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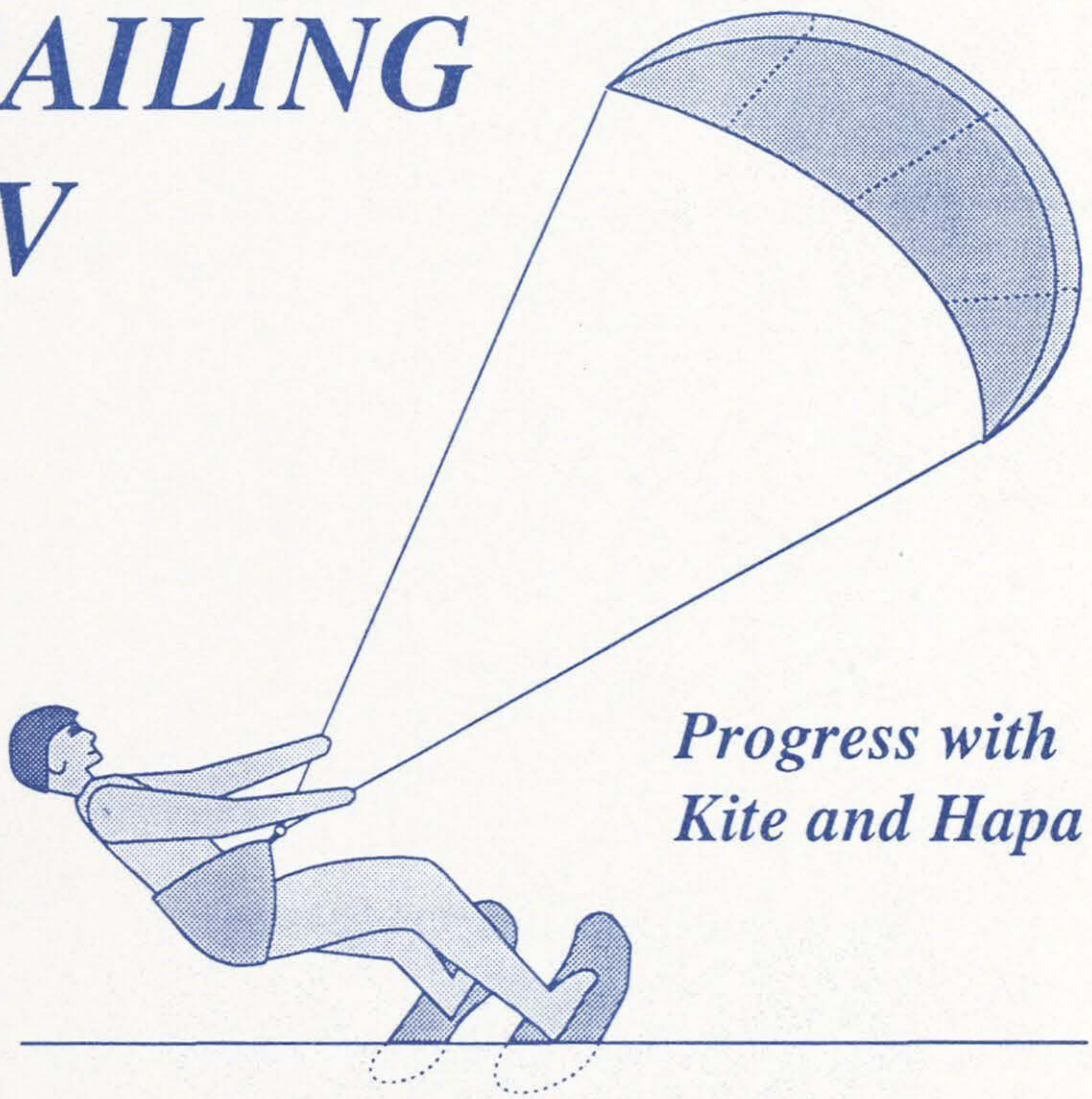

Progress with Kite and Hapa

Edited by Tony Kitson

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Ultimate Sailing IV

Progress with Kite and Hapa

Edited by Tony Kitson

Amateur Yacht Research Society

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Contents

Introduction

It is now three years since AYRS republished the 1971 paper of Professor Johan Hagedoorn from which the series title is taken. We have still not seen his dreams realised, but we are getting closer.

