings' lift on the blades. With the blades transverse to the direction of travel, the iceboat decelerated at a constant 0.56 g (from 34 knots to 3 knots in 3 seconds). After sliding to a stop and the lateral resistance was restored on solid ice, the iceboat sailed off to the northwest and accelerated into a gentle turn to starboard reaching a max speed of 40 knots. Wind was gusting to ~15 knots from 255 degrees. Note that the time base for the time history in the lower panel is expanded relative to the track shown in the x—y plot in the upper panel in order to show the linear decrease in speed (i.e. constant deceleration) more clearly.

Extending the simple iceboat model to other surfaces, the lateral reaction to the sail forces may be generated by blades, skis, wheels or centreboards when sailing on ice, snow, land, or water surfaces respectively. This simple model can be a good representation of an iceboat on hard black ice because the blade drag is low (can be less than 0.005W) and the lateral reaction between the ice and the blades can be large. There is one important difference, however, between iceboats and landyachts in how the lateral resistance is generated. Conventional wisdom suggests that iceboats blades run in grooves they melt in the ice. When the lateral loads get high enough the ice surface fails and the blade skips or skids laterally until the stress is released enough for the blade to grab again. The process is repeated as the blade loads up again. In essence the dynamic interaction of blades with the ice surface forms a relaxation oscillation where there is little or no slippage until the lateral stress builds to a level at which point the ice fails and the blade jumps laterally as the built-up stress is released. How far it yaws depends on the strength of the ice surface and the magnitude of the lateral force at failure. In extreme cases, like the previous example, the boat may end up pointed crosswind. It could also continue to spin for several revolutions depending upon the location of the centre of gravity. This highly non-linear oscillation may negatively affect the maximum speed that can be obtained on ice either directly or indirectly through a negative impact on the pilot's confidence.

With a landyacht under side-load, the sidewalls of tyres deform and the contact patch walks sideways to create leeway proportional to the load. The process is smoother than on ice and there is no sudden lateral jump as built-up stress is released. This difference in the dynamic interaction of blades and tyres with the surface may explain the observation that the same yacht is faster on land than on ice - even though the



drag area, $C_{do}A$, of the landyacht with wheels is higher than the iceboat, and the wheel drag on land is usually higher than the blade drag on ice.

3: Optimum Unconstrained Performance in a Steady Wind

Performance prediction models are essentially a steady-state balance of lift and drag forces and moments as a function of heading. Results are graphed in polar coordinates relative to the true wind speed and are known as performance polars. Differences in actual performance predictions between models are generally due to differences in simplifying assumptions, the number of variables modelled, differences in the lift and drag values used, and whether the forces are calculated from theory, estimated from published data, accurately measured on a full scale prototype or scaled from a physical model in a wind tunnel.

An example of a performance polar for Taylor's simple frictionless iceboat model with an $(L/D)_o$ = 3 is shown below. A performance polar has two circular lobes corresponding to port and starboard tacks. The lobes are mirror images in Taylor's model so only the port lobe is used below to illustrate the geometric relationship between the true wind, apparent wind and boat speed vectors. Port and starboard lobes will differ, however, for asymmetrical sails such as the standing lug or sprit rig.

The origin of the polar plot is at point O and the true wind, V_T, is blowing from right to left (vector from O to A). The size of the lobe scales with V_T : the higher the true wind, the larger the lobe. Both the iceboat heading and the vector representing the iceboat speed, V_S, are measured from the origin at O. When the vector, V_S, extends all the way across the lobe, the iceboat is sheeted for maximum speed for the heading. In this plot the iceboat is on broad reach at an angle $\gamma = 108$ degrees off the wind which is the heading for the overall maximum speed for $(L/D)_o = 3$. The tip of the vector could terminate at any point along this line if the boat speed is less than the maximum for the heading (e.g. by letting out the sheet).

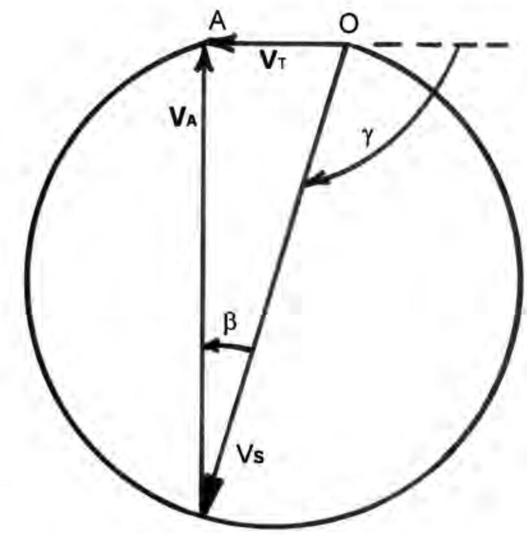
The apparent wind speed, V_A, and the apparent wind direction are represented by the vector from the tip of the boat speed vector to the tip of the true wind vector (point A). The angle of the apparent wind felt on the moving boat, β, is measured relative to the boat longitudinal axis and is independent of the iceboat heading for Taylor's simple model (i.e. β is a constant along a locus of constant L/D). Using a tell-tail, β is a directly observable indicator of the iceboat's performance; the higher the boat speed on any heading, the larger the circular lobe of the polar, and the smaller the value of β. The maximum boat speed for the broad reach shown on this polar plot occurs when the apparent wind is at right angles to the true wind.

Although Taylor's frictionless iceboat was used as an example here, the arguments are qualitatively similar and have been applied to boats on land, snow and water. Quantitatively, however, the magnitude of the surface forces depends critically on the type of surface, the lateral resistance and the drag of the wheels, skis, fins or blades generating the lateral resistance. The heading for maximum boat speed can be determined directly onboard any hyperwind boat by estimating when the apparent wind direction from the tell-tale is orthogonal to the true wind direction estimated from windrows of blowing snow, dust, or foam.

The overall lift / drag ratio of the iceboat, $(L/D)_o$, is the parallel combination of the L/D in the air and R/D_i on the surface. Using the small angle approximation,

$$1/(L/D)_o = 1/(L/D) + 1/(R/D_i).$$

As a consequence of L/D and R/D_i acting in parallel, $(L/D)_o$ cannot be greater than the lesser of the two (Davidson, 1956). In Taylor's frictionless model above the blade drag, D_i, is zero, R/D_i is infinite and $(L/D)_o$ is simply equal to the L/D in the air. Hence, R is not a part of Taylor's equation for V_{Smax}/WS given above.



In the parallel case of a frictionless windsurfer, the relevant lateral resistance and drag is generated by a fin in the water so that R/D_i in the above equation is replaced by $(L/D)_{water}$. An efficient windsurfer sail with a $(L/D)_{air}$ of 6 acting in parallel with an equally efficient windsurfer fin with a $(L/D)_{water}$ of 6, therefore, has an overall lift to drag ratio of only 3 which can readily be seen by substitution in the above equation. ;

Viz: $1/(L/D)_o = 1/(L/D)_{air} + 1/(L/D)_{water}$

$= 1/6 + 1/6 = 1/3.$

So $(L/D)_o = 3.$

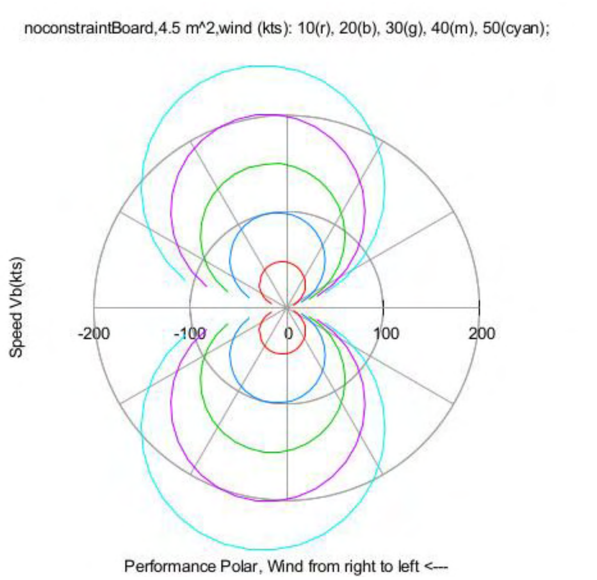
High lift /drag ratios are necessary, therefore, both in the air and in the water to maximize sailing speeds. In the above example, if $(L/D)_{water}$ is not 6 but only 3, then $(L/D)_o = 2$. The concomitant decrease in maximum performance is measured by the increase in the angle of the apparent wind, β, from 18.5 to 26.5 degrees. If a less efficient fin is used with a $(L/D)_{water}$ of only 2, then $(L/D)_o$ drops to 1.5 and β increases to 33.7 degrees. Note that a GPS is not necessary to measure performance improvements resulting from changing fins or any form of drag reduction, a simple calibrated tell-tale or Windex to measure β will do - without the need to measure wind speed.

Although skin friction and wave drag must be included in a realistic model of windsurfer performance, there is an important lesson here for windsurfers seeking record speeds. The latest strategy is for speed courses to be set in shallow water with lots of weeds in an attempt to minimize gravity waves. Unfortunately, this approach requires a highly swept, low aspect-ratio weed fin with concomitant low $(L/D)_{water}$. Any gain from sailing in smoother water is likely lost because of lower $(L/D)_o$ caused by the inefficient weed fin. A high aspect ratio fin on deeper water in the lee of a beach, sandbar or breakwater is likely to produce better results.

4: Stability Constraints on Performance

Taylor's model is the simplest possible model that can provide some insight into the performance of an idealized iceboat. The performance polars described next were calculated from more complex models that include one or more additional parameters such as blade drag, lateral coefficient of blade resistance, overall aerodynamic drag coefficient, drag area, lift and drag characteristics of the sail and stability constraints (Kenney 2001a). When available, measured values were used for drag.

The performance polars below show the unconstrained performance of one specific iceboat and sail geometry with a 4.5 m^2 sail at wind speeds of 10, 20, 30, 40, and 50 knots. Starboard and port tacks are symmetric about the true wind vectors originating at 0 in this figure (Note the multiple true wind vectors are not plotted on the figure). The value of blade drag used in the model was directly measured with a sensitive scale at the test gross weight. The drag tests were made at low speed and assumed independent of speed. With additional drag, the lobes are no longer circular but distorted in the downwind direction. The model predicts that this particular iceboat, only limited by aerodynamic and surface drag with no stability constraints, is capable of a maximum speed of 5 times the wind speed independent of wind strength.



Real-world constraints complicate simple theoretical models. It matters naught how much power is potentially available (or how little power is required) if the power cannot be applied because of other constraints. The primary constraints for iceboat design are hiking that may result in capsize and skidding that may result in spinout. The loss of stability to hiking or skidding may prevent an iceboat from reaching the maximum speed that could be obtained based solely on the overall drag. Increasing wind speeds exacerbate the instability problem.

The usual design criterion is that the incipient hike and incipient skid limits are reached simultaneously (Marchaj, 1980). The hiking limit is a function of the resultant wind force, H, the height of the centre of effort of the sail, h_{ce}, the gross weight, W, and the distance of the centre of gravity, y_{cg}, perpendicular to the roll-over line. When the hiking moment, H h_{ce}, is greater than the available restoring moment, W y_{ce}, the boat capsizes:

$$H\, h_{ce} > W\, y_{cg}$$

The resultant wind force also produces a sideload on the blades that produces leeway. The skid limit is a function of the grip of the blades on the ice, where μ is the lateral resistance coefficient of the blades and W_i is the weight on the ith blade. When the lateral sail force, H, exceeds the total grip of the blades, $\mu \sum W_i$, the boat skids:

$$H > \mu \sum W_i$$

When the centre of effort of the sail and centre of gravity of the boat do not lie over the centroid of the blade footprint, the boat will also spin as it starts to skid.

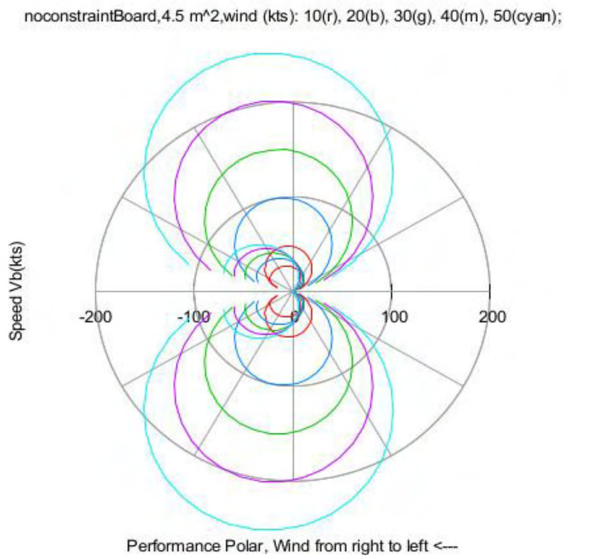
Marchaj's design criterion for hiking and skidding to begin at the same wind force is,

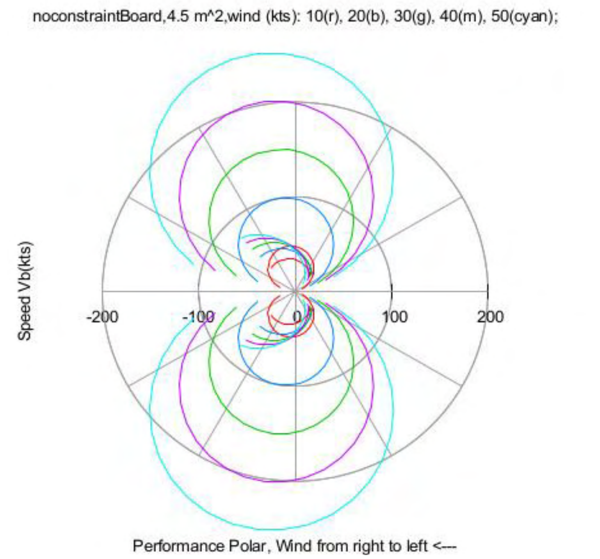
$$y_{cg} = \mu h_{ce}\,.$$

A safer alternative, however, is to design the boat to skid slightly before the capsize limit because a high speed capsize is sure to be ugly.

Although the stability criteria are the same for iceboats and landyachts, the lateral resistance coefficient and the interface drag may differ between blades, skis and wheels depending on the nature of the surface.