The development of the kite and the hapa, the elements of Hagedoorn's system, has progresssed on many fronts;

- commercially available traction kites are enabling more people to try kite sailing, we have contributions from the Legaignoux brothers (producers of the Wipicat, kite and inflatable catamaran) and Peter Lynn (producer of the Peel kites) and a review of the Wipicat by Robert Biegler,

- the availability of plans for home made traction kites, buggies and boats will enable even more people to get started, we review the essential publication 'Stunt Kites II' by Servaas van der Horst and Nop Velthuizen,

- the use of hapas in ocean crosssing has been explored by Didier Costes from whom we have information on the Zeppy and Planostat projects,

- this series is generating debate on the subject, we have a response from Dave Culp to the ideas proposed by Peter Lynn in US II, and some thoughts on 'dynamic sheeting' from the late Bill Sherts,

- last, but by no means least, we have reports on the only person currently pursuing the entire Hagedoorn concept, Roger Glencross, with a report on Roger's progress from Theo Schmidt and Roger's own report on the 1996 Weymouth Speedweek.

Windsailing for Airships and Gliders Using the 'Seadog'

by Didier Costes (1994)

Abstract

The Seadog (Chien-de-Mer) is a stabilised wing, a part of which is immersed, running under the lateral traction of a cable which connects it to an airship, a kite or a glider. Under the wind, this aerial behaves as a sail and the seadog as a keel, providing the propulsion like in a sailboat. Proposed by the author in 1966 and called independently "Hapa" in 1971 by Hagedoorn, the Seadog was progressively improved. It was used with the two-passenger airship ZEPPY-2, in an attempt (1992) to cross Atlantic from Canaries Islands.

The wing itself presents a curved shape allowing it to hook in the water at a stable immersion depth. It is stabilised in roll and course by the traction of the cable on a lateral arm fixed to the wing top. Pitching is prevented by a tail fixed to the wing and extending below the water surface, or hydroplaning above the surface. Such features allow a lift-to-drag ration in the range of 8 to 10 at mean speed. A limit stability speed appears, initially in the range of 10 knots when using some immersed cables, and now in the range of 20 to 25 knots, depending on the waves. After a jump on a wave, the device hooks again in the water.

A short history of windsailing for airships and gliders will be given, as well as current prospects for the Seadog and a companion airship, the "Planostat".

Introduction

The lateral aerodynamic lift of the hulls of airships can be profitably used for propelling them on the surface of the sea according to the principles of sailing sailboats. It is sufficient that the hull should be joined by a cable to a "keel" or "skeg" which hooks into the surface of the water, pulled sideways by the cable and moving forwards in a stable way. If the lateral lift/drag ratio of the hull is, for example, 6, and the lift/drag ratio of the "keel" in the water is also 6, with the cable almost horizontal, the assembly should move forwards at three times the speed of the wind, better than a sailboat.

The optimisation of the hull of the airship, for this way of using the wind, does not pose any great difficulties. The "keel", which I call "Seadog" because the device is attached by a lead, should be very slender and keep its hooking into the water and waves for a wide range of speeds. Since my 1966 patent, to some extent discontinued, I have studied various models. I shall describe here certain results obtained with the Seadog and shall display the "Planostat" project, an airship adapted to this way of sailing.

History

T. Schmidt (1991) listed the various names of such an apparatus: Water Kite, Paravane, Hapa, Seadog, Otterboard, or Seaclaw. The names paravane or water kite do not retain the idea of hooking into the sea surface and not going deeper. Schmidt says that in 1845 a Dr Collodon attached a kite to a special skeg, and that the assembly crossed the Lake of Geneva while going to windward.

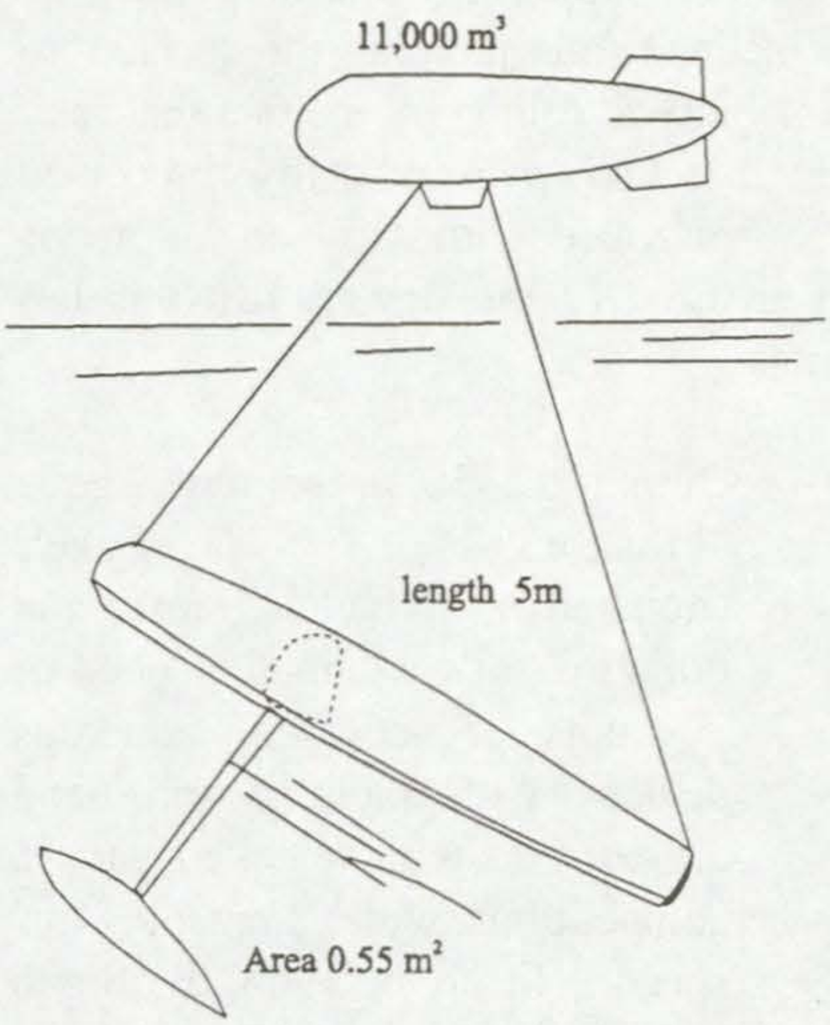


Figure 1. Burgess 1939

I add that C.P. Burgess (1939), an important designer of airships, proposed to attach an airship, by two cables, to a little boat with fore-and-aft symmetry positioned above a "hydrovane", a keel with a transverse lifting surface (Fig. 1). Initially, this system is not stable, but Burgess did not do any trials. Had he persevered, the evolution of airships for surveillance would have been quite different.