Compared to the previous example, the performance of the model iceboat constrained by capsize is substantially less on all points of sailing, particularly upwind - and it worsens as the wind increases. Instead of a maximum iceboat speed of 5 times the wind speed on a 100 degree beam reach (independent of the magnitude of the wind); the maximum iceboat speed is limited by the





capsize constraint to only 1.4 times a wind speed of 50 knots. The maximum speed no longer occurs on a beam reach but now on a very broad reach of 160 degrees off the wind.

Similar degradation is seen in the performance of the model iceboat constrained by spinout but the shape of the polars differs. The maximum speed is 1.5 times the wind speed but the maximum occurs on a 135 degree reach.

5: Stability of Trikes vs Quads - Effect of Coupling Roll, Pitch and Yaw

Another performance degrading issue associated with hiking of a 3 blade iceboat (or 3 wheel landyacht) results from the roll-over line not being parallel to the direction of travel.

When a trike capsizes, the roll-over line is the line drawn between the front wheel and the lee side rear wheel. The photo was taken looking roughly along the rollover line, which runs diagonally across the direction of travel. (Note that the SILboat pictured had a 2 wheel rough-terrain bogie mounted instead of its usual single nose wheel so that in this case the rollover line runs from the centroid of the bogie footprint and the leeward rear wheel). The triangular footprint couples the roll, yaw and pitch modes such that when the windward wheel hikes about the rollover line it moves both upward and forward; changing the orientation of the axle and the wheels. The plane of the wheels is no longer parallel to the direction of travel. Instead of pure rotation, the leeward wheel is now subject to a combination of rotation and skidding. The skidding increases the leeward wheel drag significantly and accounts for the very rapid tyre wear experienced by pilots who like to sail around in a severely hiked attitude; the higher the hike, the more the tyre skids and the faster the tyre wears. There are anecdotal reports on landsailing websites of tyres being completely worn out from two days of sailing in a maximum hike orientation. In order to save the tyres and maximize the speed of a trike it is necessary to keep all the wheels on the ground.

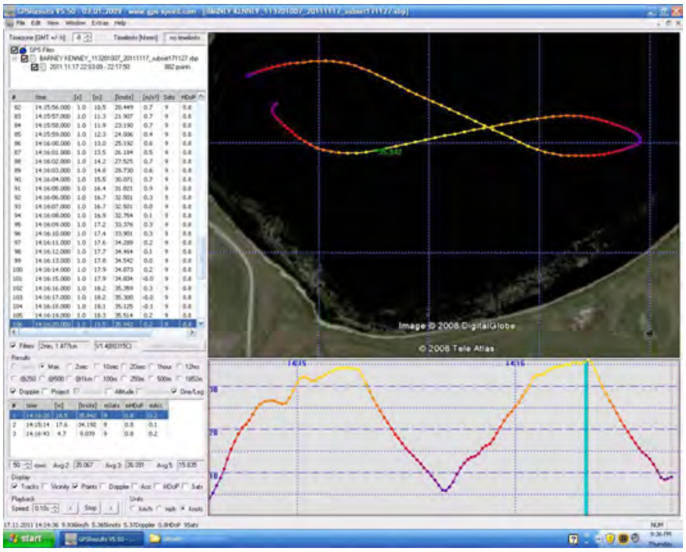
A short wheelbase on a trike increases the angle of the rollover line and the amount of roll, pitch and yaw coupling. To reduce the coupling the wheelbase is generally longer than the track on most trikes and often much longer. The nose wheel may also be extended forward of the fuselage on a springboard to reduce the coupling further. The longer moment arm also reduces wear on the nose wheel, which must overcome the yawing moment produced by the increased drag of the leeward wheel when hiked.

The problem of the rollover line not being aligned with the direction of travel is exacerbated on ice or snow when the small oval contact patch of a wheel is replaced by an elongated blade or sailing ski (Kenney, 2001b). In the case of the long rear skis shown above the skidding and the added drag produced by hiking is severe. The photo was taken looking along the rollover line for a port tack that extends from the contact point below the pivot of the front ski to the contact point below the pivot of the starboard rear ski.

The rollover line for the quad shown below is the line connecting the leeside front and rear wheels so the hiking moment arm, y_{cg}, is simply half the width of the wheel track.

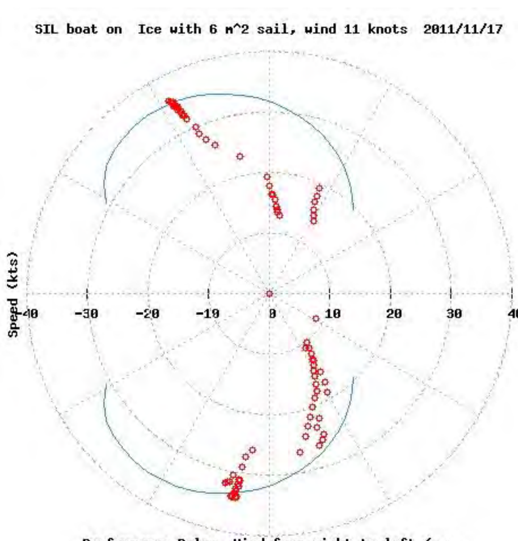
The quad was designed to operate on the two leeward wheels with little or no load on the windward wheels in a nearly level attitude. By flying the windward wheels just off the surface, the rolling drag is less than the three wheels of a trike in a level attitude. In a hike the quad has significantly less rolling drag than a trike because the plane of the two wheels in contact with the ground remain aligned with the direction of travel. The roll, yaw and pitch of the boat are uncoupled and the leeward wheels both remain in pure rotation parallel to the direction of travel independent of how high the boat hikes – up to the point of capsize. There is no drag increment due to the hike producing skidding of the wheels. The aerodynamic drag of the quad is larger, however, because it has 4 wheels instead of three but the difference can be reduced somewhat by fairings.

When wheels are replaced by the long blades shown (bottom picture), the blades remain parallel to the direction of travel independent of the hiking angle. Because the boat was designed to operate only on the two leeward blades, the port and starboard blades were optimised with an asymmetrical chisel profile for only one tack instead of the usual 90 degree V-shape profile that may run out of grip part way through a hike.



6: Integrating Steady-state Model Results with Real Data from an Unsteady World

In a steady wind, experimental data to compare with the model results can be obtained by holding the SILboat on a heading, adjusting the sheet for maximum speed and recording the max speed. The process is then repeated at increments (say 10-15 degree) for all possible headings. GPS speed measurements make this procedure simple and accurate. The small size of the slough used for testing was marginal for the high speeds of the SILboat, however, so a figure eight course (above) was utilized instead with an initial acceleration, a short run on the test heading at maximum speed and a deceleration for the turn. The wings (or sail) were back-winded with a bi-directional sheet to decelerate rapidly and remain within the boundary of the slough.



The only other data required is a measurement of steady wind speed. The weakness in this approach is the fact that the wind is never steady – in magnitude or in direction – nor in time or space. The gustiness can vary widely. A simplified procedure was used, therefore, to obtain an estimate of the true wind with which to scale the model results. At the start and at the end of each test the wind speed was measured over a short time interval (usually 5 minutes). The maximum measured wind speed was then used as a surrogate for the steady wind speed input to the model. As long as the maximum speed measured at the start or end of the test is the maximum speed that occurred at any time during the test, the model performance polar (blue lines) forms an envelope for the boat speed data (red circles). Note that all the boat speed vectors originate at the same point O and only the tip of each vector is plotted as a small red circle. The data scatter of the red circles near the blue lines reflects the actual wind variation during the test. It also reflects the sheet handling during the test and how close the boat speed was held constant at the maximum for each heading.

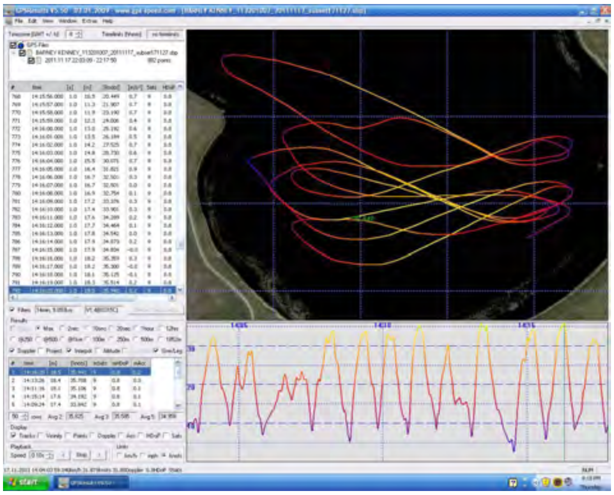
An example of the track and speed data measured with the SILboat using a 6m^2 sail is shown for a single figure eight on a small slough.

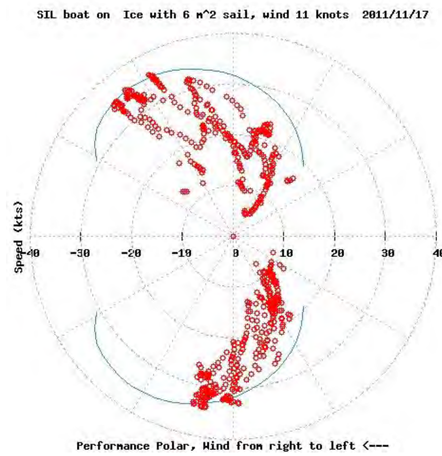
The performance prediction model was then used to calculate the maximum speed possible within the drag and stability limits of the SILboat on the various headings at the value of the surrogate steady wind speed (blue lines plotted on the performance polars shown below). The corresponding GPS data for the single figure eight are shown as red circles. The maximum measured speed agrees well with the model line for both port and starboard headings.

The accuracy of the model results is solely dependent upon aerodynamic force and moment calculations and how well the drag and stability limits simulate the SILboat. The former is well established and the latter can be verified independently by other tests, such as a coastdown test.

An example of the tracks sailed and speeds reached for a number of headings is shown opposite (top).

The corresponding performance polar (at botom) shows some scatter but there is general agreement between the maximum speed data



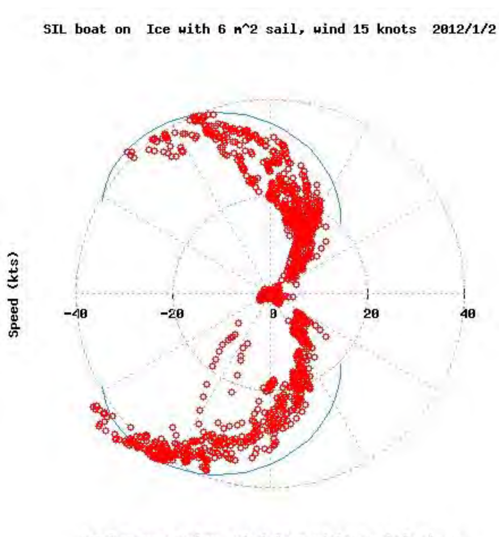


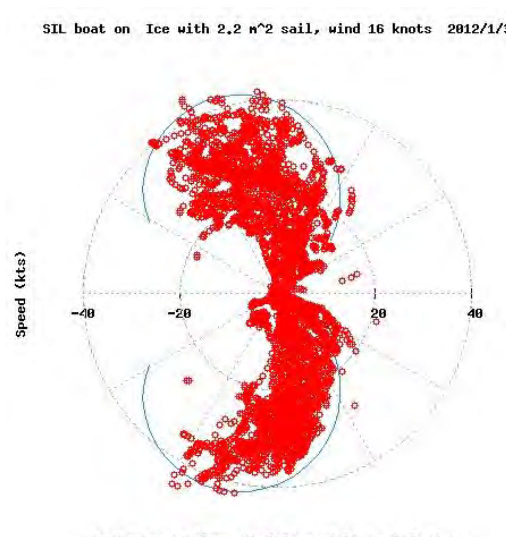
points recorded by the GPS on different headings and the blue model lines.

The results were recorded on a large lake where small changes of heading were made in succession from a close reach to a broad reach during a relatively 'steady' wind. It was important to change headings slowly to allow the boat speed to stabilize on the new heading. Otherwise boat momentum can distort the result.

When the wind is more turbulent there is more scatter in the measured boat speeds. There are also a few data points that fall outside of the envelope, which suggests that gusts occurred during the test that exceeded the maximum speed used to scale the model. The measurements in the plot (bottom right) were made using the twin wing SILboat on a very gusty day in a mountain valley.

The goal of the modelling exercise was not to create an exact dynamic simulation of each and every data point but to create steady-state engineering models that capture the essential sailing characteristics of different snow, ice and land yachts. Dynamic simulation may be possible but would require higher frequency measurements of more parameters such as sheeting angle, sail twist and apparent wind speed and direction. It would also require substantially more testing. The fit of the data within the model envelopes in this study is evidence that the steady state models meet the stated goal.





7: Using Steady-state Models for Design – the What-ifs?

Although a steady-state model cannot simulate dynamic performance, it is still very useful for engineering a new design. An accurate engineering model allows for a rational basis for comparing tradeoffs of various design elements. For example, what if the gross weight is increased? Or, the sail size is increased? Or, the C_{do} is reduced? Or, the size or configuration of the footprint is changed?

It is equally important to be aware of what a steady-state model won't do. With no time dependent terms, it does not model inertial forces or the conservation of momentum. Momentum from a high speed broad reach that carries over when the course is rapidly changed to a close reach (thereby producing a speed much higher than the steady state speed) is not modelled. Neither is sailing directly upwind before the excess momentum is exhausted.

The technique of "Sailing the Apparent Wind" in gusty conditions is also not modelled. This technique consists of rapidly bearing-off and sheeting-in the sail in gusts to maximize the speed, followed by gradually heading-up in lulls. It is a very effective technique used by knowledgeable windsurfers to plane across bands of weak or dead air. In contrast, novice windsurfers tend to head-up and sheet-out to reduce sail pressure and slow down to maintain control when a gust is encountered - exactly the wrong technique to maximize performance. Such poor technique can also result in falling off a plane and slogging in the displacement mode for long periods of time awaiting the next gust.

Experienced iceboat racers also know how to sail the apparent wind and stress the importance of keeping boat speed high at all costs, even if it means sailing a longer course. They know that it is the apparent wind that the sail feels and the faster the boat, the higher the apparent wind and the higher the wind force in the sail. The source of energy remains the true wind but, when combined with boat speed, more power is extracted from the apparent wind.