T. Schmidt then presented my constructions and their favourable trials by K. Stewart with kites inflated with helium, in just the manner proposed by J. G. Hagedoorn (1971) who, inspired by the skegs of the Melanesian proas

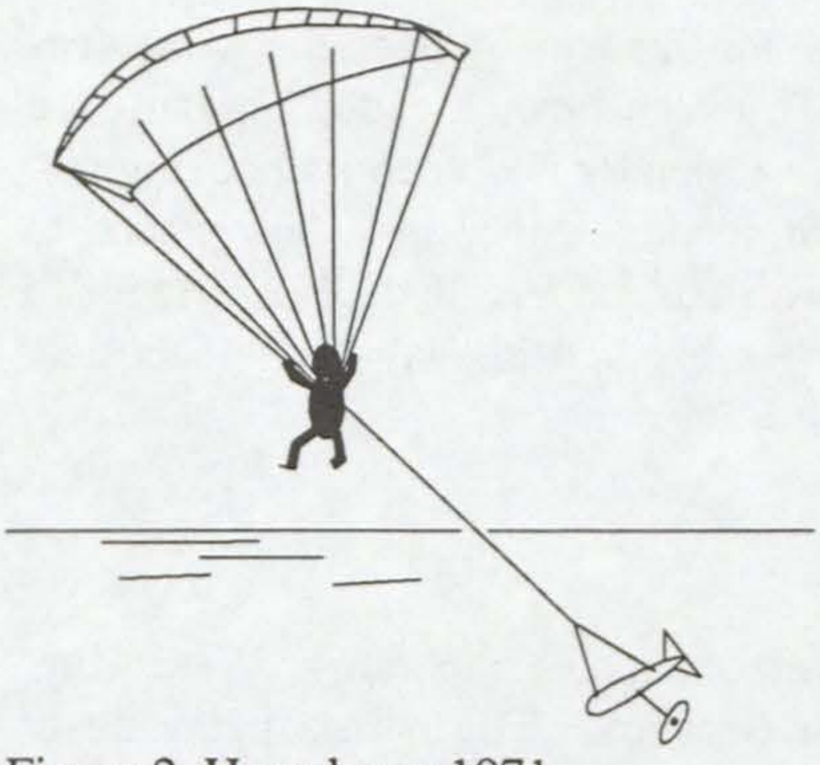


Figure 2. Hagedoorn 1971

which are incurved and hooked into the water, invented the hapa (Fig. 2), an immersed paravane shaped like the cap of a sphere, linked by a faired rod to a hydroplaning float. This device, with a slenderness of 5, was stable only up to 6 knots because of the effects of the rod. Hagedoorn described, with calculations, how to sail a working hapa, not described, coupled with a hang-glider. This has led many astray without any trails succeeding as yet, as far as I know.

Evolution of the Seadog before 1990

Let us remind ourselves of the problem of supporting a sailing boat by underwater foils or "hydrofoils". The inclined foils piercing the surface, to port and starboard of the boat, produce stability to rolling by the fact that their immersion increases the lifting surface. It is known from totally- immersed hydrofoils, with the angle of incidence controlled, either by an automatic apparatus, or by some sensors planing in front of the device, that this has recently allowed the attainment of 45 knots.

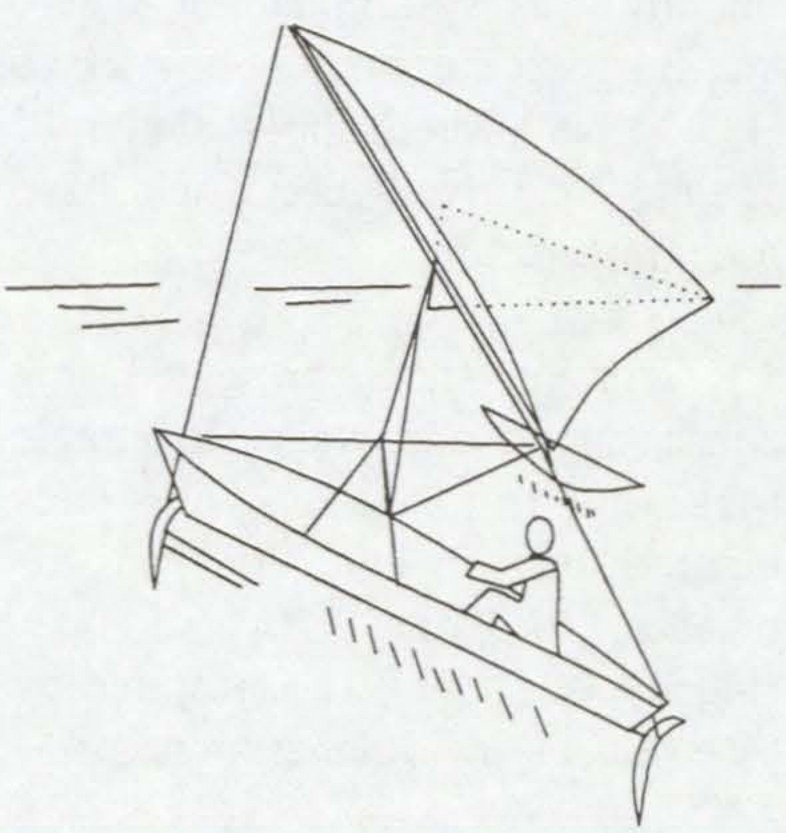
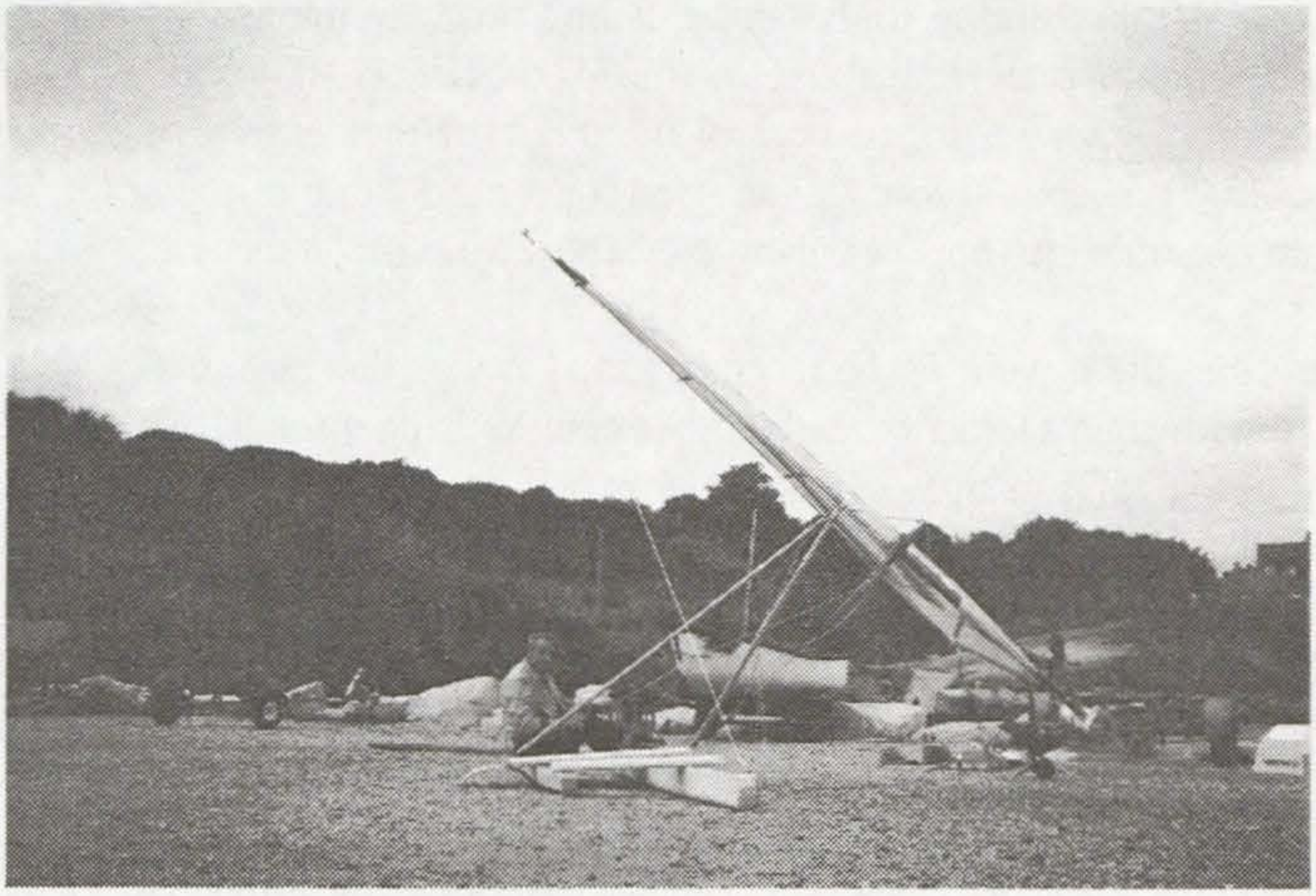