The technique of "Sailing the Apparent Wind" was specifically avoided while collecting data for the performance polars in this study. Heading and sheet changes were made smoothly and slowly to minimize distortion of the data.

8: A case study: The Quad-mini

8.1 Footprint Considerations

In this chapter, the engineering model of the SILboat was modified and recalibrated to examine design tradeoffs for a new International 5.6 miniyacht with only a few regulatory restrictions. A windsurf sail was rigged in a modified standing lug arrangement. A standing lug rig allows the sail to be balanced on a stub mast with a small static margin (i.e. net sail forces to act through the stub mast) and very small sheeting loads. There is no net torque in the horizontal plane because the centre of gravity and the centre of effort are directly over the centre of lateral resistance. Unlike the SILboat shown previously, should the quad-mini suddenly

lose traction or get airborne coming off a bump there is no tendency to spin when it skids. The main advantage of this standing lug rig, however, is a wide variety of sail sizes can be employed without affecting the trim (no lee or weather helm). Because the sail can be fully sheeted out, the standing lug is also safer than a conventional sail where sheeting is restricted by the mast shrouds.

The International 5.6 Miniyacht (I5.6) is a new racing class for small landyachts defined by only 3 rules.

1. The mast must be round in section.
2. The tyres must be 4.00 x 8.00 maximum.
3. All wheels that touch the ground must do so inside a piece of rope 6mm in diameter and 5.6 meters long.

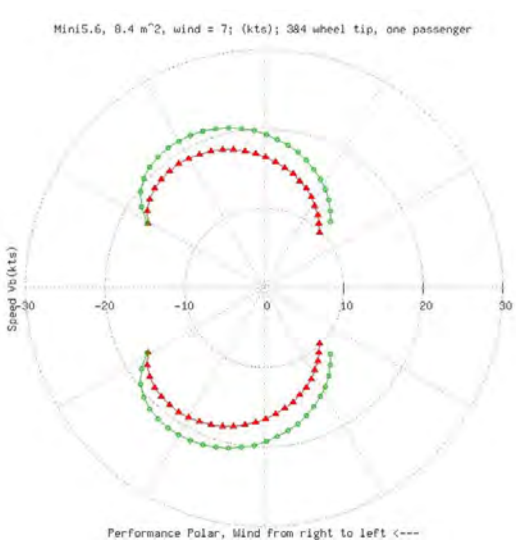
I5.6 mini Specifications

	Trike	Quad
Gross Weight (lbs)	235	235
Wheelbase (ft)	6.25	4.0
Track (ft)	3.9	5.17
SCP/W	0.183	0.283
Angle of Rollover Line (degrees)	17.3	0.0

The I5.6 rules restrict the combination of wheelbase and track width to a small footprint on the ground with no restriction on sail area, mast height or gross weight. Consequently, many 5.6 miniyachts are too tender even in light winds. One central issue to be resolved, therefore, is the shape of the optimum footprint for maximum speed. Is it better to have 3 wheels or 4? And, is it better to have the wheelbase larger than the track?

As a first approximation, the relative stability to capsize of the I5.6 trike and the I5.6 quad specified in the table was estimated simply based on the sail-carrying-power-to-weight ratio (SCP/W) of Bethwaite, 1991. Both had identical sails and weights for the calculations, only the footprint differed. The trike has a SCP/W ratio of 0.183 while the quad is more resistant to capsize with a SCP/W ratio of 0.283, an increase of 50%. This suggests that a quad may be the preferred configuration for an I5.6 miniyacht from a stability perspective.

A more detailed analysis using performance polars from the engineering models described previously is shown below. These polars show the relative



influence of capsize stability on the trike and the quad as a function of heading for one value of wind speed and one very large sail (7 knots, 8.4 m^2 sail). The higher capsize stability of the quad is clear in the performance polar. The quad (green circles) is significantly faster than the trike (red triangles) for all points of sail except the broadest reach (150 degrees off the wind) where the longer wheelbase of the trike reduces the possibility of pitchpoling. Similar results were obtained for different wind speeds and sail sizes.

When sailing at high speed the apparent wind angle, β, reduces as the boat speed increases. The apparent wind is only slightly off the nose of the boat (β = 14°) when boat speed is 4 times the wind speed. Because the L/D of a sail is typically greater than 5, the largest sail force (L) is directed laterally across the boat at high speeds. On the one hand, therefore, the track should be larger than the wheelbase to resist the heeling moment tending to roll the boat over. On the other hand, the angle of the rollover line and the roll-yaw-pitch coupling intrinsic to a trike are reduced when the wheelbase is larger than the track. To optimise the performance of a trike design, therefore, involves a detailed analysis and careful tradeoff of track vs wheelbase. The problem is exacerbated by the 5.6m rule restricting the size of the footprint.

Quad design is simpler because there is no roll-yaw-pitch coupling. Resolving the lift and drag forces of the sail into components in the direction of travel and laterally, the largest component is laterally across the boat and is resisted by the wheels (or blades). The track needs to be as wide as possible to counter the large heeling moment. The thrust, the sail force component in the direction of travel, is smaller than the lateral component and is balanced by the rolling resistance, the aerodynamic drag on the fuselage and inertial forces concomitant with acceleration that are not included in the steady-state model. The moment arm requirement for the wheelbase is generally less than for the track, although a long wheelbase may help if the front wheels hit an obstacle large enough to trip the boat. A ratio of track to wheelbase of 1.3 has proven adequate for the quad pictured above.

8.2 Gross Weight Considerations

Another design variable within the I5.6 rules that can be studied with an engineering model is gross weight. Heavier is better for both capsize and spinout resistance but detrimental when accelerating from a standing start. The model performance of the two

seat quad (shown above undergoing a coastdown test) (green circles in the graph below left), is much better on most headings than the single seat trike used as a baseline (red triangles). The longer wheelbase of the trike gives it an advantage, however, on a very broad reach. Several iterations on the relative size of track vs wheelbase were required to finalize the design. .

8.3 Streamlining Considerations: Effect of Overall Drag Coefficient on Performance

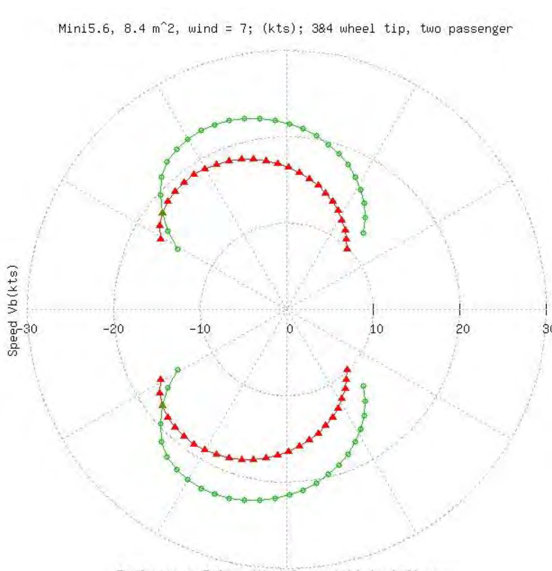
The final design factor considered was the effect of streamlining. What-if an open frame trike is enclosed with a streamline body? How does reducing the overall drag coefficient, Cdo, affect the performance polar relative to the baseline trike shown in red triangles below? The engineering model results (bottom right) show that cutting Cdo in half increases the speed of the trike on all headings - with a maximum increase of 25%. Similar speed increases occur on all headings for different wind speeds and sail sizes.

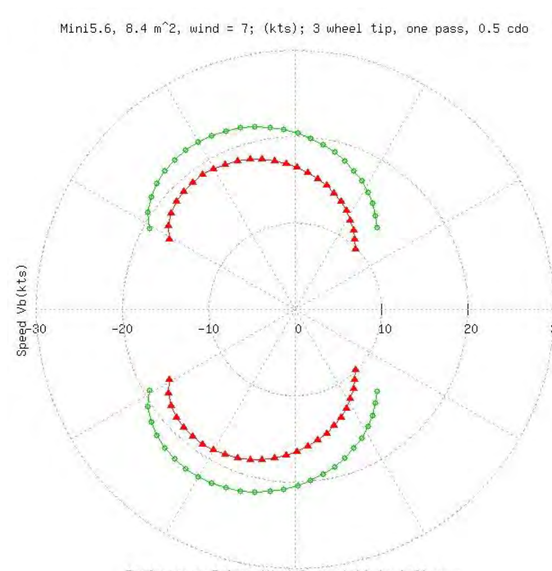
Reducing Cdo to one quarter of its open frame value improves the performance even further although that level of streamlining may be difficult to achieve in practice.

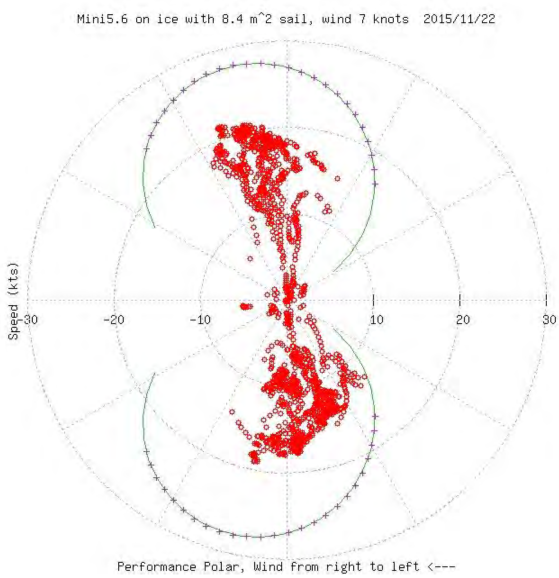
International racing of 5.6 miniyachts over several years has clearly shown the advantage of reducing the overall drag coefficient. Open frame miniyachts were not competitive with minis enclosed in a streamline body so the organizing body (FISLY) has recently decided to split the I5.6 class into two.

8.4 Quad-Mini Performance Polar Limited by Skidding on Ice

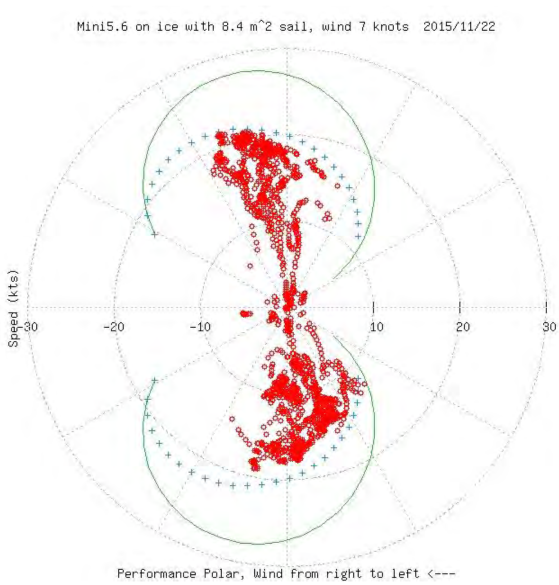
Data were collected for the I5.6 quad on smooth ice in 7 knot winds using an 8.4 m^2 sail (red circles shown top of next page). The solid green lines are the theoretical performance polars for the quad with no capsizing or skidding constraints. These green lines represent the maximum speed that can be reached as a function of heading for the given wind speed and drag conditions (Cdo , runner drag, L/D) with no skidding or hiking. The plus (+) symbols show maximum speed possible when the







skid constraint is imposed; i.e. the maximum speed that can be reached on any heading before the mini starts to skid. The fact that the plus (+) symbols lay directly on top of the solid green lines shows that there is insufficient force produced by the $8.4m^2$ sail in 7 knots of wind to break the runners free on ice and cause the quad to skid. The maximum speed is only limited by drag and the thrust available. Note that the measured data (red circles) do not fill the maximum performance envelope so that there must be another condition limiting the speed. As shown in the next section, that condition is the stability limit for capsize.



8.5 Quad-Mini Performance Polar Limited by Capsizing on Ice

As before, the measured data are shown as red circles and the unconstrained performance limit is shown as the solid green lines in the polar plot bottom left. The calculated maximum performance polar at the capsize limit is shown as blue + symbols. The loci of these symbols represent the maximum speed of the quad on any heading before tipping over. The small footprint, imposed by the miniyacht rules, significantly reduces the maximum performance over that possible when only limited by thrust and drag (green line). The measured data (red circles) fit within the envelope defined by the calculated + symbols. Data points much slower than the maximum speed on any heading may reflect a lull in the wind during the measurement period or the sail not sheeted properly for the heading, as before.

Similar results were obtained for the quad on wheels. Higher wind speeds and larger sail sizes exacerbate the role of stability on maximum performance for miniyachts with the small footprint specified in the rules.

9. Summary

Hyperwind sailing performance is a function of the overall lift/drag ratio that results from the parallel combination of the L/D in the air and the L/D on the ice, land, snow or water surface. The greatest improvement in performance results from increasing the smaller L/D. When performance is limited by stability rather than drag, the quad configuration is more stable to capsize than the trike. The additional stability is most beneficial for boats restricted to a small footprint by racing rules. The quad configuration also eliminates the roll-yaw-pitch coupling intrinsic to a trike that up until now has inhibited sailing a boat on snow. The stretched version of the quad-mini shown below being tested on ice markedly improves performance, eliminates capsizing previously experienced by the trike with a conventional sail and opens up many new venues for sailing on snow and ice.

Barney Kenney
59 Hillgrove Drive SW
Calgary, Alberta, Canada
T2V 3L5
June 20, 2017

References

Abbott, I.H. & A.E. von Doenhoff, 1959. Theory of Wing Sections, Including a Summary of Airfoil Data, Courier Corp., 693 pp.

Bethwaite, F., 1991. High Performance Sailing. International Marine, Camden, Maine, 414pp.

Davidson, K.S.M., 1956. The Mechanics of Sailing Ships and Yachts. In: Surveys in Mechanics. Cambridge Univ. Press, 431-475.

Fuchs, M., 2009. GPSResults V5.50 (Published online by the author) info@GPS-speed.com

Hoerner, S.F., 1965. Fluid-Dynamic Drag. (Published by the author) Midland Park, NJ., 452pp.

Kenney, B.C., 2001a. Hyperwind Sailing. Catalyst, J. Am. Yacht Res. Soc., 6, 24-26.