Figure 3. Costes 1975 Exoplane-2

During the 50's, the monocoque "Monitor" of F. G. Baker, equipped with inclined foils and orthodox sails, attained a speed of 30 knots. Since then, numerous devices with inclined foils and orthodox sails have taken part in competitions, without reaching this speed. In about 1963, B. Smith described structures with inclined foils and a rigid lifting sail carried to leeward to obtain stability against rolling.



Exoplane at Weymouth Speedweek 1996

Having started already on inclined foils, but inspired by Smith's book, I conceived the "Exoplane" proas with a hull, two small foils in tandem, a non-rigid lifting sail, and a float to leeward, which was planing but capable of becoming airborne. It is necessary to have hydrofoils that, in strong winds, do not skid sideways and do stabilise their immersion themselves; hence the curved hook shape. The idea of a lifting sail with an incurved foil led to my Patent of 1966 on a "aquatic glider" attached to the mast or rigging of a boat or to an aerial glider (Fig 4).

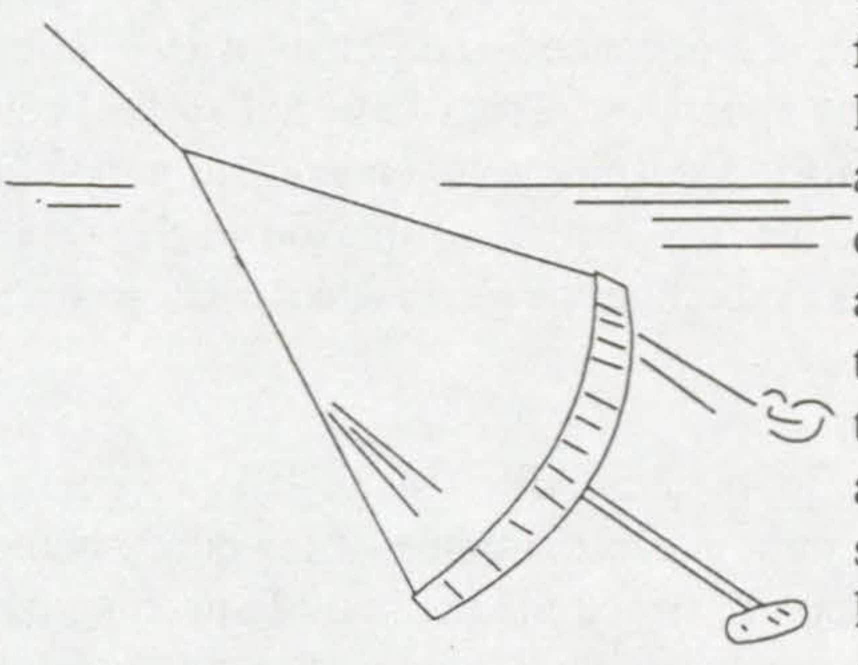


Figure 4. Costes 1966 Chien-de-Mer

This apparatus was composed of a foil curved symmetrically along its length and equipped on its axis with a tailfin to control pitching, and drawn by a harness of two cables attached to the ends of the foil, so that one of the cables was immersed to a certain extent. In tacking the apparatus was returned to the surface. Various models in laminated wood or foam-filled composite have been constructed with a NACA profile. The overall lift/drag ratio was originally of the order 8 to 10, but during trials with a sailing boat, an intense vibration of the immersed cable occurred above a speed of about 10 knots, creating an unacceptable drag. Also, to control the angle of incidence as necessary for best sailing, one should foresee the need for a third cable to the tailfin with its own drag. Some attempts at fairing the cables were inconclusive.