Kenney, B.C., 2001b. High Efficiency Ski for Sailing on Snow or Ice. United States Patent 6257620.

Lanchester, F.W., 1907. In: Aerodynamics, Vol. 1., A Constable and Co., London, p. 431.

Marchaj, C.A., 1980. Ice Yachts. In: Aero-Hydrodynamics of Sailing. Dodd, Mead & Company, N.Y., 130-141.

Milliken, W.F. and D.L. Milliken, 1995. Race Car Vehicle Dynamics. Society Automotive Engineers, 890 pp.

Perkins, C.D. & R.E. Hage, 1949. Airplane Performance, Stability and Control. Wiley & Sons, N.Y., 493pp.

Taylor, E.S., 1974. Performance of an idealized iceboat. In: Dimensional Analysis for Engineers. Oxford Univ. Press. , 129-134.

Acknowledgements

I thank Klaus Faisst for his enthusiastic review of a rudimentary draft of the manuscript and his unwavering encouragement to complete the paper. Stephen Kenney is gratefully acknowledged for his assistance with testing and for editing the final draft. I also thank Paul Sufady for assistance in fabricating the prototypes.

QUILL: a tacking Proa with a Crab Claw shaped sail.

Designed, built and sailed by Kim Fisher

Over the past ten years or more discussions have raged around the Amateur Yacht Research Society about Marchaj's data on Crab Claw sail performance but nobody seemed to have built one to prove or disprove what he said. I just wanted to try one myself – hence I have built *Quill*.

Quill is a 15' LOA x 4' beam single-handed sailing dinghy with a crab claw shaped sail and a tacking proa layout.

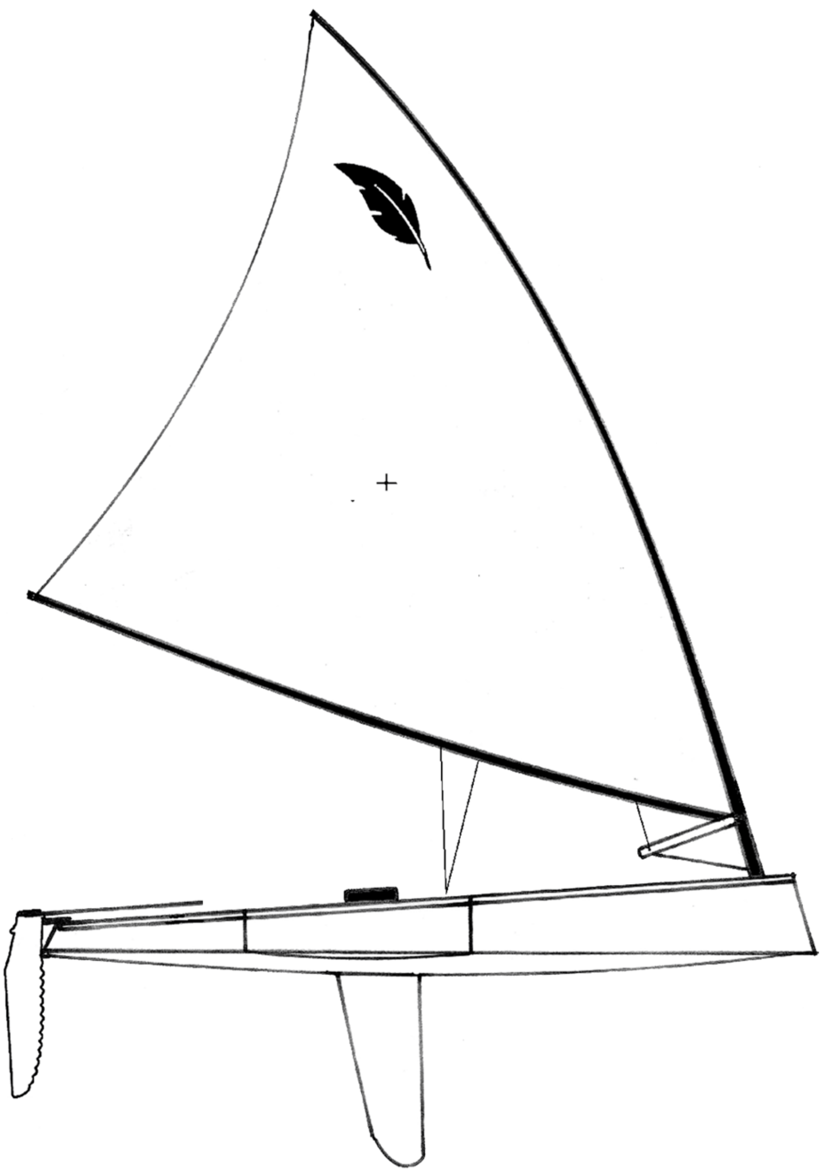
It is GRP foam sandwich construction with carbon-fibre sliding seat, mast and boom.

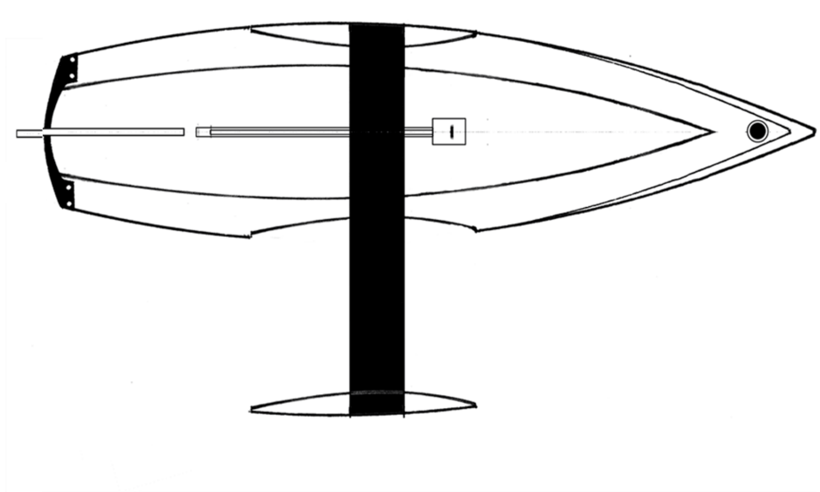
It has a pivoting centre board and a "tubercle" shaped rudder blade. The cockpit is self-draining.

Total all up weight including rig is 107kg (236 lb.).

The Rig

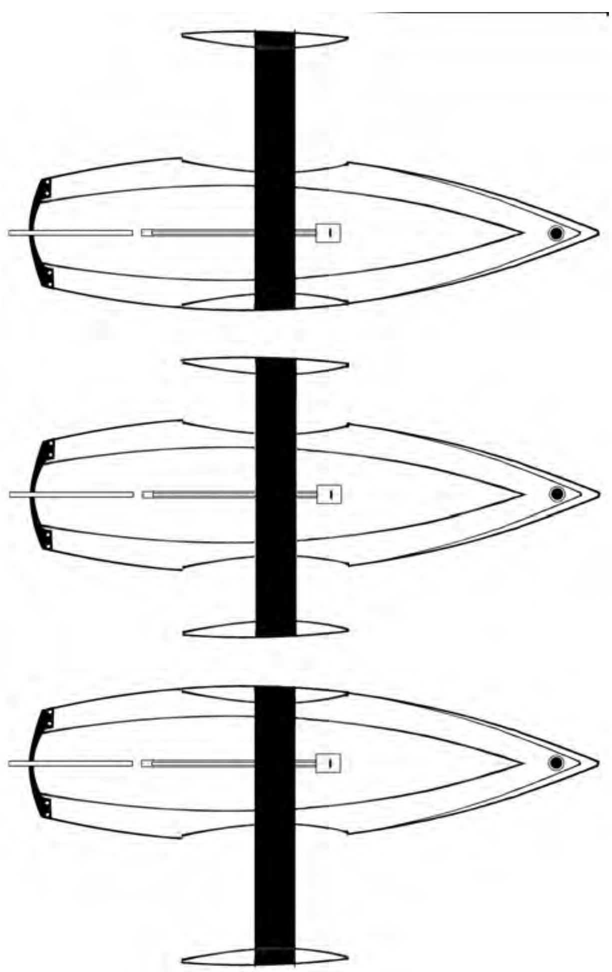
The 10 sqm (108 sq. ft.) rig is different from other crab claws in that the yard is extended and becomes the mast similar to a cat boat. The un-stayed, rotating mast is a lightly built OK dinghy mast with 50% less carbon fibre than standard to allow it much greater bend. The mast fits into a "dreadnought bow". The boom is a standard windsurfer mast which has been bonded together and a sail track added.





Both spars are built straight and bent by a powerful kicking strap to take up the flat sail's curved edge shape.

In true crab claw fashion the sail is cut absolutely flat. The only controls are kicker, outhaul, mainsheet and topping lift which is used to add fullness to the sail. To ensure the mast doesn't snap at deck level an extra 2" diameter carbon tube was inserted into the first 1m of mast. The boat performs very well when close hauled, reaching and downwind. The tacking angle is approximately 92 degrees. I have also devised a system which allows the mast rake to be rapidly altered while sailing and can move the mast 17 degrees to vertical relative to the waterline.



Another design feature: the tacking ama assembly.

In the past I have sailed a boat with a sliding seat, a Toy sailing dinghy, and this frequently capsized to windward when I got it wrong! I therefore designed a seat with floats on the end to help prevent this.

Quill has floats (amas) shaped to fit perfectly into cut-outs in the boat's sides. When fully extended to one side the other ama is flush with the hull side - thus contributing little drag. The system has proved very stable and simple to operate. The ama to windward acts more like a stabilizing weight rather than a float as it gently flies most of the time - a true "flying" proa. The boat's waterline is just below the chine line so the dent in the side does not actually cut the water very often - the boat sails at low angles of heel. A similar sliding outrigger was used in the 1978 world sailing speed record contender *Slingshot*. According to archival photos, the leeward ama tucked up against the hull did cause considerable spray.

Videos

Quill was displayed on the AYRS stand at the 2016 RYA Dinghy Show at Alexandra Palace.

A video of *Quill* sailing is available to view on Youtube: search Quill Worsley. https://www.youtube.com/watch?v=A9MF2Mlp3Jw (This video was kindly produced by Peter Worsley, AYRS member.)

Perceived sailing qualities of *Quill* after only 6 trips:

The boat is very lively despite being reasonably heavy for a 15’ dinghy (107 kg all up weight). The sail will point as high as a Bermudian rig but does not deliver the same power tight upwind for its sail size. It can quickly stall and you need to bear away rapidly to regain power – less tolerance than a Bermudian rig. Once slightly off the wind the power kicks in. It may well be better to sail freer and go faster.

When on a close to broad reach she is a delight. The reduced height of the sail C of E and the stabilising weight of the ama combine to give a ‘safe’ feeling as the speed climbs. There is also dynamic stability generated by the hull shape and the transition to planing is almost imperceptible as there is no ‘fuss’ at the ‘dreadnought’ bow. I think the bow waves are being directed slightly backwards by the overhanging chine section and maybe increasing lift.

On the run she was designed to have the amas out equally on both sides but in practice this creates more drag than with the amas shunted to port or starboard. In reality having one ama flush and the other gently flying reduces drag and still retains the ama safe stability. Gybing is very simple and calm. There are no stays to limit the mast rotation and the power in the sail can easily be feathered by letting the boom go out and forward (beyond 90 degrees). The boom does not appear to want to ‘kick up’.

One anomaly has appeared. When the sail is let out so far that the boom begins to point forward the sail seems to re-power up! This has happened more than once when trying to land on a lee shore!

The whole rig can have its rake altered while sailing. It can easily be changed from mast-vertical to up to 17 degrees aft rake. This is achieved by pulleys moving the mast shoe backwards and forwards. This was built in as other research has shown that rake changes to crab claw sails allowed greater pointing ability by moving them more vertical. I have used this on several occasions and found that moving the rake to near vertical did improve the pointing ability but the C of E of the sail moved forward and caused the bow to sink slightly which in turn improved the beating further (due to more side panel being immersed at the bow). All of this came at the price of reduced speed.

I believe the increased side panel immersion does improve beating ability but I was able to do this by moving my body forwards in the boat and not alter the mast rake (much more easy and rapid to change than the mast rake.) Much more sailing in different wind speeds is required to test this feature.

The sail shape is created by the tension along both the sparred edges and considerable tension on the kicking strap. This tension is easily applied by pulling in the mainsheet hard and then locking off the kicker. I have not altered the kicker very much during sailing as this tends to induce creases in the flat sail

with a perceived reduction in power. The topping lift is used during sailing and I have found it can increase fullness easily when going down wind but my current system is not able to finely adjust this (required). More pulleys etc. needed!

In papers discussing how a Crab Claw sail works the Edge Vortex theory has been widely proposed. To try and capture the air flow directions over *Quill's* sail I have covered it with tell tales over both sides. I have more than 100 pictures from a single outing, which show these flow patterns clearly. None seem to show what might be expected if edge vortex was acting on the sail. Where a photo shows a disrupted airflow over the sail it is normally when on a run or it was taken when the sail was incorrectly set and not yet 'pulling'. I am not well versed in assessing these images and would welcome anyone who is knowledgeable in this area who would like to view them and give their opinion. The ultimate way to assess this would be for somebody to actually sail the boat – any volunteers?

One problem occurs when hoisting the sail: you have to feed both the bolt ropes into the boom and mast at the same time as hoisting both simultaneously because the boom is fixed permanently to the mast. It is awkward but works. I have not yet devised a way to reef the sail.

The sliding amas work more easily than I anticipated. The carbon sliding-seat is trapped by stainless steel hoops, as per Australian 'plankers' and runs on acetal pads. You tack the seat when the boat is levelling out and turning, which allows you to use the ama's side to help push it across. I have found that as the mechanism is so free running the seat will often slide back in when you move out onto the end of the seat. This is un-nerving and also pushes the ama out of the leeward side and induces drag. To prevent this I have built in a seat lock, which you loosen when tacking. I am 16 stone in weight and 60+years old so have only infrequently sat on the very end of the seat to keep the boat upright. I would be delighted to see someone lighter and more agile sail the boat – any volunteers?

The tubercle rudder blade has been faultless. It has never cavitated when I have 'overcooked it' going downwind. It has been 'fit and forget'. Its only foible is that it **must** be fully down and vertical to feel resistance free. The centreplate is from a Fireball dinghy and I think it is much too big. On occasions, I have been happily beating and noticed the plate is up! I think the boat's vertical sides and waterline chine along the entire length considerably reduce the boats leeway.

The boat is easy to right after a capsize as it floats with the centreplate close to the water and is self- draining. It has very low freeboard at the stern enabling easy re-entry back into the boat. Another plus is that the leeward ama floats upwards when the boat is on its side meaning that when the boat is righted the seat is already extended on the windward side and prevents the boat from rolling back over to windward.

Since the video was shot I have reduced the number of pulleys in the mainsheet system and fitted a centre mainsheet cleat which has made sail setting very much easier. I have also added a strop supporting a pulley forward of the mainsheet cleat which has drastically improved the sheeting angle of the boom and hence the boat's windward performance.

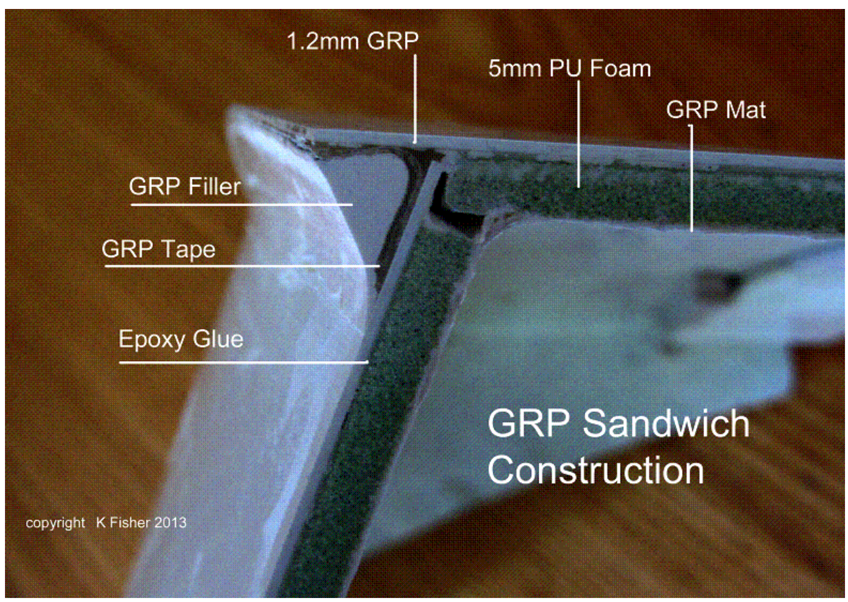
More experimenting will be taking place in Suffolk this summer.

QUILL: How it was conceived and built.

Kim Fisher.

Many years ago, I wanted to build a sailing boat; one that would not require painting (I hate painting) or rot if left outside (plywood just doesn't last).

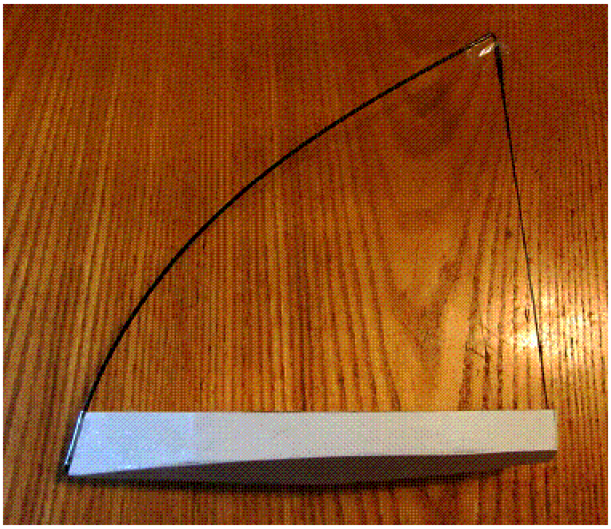
I had worked as a GRP layup operator when a student and knew how to make moulds, mouldings and general fabrication.

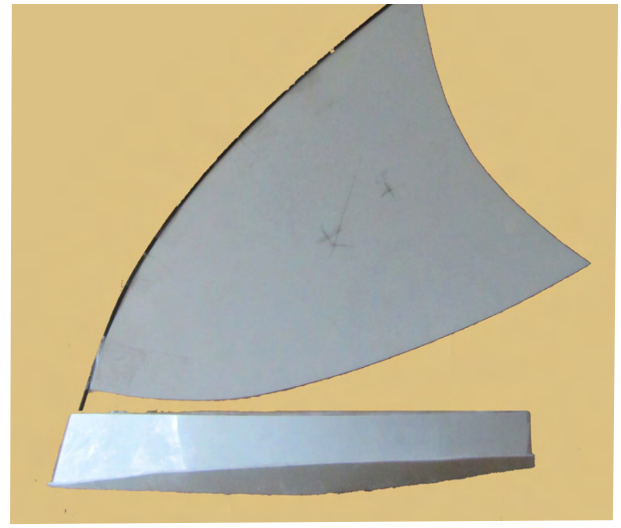


To make a standard GRP boat you first need to make a plug, then a mould and then the moulding. You have to effectively make 3 boats to get a GRP boat. It was not a process for one-off designs. When I retired, I had time to pursue this long felt want. It was then that I came across industrial GRP sheet which is being used to clad lorry bodies. I acquired a sample of this material from Coldsaver Panels in Yorkshire http://www.coldsaverpanels.co.uk/ . It is supplied in widths from 2m to 3m and up to 60m in a single length. It has a gloss white gel coat on one side and rolled flat glass fibre on the other.

My idea was to bond closed cell foam to this 1.2mm thick material and then to CNC cut out panels which would be 'stitched and glued' together as if they were pre-painted plywood pieces.

With the gel coat on the outside and the seams glued I would then glass the entire inner surface of the hull to create a foam sandwich GRP boat which was totally watertight. No mould, no jigs, no painting and structurally strong, light and rot proof.



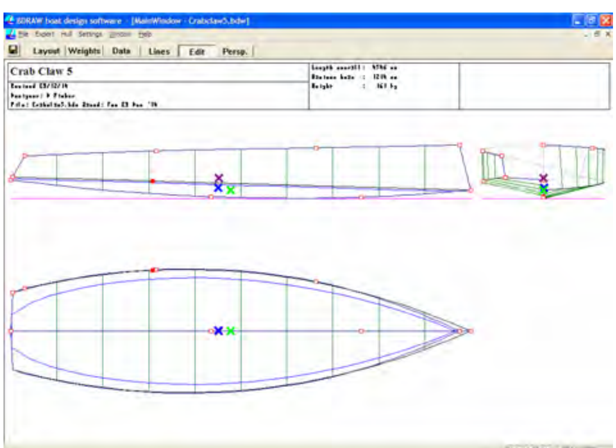


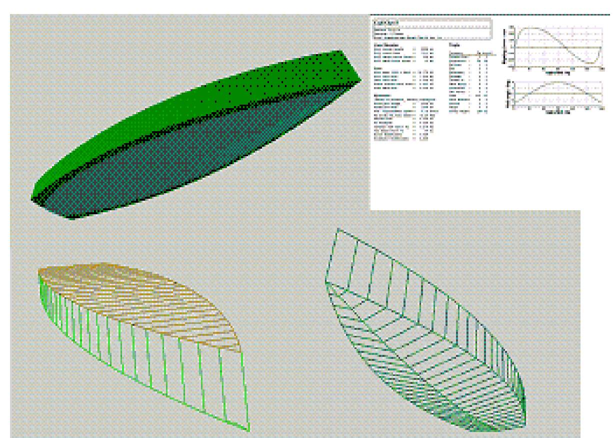
First trials

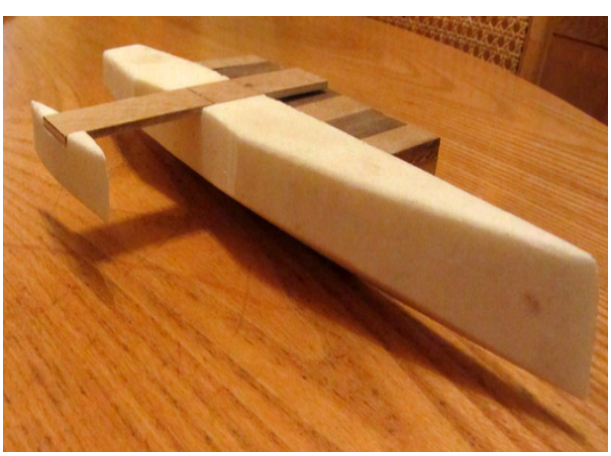
My first design was to use a crab claw rig. Marchaj's data had always intrigued me and I wanted to try sailing one.

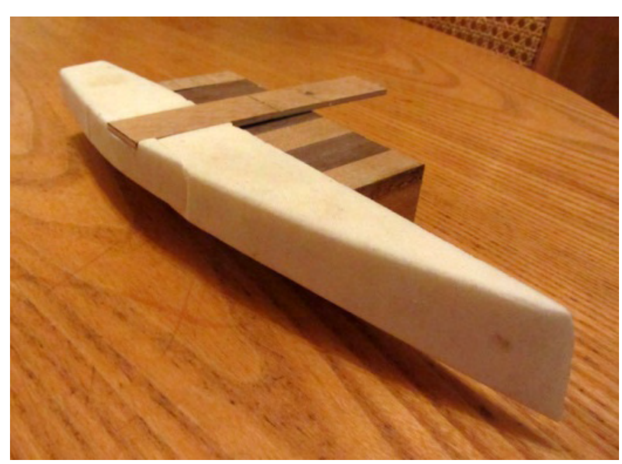
I decided that a crab claw shaped sail could do away with the restrictive 'A' frame mast if the top spar was extended and inserted into the bow of the boat, hence the Cat boat style Crab Claw concept. This also required a rather fashionable 'Dreadnought ' bow.

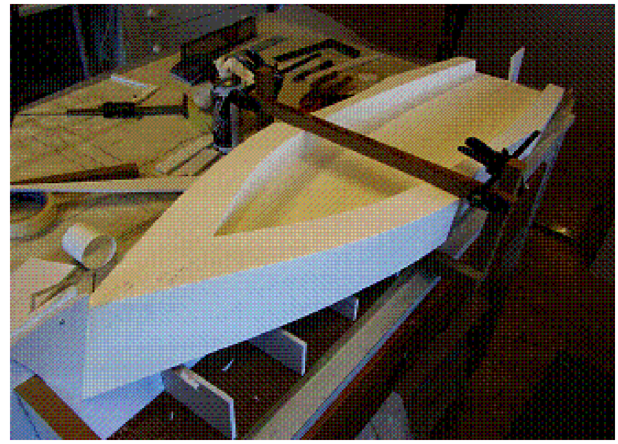
The next concept was to make a narrow hull for speed and use a sliding seat to keep the boat upright.









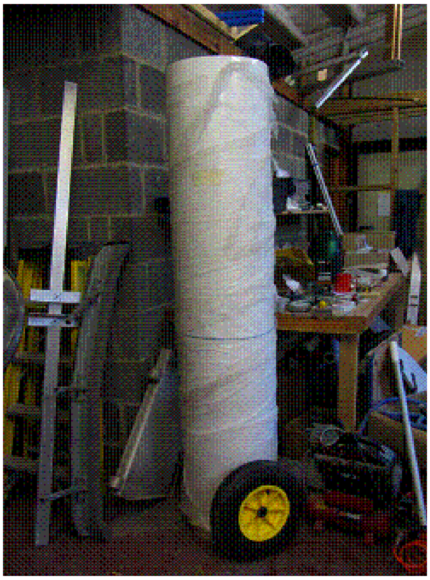


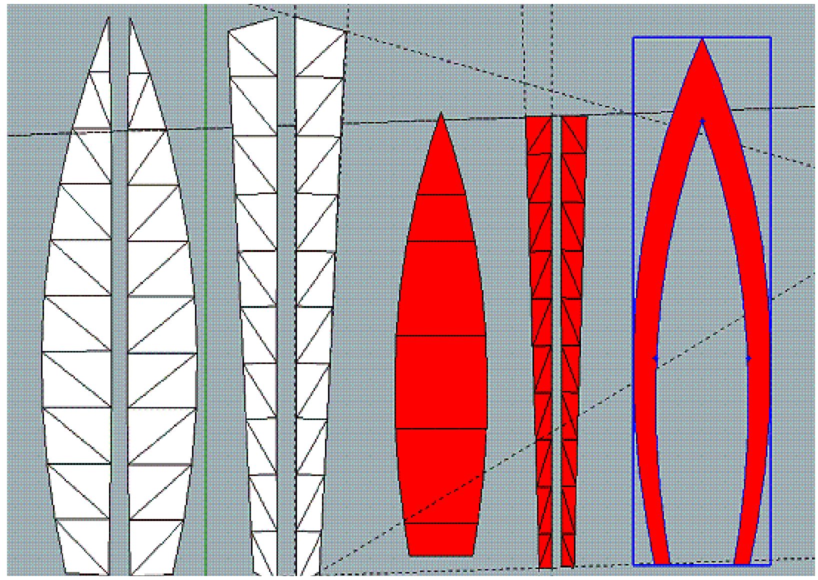
Experience from sailing a *Toy* dinghy in the 1970's had persuaded me to put floats on the ends of the seat for added stability. When designing this it was discovered that the floats could be made flush with the hull sides when fully retracted. This was added to the final concept.

I used a simple CAD program which AYRS member John Perry created to do the 3D hull design and check its performance characteristics. From this information I made a 1m long model.

I have found, over time, that anything less than a 1m long hull model does not reliably scale in hydrodynamic terms.

After sailing the model and viewing my numerous videos I decided to build a full sized boat.

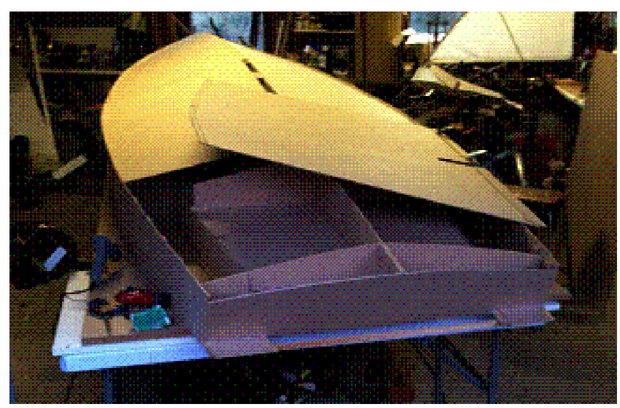




Full Size

I purchased 15m x 2m of GRP sheet which came as a large, heavy roll and plotted off the panel shapes from a CAD program. To double-check the panel sizes were correct I built a 3mm thick MDF full size dummy of the boat hull. (Only £36 worth of MDF made sure the panels were right!)

Then the panels were made by vacuum bagging foam and glass onto the raw GRP sheet.



All the panels had foam and an inner layer of glass added except for the hull bottom panel, which only had foam to enable it to be bent more. Because of the panel sizes (some more than 16' long) it was necessary to use Infusion polyester resin with a long cure time, which enabled at least 1 hour resin working time to complete the layup before the vacuum was applied. A long flat table was created using several catering tables covered with 19mm MDF and topped with a single 16' sheet of the GRP sheet (used later for final small panels).

The cut panels had channels routed around the perimeters down through the inner glass and foam to the inside of the outer GRP sheet. This enabled the sides of the boat and deck to be slotted in on top of wet resin and then a fillet of glass applied to bond the 'verticals' to the 'horizontals'. The deck panel had plywood inserts moulded in to support the sliding seat mounts and transom bar. The whole boat was built upside down on the table as the deck was completely flat.

The centre box was made of GRP sheet/foam/glass and the bulkheads were made of glass /foam/glass panels. All were glassed in. When the bottom panel (made with only GRP sheet and foam) was applied it was unfortunately too floppy to use un-supported so triangular wooden stringers had to be added!

The entire bottom panel is one piece (16'long and max. 4'3" wide) with a slit in it from the back of the centre box to the bow which meant when these edges were brought together the rocker and hull shape was formed. It was bonded to the bulkheads and around the outside where it sat inside the chine on a ledge left by routing away the foam from the side panels leaving a small overhang of the side panel.

Before bonding on the bottom of the hull a 'bell bottomed' moulding was added in the bow to hold the mast and rake mechanism. It was created in two halves around a crude plaster and wax plug. The finished sealed unit protruded through the deck.

The floats (amas) were then cut out of the side of the completed hull. A scary moment when you take a jig saw to a pristine hull. Panels were added to the ama inner sides after filling them with shaped PU foam for stiffness and guaranteed buoyancy.

The sliding seat was made from carbon tubes with panels and ribs of glass and carbon fibre added. The upper seat surface was covered with peel ply which left a textured non-slip surface when removed after curing.

The boat was then fitted out. Stainless steel hoops added to guide the seat and a hardwood trim was added to the deck/hull join line to protect this edge. The only bit of varnish on the whole boat! The mast rake pulley system can be seen in the centre of the boat. The stern bar and rudder had been fitted and the carbon/bamboo tiller extension is seen lying across the sliding seat.

Rigging

The mast was laid up using pre-impregnated Carbon and consisted of 2 x 10' lengths , each made of 2 halves, elliptical in section. The assembled pieces were then wrapped in a single woven layer of carbon bonded with epoxy and shrunk wrapped.

The mast and boom were rigged on the boat, taken to the sailmakers (SailMedic, Ipswich) and tensioned up to enable measurements to be made. The flat sail was made and fitted beautifully.

Lessons Learned

Things I have learnt during this project:

- Large flexible GRP panels are easy to make but difficult to move, locate and prevent being damaged.
- Don't tightly roll up GRP sheet in the cold as it cracks the gel coat.
- It is easier to mask a surface from resin splash than remove hardened resin from presentation faces
- Bonding and filler paste is heavy.
- Measure 3 times - cut once!
- Sharp edges on boats get easily damaged.
- It is massively satisfying to sail around in an 'Idea' you have had for years.

I would like to take this opportunity to thank Simon Cox of Synergy Marine, Waldringfield, Suffolk for his time, expertise, workshop space and equipment which made this build possible.

niB: new inspiring Boat
a children's sailing boat design.

Kim Fisher

Why design a new boat?

Currently there are a few boats manufactured which are aimed at inspiring and teaching children to sail. The Optimist is by far the largest class in this sector. It was designed in 1947 and is the slowest boat on the Portsmouth Number rating scale. This simple boat can cost in the region of £2500. The appeal of this class appears to be down to its International quality racing circuit and its place as a lead-in boat to other racing classes. It's a racing boat trainer – many kids just want to sail.

Newer boat designs have appeared:

The Tera, the Laser Bug, the Open Bic etc. have all been designed for this market sector but they are all made from rotational or vacuum mouldings which result in heavy boats which are not easily or economically repaired. The requirements of sailing schools and holiday companies have driven this approach and resulted in 'cheap machines for teaching sailing' not a boat to inspire or desire.

In the past small dinghies were home built mainly from plywood which requires considerable maintenance. These dinghies enabled many to learn how to sail cheaply and to race if they wanted.

I wanted to design a very simple boat which could be cheaply made, even by an amateur. It should be lightweight, fast, easy to mend and appealing to a modern youngster.

How to make it cheaper?

Use less parts, materials, labour and simple, cheap tooling.

The initial start of this project was to create simple and quick hull tooling utilising a method used by sculptors to create complex shapes quickly. The method involves using a large sheet of latex stretched over a frame and then draping it over various raised shapes on a table which produces a succession of flared-in 'mountain range 'type shapes. This skin of latex is then covered in thin gelcoat (several layers) and then backed up with GRP tissue. As it gets stiffer it is then re-enforced with chopped strand mat. The mould formed is then used to create final mouldings.

This method was used to make the mould for the niB 1m long model. The plug was made in ½ a day complete with a gloss, flared in surface. The mould was subsequently made in 1 day and a hull moulding made the next day. Changes to the hull shape are easily made by changing the initial wooden 'ribs' and repeating the mould making process. A 1.5m x 1.0m x 0.4mmm thick sheet of Latex was used for the 1m model plug. To create the full size (2.44m long hull) 2m x 3m x 0.8mm Latex will be used. (available from Pentonville Rubber).

This initial design is envisaged as 2.44m long (8') x 1.22m wide (4') and have an initial sail area of 3.3sqm (35sqft) – very similar sizes to the Optimist but with an **all up** weight of less than 30kg.

It is envisaged that this basic hull moulding would be made in quantity by a GRP moulder rather than a skilled boat builder. It could then be finished by an amateur or professional boat builder.

The complete decking has been designed to be made from one 2.44 x 1.22m (8' x4') sheet of 5mm marine ply which has been bonded to 5mm PU foam and covered in woven glass. The hole in the top deck is the exact shape needed to create the inner deck which sits on the boats chine and is attached using GRP bonding paste. The central centreboard box has a flared top which creates the central deck support around the capping. No ribs are used below the deck.

The sail and mast will use design experience from windsurfers and will utilise a deck mast lock. The sail has an internal boom which can flex horizontally but not vertically to maintain sail shape like a batten. The boom will be high up to miss children's heads. No kicking strap is proposed as the sail shape can deliver this function. There will be a centre main and jammer for simplicity.

Initially a fixed rudder and dagger board are proposed for simplicity and cheapness. A lifting rudder may be made available if there is a demand. One central toe-strap is proposed but this needs to be chosen and positioned in the full-size boat.

Next steps:

More testing of models to finalise the hull shape to get the correct balance and to perfect the self-draining deck.

After this a full-size plug and mould will be made and detailed costings obtained. It is then hoped to trial a completed boat with various sailing clubs to gauge interest.

Ultimate Sailing for Oldies

Roger Glencross

Introduction

Now that Ultimate Sailing has been achieved by the French, using hapas inspired by Didier Costes and designed and manufactured by Stephane Rousson, it is opportune to upgrade Professor J. G. Hagedoorn's booklet "Ultimate Sailing, introducing the hapa". I propose to move from Hagedoorn's theory to the practice of existing aerofoils and hapas.

Hagedoorn considered using the 242 square foot Notre Dame Para-foil of aspect ratio of two as his aerofoil. He did not design or build a hapa that was stable at speed. He computed the triangle of velocities (true windspeed, apparent windspeed and water speed) for notional kite/hapa combinations with lift/drag ratios of kite and hapa of five to one each, on a towline slope of three in ten. He also computed the air speeds and water speeds for a notional range of kite/hapa combinations with lift/drag ratios from two to ten for both elements, with pull over mass on the towline of from one to twelve, all at a towline slope of three in ten.

But the practice is somewhat different from Hagedoorn's mathematical models! Kites parafoils and hanggliders have progressed greatly since his 1960's designed Notre Dame Para-foil. However kites and hapas with lift/drag ratios of five to one, let alone ten to one, have not been realized. Also the towline slope posited of three in ten is yet to be proved and may not be constant.

Let us consider existing hapas (The marks are my own).

- Mark 1 — 0.833 square foot projected area — Aspect ratio 8.5 to 1
- Mark 2 — 1.3 square foot projected area — Aspect ratio 4.46 to 1
- Mark 3 — 1 square foot projected area — Aspect ration 5.7 to 1
- Fabric — 18 square foot projected area — Aspect ratio 0.42 to 1
- Fabric — 3.67 square foot projected area — Aspect ratio 0.27 to 1

The Mark 1,2 and 3 hapas seem to have drag angles varying with speed from 25° to 35° , i.e. lift/drag ratios from two to 1.4. The Mark 3 hapa worked well at October 2016 Speedweek. I do not know the lift/drag ratios of inflatable kites, but as kitesurfers are not very close-winded, even when using efficient boards and skegs, I suspect they are low.

In order to lift the weight of a person one must have sufficient vertical projected kite area and sufficient apparent wind. An enormous kite is dangerous in untrained hands. The vertical projected kite area is reduced by the semicircular shape and the far from vertical slope of the kite lines of kitesurfer kites. Thus all kitesailing man lifting has succeeded only at relatively high water speed. Until now! Happily Mark 1,2 and 3 hapas cope well at such speeds, but unhappily they confine ultimate sailing to the Young, the Athletic, the Strong and the Light in Weight.

What is left for us Oldies? I am not concerned with how close-winded I may fly, but only with flying! So I am only concerned with lift, not drag. I plan to deploy my 18 square foot fabric hapa initially in drogue mode, which would produce a drag co-efficient of 1.2 (see Ian Hannay's Natural Aerodynamics, AYRS 117 page 41). For the aerofoil I would use a Skyhook 111A hangglider of 216 square foot wing area, aspect ratio 2.63 to 1, which flies at an airspeed between 15 to 25 MPH (22 to 37 feet per second).

The advantage of a hangglider over kites is that the flier has control over the angle of attack in a hangglider via the A frame control bar, provided the Aquaviator's arms are long enough and he has the strength to push forward hard enough. This ability to produce "superlift" i.e. lift above the sustainable figure, for a short time before the flow collapses, is necessary for the craft to take off. See AYRS 117 page 39.

Abbott and von Doenhoff tell us that a lift co-efficient of unity is the best that one can normally expect at an acceptable lift/drag ratio. So with the Skyhook 111A hangglider we get:-

$$\text{Lift} = C_L \times \tfrac{1}{2} \times \text{Air density} \times \text{wing area} \times \text{velocity}^2$$

The minimum airspeed is 22 ft/sec so we get:-

$$\text{Lift} = 1 \times \tfrac{1}{2} \times 0.0024 \times 216 \times 22 \times 22 = 125\text{lbs}$$

But the all-up weight is 250lbs so we either need to operate at a C_L of 2 ("superlift") or increase the flying speed to over 31 ft/sec (nearly 22 mph), which is a little high for my liking.

Hence we have a need for superlift by pushing forward the A-frame control handle, effecting a larger angle of attack, and producing a lift co-efficient of 2.0. A "B" bar would be better, enabling the Aquaviator to pull it back to his stomach while still enabling him to push the bar further out.

In practice not all of the 250lbs lift will available to lift the Aquaviator, due to the positive angle of the hapa line with the horizon. But the effect of this is not significant, in my opinion.

The drogue must produce sufficient resistance to resist the aerofoil from merely blowing downwind and losing its apparent wind of 22 ft/sec. The hangglider will have a lift/drag ratio of less than its advertised five to one ratio due to its enhanced angle of attack on takeoff, so let us say three to one. So the required resistance is 250 lbs ÷ 3 = 83lbs.

The 18 sq ft drogue has a drag co-efficient of 1.2 (AYRS 117 page 41), so it will develop a resistance of 83lbs at a water speed given by:-

$$83\text{lbs} = 1.2 \times \tfrac{1}{2} \times 1.956 \times 18 \times V_W^2 \text{ ft/ sec}$$

or $$V_W = 1.98 \text{ ft/sec i.e } 1.3 \text{ MPH.}$$

This nearly 2ft/sec water speed downwind must be added to the aerofoil's air speed of 22 ft/sec, making a required true windspeed on 24 ft/see i.e. 16 MPH.

Before the "superlift" collapses the drogue must be deployed into hapa mode while the hangglider reduces its angle of attack as it picks up speed and becomes less downwinded. The lift/drag ratio of the 18sqft fabric hapa is poor, that is about one to one, a drag angle of 45°, but as I am only concerned with flying and not with travelling close-winded or achieving a fast ground speed, all that is required from the hapa is sufficient resistance to stop too much leeway. Thus I will maintain sufficient apparent wind to fly.

The hangglider would fly close to the sea surface so ground effect would reduce the induced drag. This is the main component of drag in a low aspect ratio aerofoil with a lift co-efficient as high as two due to the wingtip eddies, i.e. vortex lift, which are so marked in delta wing aircraft. Ground effect also increases the amount of lift generated. The quantity of ground effect depends on the height of the wing tips divided by the length of the wingspan. The lower the wingtip height and the lower the aspect ratio the more the benefit of the ground effect is felt.

The wing span is 24 feet and I compute the wingtip height at one foot. This gives a 70% reduction in induced drag. (see K. Sherwin "Manpowered Flight" page 53). I have not included this welcome bonus in my figures (yet - see later parts), but not because of any lack of faith in the benefits of ground effect.

If, in the process of the above project, I invent the slowest, lowest, most inefficient manned aircraft ever, so much the better!

What could possibly go wrong?

Roger Glencross
October 2016

Appendix 1: Weight breakdown

Pilot	150
Hangglider (dry)	45
Campari Catapult dinghy as undercarriage	55
All-up weight	250lbs

RYA Suzuki Dinghy Show2017

The show was definitely celebrating the growth of foiling. In the entrance foyer there were examples of an International Moth, a Waszp and Bill Sunnucks' Vampire catamaran (above) and foiling featured in the talks given from the Main Stage

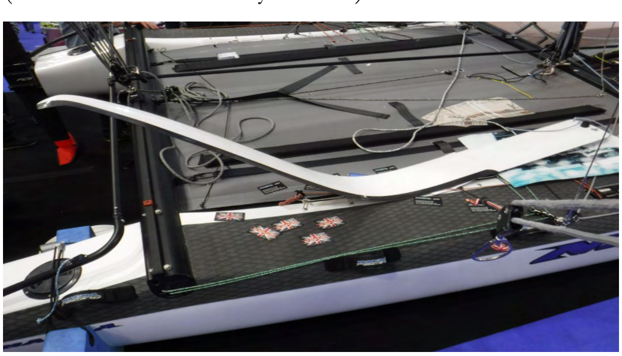
As usual the way in guides the visitor through the RYA area where membership and publications can be bought, and where some of the lecture demonstrations take place: well worth watching various skilled teachers explaining sail control and race tactics.

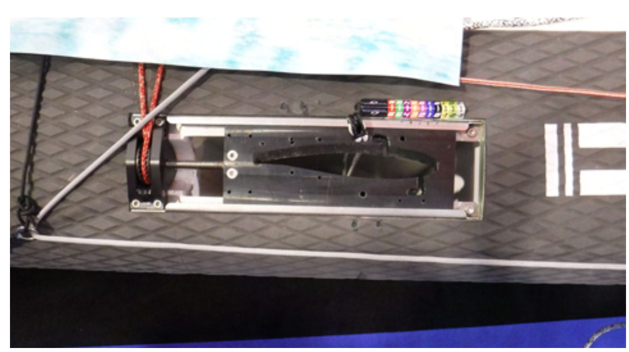
The Great Hall had many of the active classes of racing dinghies and catamarans on display as well as some of the larger suppliers of clothing and fittings

In the West Hall some other classes were on display including an Uffa Fox designed Flying 10, just like a Flying 15 but smaller. This one had a perfectly varnished hull. For the most part though, it was sailing clubs and training centres, including Barton Turf Adventure Centre who were sharing our stand (or was it the other way round?)

The Flying Mantis: a trimaran which can be sailed with either conventional dagger board and rudder or on foils - much more stable and can be launched using a trolley as the foils retract and are pushed down once in deep enough water.

NB No connection with David Chinnery's Mantis (see AYRS#72)





The specially shaped inclined lifting foil of a Nacra 17 and the adjustable slot into which it is inserted allowing the angle of incidence to be changed www.nacra.org

Beale Park Boat Show

My general impression was that the show had less stands than usual, the noticeable difference was that the Wooden Boatbuilders didn't have their usual large presence, the area they normally occupy was taken up by an auction with about 25 lots of mainly traditional rivercraft, However It was still an enjoyable show and our stand attracted attention and was able to take some memberships and sell a few books etc.

Fred Ball

Our Stand

John Perry and Josephine took part in the Home Boat Builders trip down from Lechlade using their new rowing boat which was entered in the Amateur Boat Building competition. It looked good and performed well.

Dennis Adcock won the Cordless Canoe challenges

Part of Amateur Boat Builders display including John's Green Boat

Below Start of a CCC heat with Slade centre and Dennis on the right

NORTH WEST LOCAL GROUP

Report on the Northern Boat Show 2017

The North West Local Group manned a Stand at the 3rd Northern Boat Show which was held on the Liverpool Waterfront over the weekend of June 23rd to 25th. As well as the marquee, display boards, copies of the Catalyst magazine and AYRS Technical Booklets, the group also showed a model of a Transonic Hull and a section of a Wing Mast, both projects currently under development by AYRS NWLG members.

Colin McCowen's outrigger sailing canoe graced the pontoon and Colin, sporting the AYRS emblem on his red sail, demonstrated its performance by sailing the length and breadth of the adjoining Salthouse Dock. Two small boats, a punt and a canoe, both constructed from Correx sheet by Mike Howard, also drew a lot of attention from both canoeists and those contemplating building a small boat.

As far as recruitment of new members to the Society was concerned, the show only yielded two new members with contact details being given to seventeen potential new members. The footfall was certainly down from last year and there seemed to be less 'yachting types' about. This can in some ways be attributed to both the often cold and blustery wind and grey skies and the amount of other events with which we were competing.

This boat show is held during the Merseyside River Festival Weekend and it also coincided with National Armed Forces Day (Saturday). The public at large were treated to jetski demonstrations, a wake board competition and a jetpack man who rose over six metres above the water. Power boat racing took place on the River Mersey, while in the skies the crowd were treated to both aerial acrobats and a fly past by the Red Arrows. Several 'tall ships' and the Type 45 destroyer HMS IRON DUKE were moored nearby and open to the public. There was a plethora of other maritime related stands scattered about the Albert Dock and Pier Head.

As with many small boat shows these days, there was a mix of marine exhibits and unrelated leisure pursuits and clothing stalls. In the marine sector the emphasis was on selling marina services, canal boats, fishing boats, outboard engines, electronics and a couple of yacht chandlers. There were only three sailing boats on show. The essence of a 'pure' boat show had been lost. As the boat show stand area was free to enter most of the public were simply sightseeing.

On the plus side it was a venture in which the majority of the AYRS NWLG members participated over the three day event. The enthusiasm for our group's activities was plain to see on the smiling faces and friendly manner in which potential members were approached. Over the next few weeks the AYRS NWLG will closely analyse our approach to recruitment and see if lessons can be learnt from this our second boat show.

Mike Howard

Record of Summer Meeting Saturday 8th July 2017

Seven out of the current membership of ten members of the North West Local Group attended the Summer Meeting. Apologies were received from James Nielson, who was away on holiday.

The first topic to be discussed was the Northern Boat Show which had been held on the 23rd, 24th and 25th of June. The AYRS NWLG manned both a stand and a pontoon. Only two new members had been recruited in spite of the best efforts of the majority of members who supported the venture. Mike Howard asked for the members opinions. Almost without exception, the conclusion was that the show had lost its flavour as an out and out boat show and there had appeared to be fewer visitors with an interest in yachting. Colin McCowen commented that his Water Feature had drawn less attention and Mike Howard suggested there were less children in attendance compared with 2016.

Mike Howard stated that the 2018 Northern Boat Show is to be held at the same time as the Tall Ships visit to Liverpool. over a four day period embracing the late May Bank Holiday weekend. He asked if the NWLG should consider attending. The general consensus was that the Tall Ships event would overshadow the boat show and in view of the rising cost to exhibit we should abandon the Northern Boat Show in favour of other ways of recruiting new members. Adrian Denye suggested approaching the Organisers and offering a token sum, well below the 'official' stand cost, for stand space on the basis we were a charity not a business and we had little to gain from appearing at the show. Alternately, leave it to the last minute and then negotiate a paltry sum to 'fill the space'. Adrian stated that both of these are tactics adopted by other maritime based charities at the major boat shows.

On the question of recruitment Mike stated that there had been some adverse comments by members that our display boards presented a rather 'old fashioned' and stuffy picture of AYRS. Mike explained why he had adopted this stance. Colin McCowen offered to make a couple of videos suitable for YouTube. One subject was 'The History of the Sailing Speed Record' and the second video ' Why a sailing boat capsizes'. A discussion took place on the legal aspects of utilising photographs, copyright, and obtaining the right to use such photographs.

Mike said Colin would require the AYRS Committee permission and he would approach them with Colin's idea. Colin asked how they would know if new members had joined AYRS as a result of watching his videos. Mike suggested a membership discount if they mentioned YouTube. A further suggestion was that AYRS, through their website creator, might produce the key words necessary to create the maximum number of 'hits'. Mike said he would follow up this suggestion.

John Shuttleworth offered up a couple of 'samples' of how he saw AYRS, and in particular the NWLG, portrayed. Mike said he would circulate John's ideas and hoped members would enter into the spirit of trying to find the words, phrases or slogans to truly reflect the current role of AYRS. A suggestion we target Universities who sponsor maritime subjects and boat building colleges and boat building training establishments was noted.

After tea, coffee and home made carrot cake and lemon drizzle cake (Yes, I know, the members of the NWLG are really spoilt!), a discussion took place on the AYRS Microtransat Challenge 2018. Mike stated that the Feasibility Study had been concluded and the results would soon be circulated to project team members. Mike also stated that SB SAILBUOY, entered by a Norwegian company, Offshore Sensing AS, was sailing/drifting Eastwards. It had been at sea for 33 days and had covered approximately 615 nautical miles of the 1620 nautical mile voyage at an average speed of 0.75 knots. Both Mike and Adrian commented on the small size of the wing sail

Colin Weir then presented his rather unorthodox 'Wing Sailor'. Originally conceived as a one man, totally enclosed sailboat in which the helmsman sat inside the hull, which was an extension of the wing sail, he had adapted the design to suit the Microtransat Rules. Adrian said the design reminded him of high speed ice yachts. Mike suggested there were some similarities between Colin's design and his own thoughts on a sailing version of a SWATH monohull. Mike pointed out that early SWATH ships lacked the ability to overcome severe pitching in certain types of wave patterns. A discussion on the fore and aft stability and the design's resistance to pitching/hobby horsing took place. Colin hopes to build a scale model to test out his theory.

As most of those present had initially registered an interest in following the progress of this venture, some aspects of the current thinking regarding the AYRS Microtransat Challenge 2018 took place. (Due to the requirement for Confidentiality the details of that discussion have not been published here).

As Adrian had not seen Mike Howard's scale model of a Transonic Hull, Mike presented it to the meeting. Adrian suggested an extension to the bottom skin aft of the transom to alleviate drag from vortices forming if the transom tried to 'dig in' underway. Mike commented that Calderon had shown trim tabs on several of his high speed versions of the Transonic Hull.

During several more light-hearted moments, Steve McKenna related a story of grounding a hire yacht on Lake Windermere, not once but twice! Adrian followed up by relating the stories of two ill fated attempts by members of his yacht club to sail to the Isle of Man and back. Adrian, an avid follower of the America's Cup, also updated the meeting on the latest rumours about the possible re-introduction of more conventional yachts, possibly 30 metre long monohulls, as a way of improving and capitalising on the technology developments within Formula One yachting.

As a final note to the meeting Mike mentioned Dylan Winter's excellent series of films, available on YouTube, under the banner of KEEP TURNING LEFT. Dylan is attempting to circumnavigate the British Isles and to sail or motor up every creek, river and loch to its head of navigation - 20,000 nautical miles in all. Dylan is desperately short of funds to continue his popular series, currently in limbo in the Western Isles. Mike suggested members watch the films and donate via the PayPal button.

The meeting ended at 5.30 pm.

Mike Howard

Record of the Autumn Meeting held on Saturday 9th September 2017

Only four out of the twelve local members attended the meeting although apologies for absence were received from Adrian Denye, John Shuttleworth, Colin Weir and Steve McKenna.

Mike Howard opened the meeting with a brief update on the fallout from the Northern Boat Show. The organisers did not send out a post-show questionnaire but merely offered discounts for the Liverpool and Bristol 2018 shows. Mike Howard has informed the organisers that AYRS NWLG will not be attending in 2018 unless a substantial discount is offered as the show is too expensive for a charity like AYRS to justify. The cost for the 4 day show, with discount, for stand space only was offered at £685 plus VAT.

Mike then gave a brief update on the AYRS Microtransat Challenge 2018 project. He told the members that the Feasibility Study had been concluded in early July and that the first project team meeting had been held on the 9th August. A further project team meeting is scheduled for the 27th September. The outline specification for the challenger is starting to come together although there are several aspects of the responses to the Feasibility study yet to be discussed. The AYRS Committee have indicated their support for the project which leaves the door open for a grant application to the Howard Fund to be submitted in early October.

Mike stated that Adrian Denye's catamaran hull was being considered. John Alldred, who used a hull from this mould as a stabilising outrigger float, commented that the hull had a lot of surface for very little volume. A catamaran would solve this problem apart from the fact it would be impossible to right from a total inversion. Mike agreed and stated that a catamaran configuration had already been eliminated from their choice of hull configurations.

Mike made mention of the document sent out to all members after the last meeting asking members for their 'take' on a descriptions of AYRS and its members endeavours which reflected the Society in the 21st Century. Only two replies, apart from John Shuttleworth's original comments, had been received. The subject was left open for discussion at the next meeting.

After a short break for tea and cake, Colin McCowen outlined his research path and the development of his rigid wing mast and soft single skin wing sail. He showed photographs of the Wing Mast construction and the assembly mounted on his outrigger canoe. A lively discussion took place about ways of varying the stiffness of the full length battens and Mike donated three long GRP battens to Colin's project.

Colin stated that so far the performance had been 'startling' but he had no idea how fast he was going. John Alldred mentioned a free downloadable software package for Android devices called SAILDROID. This can be downloaded onto a mobile telephone and using GPS technology will give boat speed, etc. Colin took note. Colin showed a photograph of the mast crane which he uses to tension the leech of the sail. Various aspects of his craft were discussed and alternative solutions offered by several members. Colin stated that further development was required. (Isn't that always the case with AYRS projects? – Mike).

Colin also outlined the method he has successfully used to bond a timber pad to the inside of his polyethylene canoe hull. The timber pad and the inside of the canoe hull are warmed with a hot air gun and hot melt glue applied to both surfaces. The faying surfaces are then clamped together and a fillet of hot melt glue applied around the perimeter of the timber block. Colin has utilised this method to bond in place both a mast heel fitting and the base for a snubbing device.

As the meeting closed at 4.30 pm Mike drew the member's attention to the fact that the Winter Meeting and Buffet lunch was now going to be held on the 16th December, 12.00 for 12.30 pm.

Mike Howard

Meeting at Weymouth Speedweek, 18th October 2017 at the Weymouth Sailing Club

Fred Ball Vice Chairman of AYRS was in the chair and, having briefly described AYRS and what its members can do, asked how many present were members. About 10 hands went up out of the 60-ish present.

The first speaker was Neils Haarbosch, who in the past had been working with natural fibres and resins, and was now investigating the potential of 3D printing using a robotic arm and glass reinforced thermoplastics. The main advantages being related to having no need for a mould, and the arm can lie sideways allowing a sloping surface without failure of adhesion. The present arm can work around a 2x1 metre area and a height of 1 metre i.e. a potential volume of 2 cubic metres. He displayed an intricately woven backrest and a cross section of a canoe that was being developed.

Tim Daish, one of the IT team involved with Speedweek, spoke about progress with developing a replacement for the GT31 units currently used for recording runs (many are now failing and replacements are not available) . The LocoSys GW-60, a watch type unit, whilst ideal for an individual user, had such a slow transfer of data rate it was unsuitable for use at the moment; but it might become useable if individuals simultaneously downloaded their data to a web site, rather than one unit after another. The GW60 however appears to be more vulnerable to damage.

Sav Salvage spoke about hydrofoils for wind surfers, reminding us that the foil had to support at least the weight of the board and rider, and that wood was not strong enough to make thin foils. He was experimenting with simple flat aluminium ones, and a 3-D lay up of carbon fibre (a wide strip with progressively narrower strips on top to give an aerofoil section), but that needed careful sanding to give the correct final shape. *[In conversation with Bob Date on the following day, Bob described to me how he has laid up foils in a similar way in a mould of the curved shape an then finishing the flat face by sanding.]*

Sav also went on to say that he felt a long lever arm was necessary to maintain longitudinal stability and he was going to experiment with a wand system.

Peter Stephenson, an Australian competing in Speedweek using "Glide Free Design foiling Laser", (he is one of the development team) described a perpetual motion machine which sounded plausible except that, as Peter said he didn't know of a valve that would be needed to make the system work!

Sean Owens, a Professor at the University of California, spoke of the research he was doing into Speedweeks past and how much he was enjoying attending the event.

Pete Davis spoke about the need for boats to take part in Speedweek as they were what started the event and frequently were not off the shelf. He managed to get 11 potential entries for next year!

Emile Lautier was the final speaker talking about his kite boat project saying that it needed to be safe and practical to handle easily. The present version is 1.2m x 1.8m, with a planing hull, the kite attached to the pilot, a front mounted rudder and curved foils aft to provide lateral resistance from the leeward side (the windward one being retracted). At the moment, the centre of lateral resistance needs adjusting, and he hopes to attend next year with a much improved version.

I closed the meeting at about 10.00pm with the announcement that Zara Davis had taken the Ladies Portland Harbour Record to 32.82 knots and of course a vote of thanks to the Weymouth Sailing Club for making us so welcome.

Fred Ball

Emile Lautier's kiteboat waiting to be launched 19th October

Emile sailing

Report of AYRS meeting at Thorpe, Surrey - 5th November 2017

Many thanks to Fred Ball (and Margaret who provided refreshments) for once again arranging this wonderful meeting in the village hall at Thorpe in Surrey UK.

Several hours of presentations of members' projects were interspersed with chat over tea/ coffee breaks together with a mid-day break for our packed lunches.

Fred Ball welcomes some new arrivals

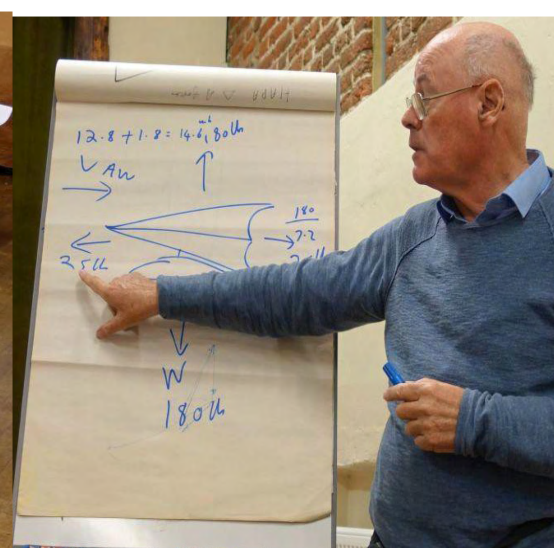
A 15 foot rowing boat (below) was completed by John Perry over the winter 2016/17. It has folding outriggers for the rowlocks, a sliding seat, storage space for camping equipment for two persons, a lifting rudder remote controlled from within the boat and clip on wheels for launching/ portaging. There are two positions for the outriggers allowing for rowing either solo or with a passenger. The hull is 3mm plywood externally sheathed with glass and epoxy, weight including all fittings but without crew and stores is 41kg.

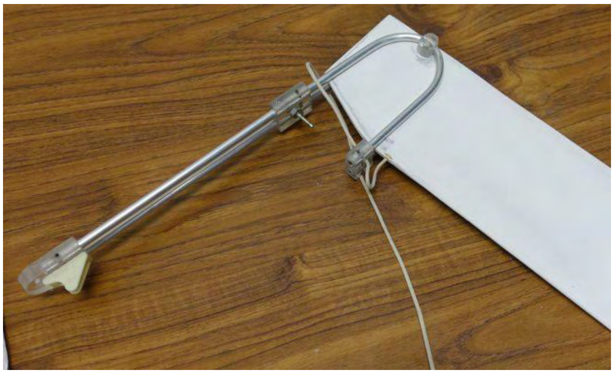
This boat has already been well used having completed the Lechlade to Beale park Thames row in company with a Home Built Boat Rally fleet, several weekend Dinghy Cruising Aassociation meetings and a number of day trips on west country estuaries, also a few canal trips.

The drag of this boat was predicted using Michlet software and the day before this meeting a group of members attempted a tow test on the Basingstoke canal to compare tow test results with the Michlet predictions. The tow test drag measurements were in the region of twice the predicted drag, but the tow force fluctuated very widely (at least 4:1 range) during the test, so these results are uncertain and I don't think any conclusion should be drawn at this stage. The reason for the wide fluctuation in tow force is uncertain, but may perhaps have something to do with the towed boat moving in and out of the propeller wash from the towing boat – a longer tow line and more accurate steering may help. Just shows that what you might think would be a simple measurement to take can prove far from simple when you actually try it on the water!

Roger Glencross (below) takes us through his calculations for sailing with a hapa and hang glider combination, the pilot/skipper being suspended in a harness part way between the hapa and the glider. This is Roger's most recent iteration of a concept that he has developed over many years.

The small dinghy rudder (next page, top left) was very neatly designed and constructed by Kim Fisher.

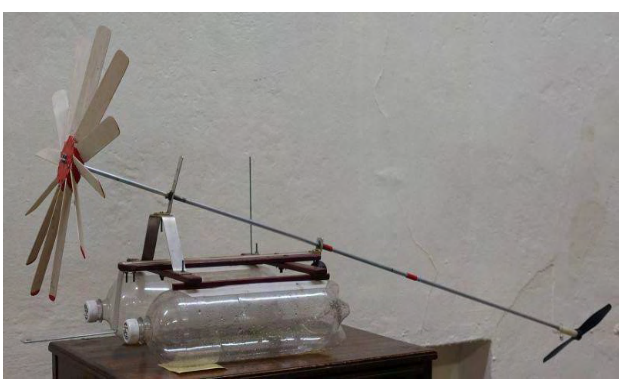




The tiller/stock is mainly stainless steel tube. The blade is hollow and made from the sheet grp material (also used as liner for refrigerated lorries) that Kim has utilised in several of his boat building projects.

Slade displays one of his prototype hapas (right) – this was one of several hapas on display at the meeting, these showing a range of very different designs. This Tee foil version has a 'tail fin' the angle of which can be controlled by two cords lead down the strut.

The model (below) by Peter Worsley (not present at the meeting) is the classic demonstration of Down Wind Faster Than The Wind – a concept that attracted much interest from AYRS members a few years back.



Taken during Kim Fisher's digital projector presentation, Kim is describing his custom built stand up paddle board which features air filled cavities in the bottom to reduce wetted surface and so reduce drag. For this prototype small outriggers were added for stability since the air in the cavities tended to escape from the corners of the cavities when the board was slightly heeled. Kim thinks a small design change could avoid this. (sorry about the poor photo)

A prototype track link (next page), made from low cost materials, was shown by Mark Tingley. This is a single track link for a proposed amphibious vehicle having buoyant caterpillar tracks that carry the weight of the vehicle and provide propulsion on both land and water. Buoyancy is provided by 1 litre empty plastic milk bottles. The total buoyancy

for two complete tracks will be about 1000lbs, so that's about 450 fully submerged milk bottles, presumably the total number of bottles will be somewhat more than twice that. The project is named 'Milkfloat'

Kim Fisher also showed this water pump connected to a commercially available 'air mover' (centre right). The air mover is normally used to create a blast of air at ambient static pressure from a smaller flow rate of compressed air. Kim suggests using this as a propulsion device for a water craft.

The propulsive efficiency provided by water emitted from the air mover may well be greater than could be achieved using just the jet of water from the pump without the air mover connected. How will it compare with a conventional propeller driven by the same prime mover?

Kim Fisher showed female moulds (bottom) used for making small streamlined grp floats that could be used as canoe outriggers (including 'cordless canoe' outriggers!). Kim's first use of these moulds was to make the floats that stabilise his prototype paddleboard, see above. The idea is that these moulds can be joined together in different combinations to make various lengths of float.

A fascinating meeting – enjoyed by all!

A further meeting at the same venue will be combined with the AYRS AGM on 21st January 2018

These meetings are open to all who have an interest in boat design/research/development, not just AYRS members

John Perry

All AYRS meetings and events are open to non-members.
Please conact the organisers for more details or see our website
https://www.ayrs.org/events/

Catalyst Calendar

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

January 2018

21st All-Day AYRS Meeting
9.30am-4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey – follow signs to Thorpe Park, then to the village). Tea and coffee available but bring your own lunch. Donations invited to pay for hall. Further details from Fred Ball, tel: +44 1344 843690; email: fredball@ayrs.org.

21st AYRS ANNUAL GENERAL MEETING
4pm-5pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey, immediately after the All-Day meeting (see above). Agenda, Committee report and other papers will be found on the AYRS website https://www.ayrs.org/forum.
AYRS desperately needs new Committee members, especially those with computer skills! Contact: Fred Ball tel: +44 1344 843690; email: fredball@ayrs.org

March 2018

3rd - 4th RYA London Dinghy Show
Alexandra Palace London N22 7AY. See www.rya.org.uk/programmes/dinghy-show/Pages/hub.aspx
The RYA Dinghy Show is a great day out for all the family and offers visitors the opportunity to visit the AYRS on Stand H24!

TBA SW UK Area Meeting
John Perry's house, 7 Cross Park Road, Wembury, Plymouth, Devon PL9 0EU United Kingdom .

TBA AYRS NW UK Local Group Spring Meeting
Lydiate Merseyside. Contact: Mike Howard, email: ecotraction@aol.com

May 2018

5th – 7th Sailing Trials Weekend Portland and Weymouth Sailing Academy, Portland Harbour, Dorset UK
A weekend messing around with boats in Portland Harbour. For more details contact Norman Phillips email: wnorman.phillips@ntlworld.com

25th -28th Northern Boat Show
AYRS will not be at this event this year as it has not proved a success for us.

June 2018

1st - 3rd Beale Park Boat Show
As usual we will have a stand and would appreciate small exhibits and display material and, of course, offers of help to run the stand. Contact: AYRS Secretary, email office@ayrs.org

July 2018

TBA AYRS NW UK Local Group Summer Meeting, Lydiate
Contact: Mike Howard, email: ecotraction@aol.com

September 2018

TBA AYRS NW UK Local Group AUTUMN MEETING
Contact: Mike Howard, email: ecotraction@aol.com

October 2018

13th – 19th Weymouth Speedweek
Portland and Weymouth Sailing Academy, Portland Harbour, Dorset UK. See http://www.speedsailing.com/

17th Speedsailing AYRS Weymouth meeting
19.30 for 20.00hrs, Weymouth Sailing Club, Nothe Parade (near Brewers Quay), Weymouth, Dorset DT4 8TX.
Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX.
Check the AYRS website before going.
Note: the parking at the Council Offices is free after 6.00pm and about 300 yards walk away.

November 2018

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

December 2018

TBA AYRS NW UK Local Group WINTER MEETING
Including a buffet lunch.
Contact: Mike Howard, email: ecotraction@aol.com

To keep up to date with AYRS events, go to the AYRS website and forum:
https://www.ayrs.org/events
https://www.ayrs.org/phpbb/viewforum.php?f=13

How to supply information for publication in Catalyst:

The best way to send us an article:- an electronic (ascii) text tile (*.txt created in Notepad, or Word, with no formatting at all, we format in Catalyst styles). Images (logically named please!) picture files (*.jpg, gif, or *.tif). If you are sending line drawings, then please send them in the format in which they were created, or if scanned as *.tif (never send line drawings as JPEGs because it blurs all the lines)

Any scanned image should be scanned at a resolution of at least 300 ppi at the final size and assume most pictures in Catalyst are 100 by 150mm (6 by 4 inches). A digital photograph should be the file that was created by the camera. A file from a mobile phone camera may be useful. Leave them in colour, and save them as example *clear_and_complete_title.jpg* with just a bit of compression. If you are sending a CD, then you can be more generous with the file sizes (less compression), than if emailing, and you can then use *.tif LZW-compressed or uncompressed format.

For complex mathematical expressions send us hardcopy or scan of text with any mathematical characters handwritten (we can typeset them), but add copious notes in a different colour to make sure that we understand. We can also process MS Equation and its derivatives. Include notes or instructions (or anything else you want us to note) in the text file, preferably in angle brackets such as <new heading>, or <greek rho>, or <refers to *image_of_jib_set_badly.jpg*>.

Otherwise: — If you write in longhand, and sketch or include photographic prints, and trust to snail mail (a copy, never the original) then all can and will be dealt with in due course. If you have trouble understanding anything in this section, email to ask.

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

Send a copy of your work (copyshops can scan to file and email for you):

by email: catalyst@ayrs.org,
by post: Catalyst, BCM AYRS, London, WCIN 3XX

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

On the Horizon . . .

Nothing much really.

Would you like to write something?

Email it to catalyst@ayrs.org please.
Guidance notes are inside the front cover.

ISSN 1469-6754

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

Printed by Rapidity Communications Limited, London EC1V 7JD