At the time, there were no hang-gliders, and it was dangerous to send gliders or kites with rigid elements above other people using stretches of water. One hardly spoke of airships. For speed in a boat, it therefore seemed to be indicated to use foils fixed solidly to the structure with its sail, the Seadog having mainly a theoretical interest. I, myself, concentrated on the problem of a boat with a lifting sail, with some results, but without breaking speed records as I had hoped, and have only worked much later on the Seadog without its parasitic drag.

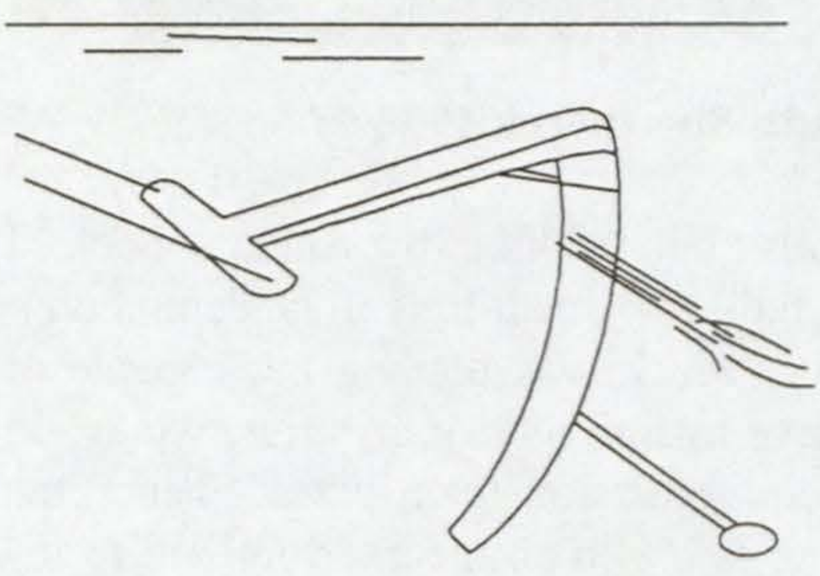


Figure 5. Costes 1978 Chien-de-Mer

In 1978, I described a Seadog no longer symmetrical along its length but with a symmetric profile (the arc of a circle and its chord) and a partially immersed gait without a tendency to rise too high (Fig 5). The tailfin is jointed so that it sets itself pointing towards the stern. There is no longer a cable in the water, the foil being fixed on an arm over the water, to shift sufficiently the point of attachment of the traction cable. Using two traction cables, fixed on a transverse bar on the arm, one can control the angle of incidence and tack at a distance. The Patent of 1978 cites the use of the Deltaplane with such an apparatus. Trials have not so far been very conclusive because of lack of stiffness, leading to a tendency to jump out of the water at high speed. In principle, the section of the foil in the wave crest can create a wave drag, less important however than that from a submerged cable.

My Patent of 1979, presented at the Colloquium AERALL of 1979, concerns an airship for sailing with a Seadog on a cable, the angle of incidence being controlled from a distance. This Patent described the method of attaching the cable to the side of the airship, which can have a hull thin horizontally towards the stern by internal horizontal partitions (derived from Couzinet's type) to increase the lift.

The ZEPPY-2 Adventure

Fresh developments of the Seadog are linked to the adventure of ZEPPY-2, the two-seater airship for crossing the Atlantic in 1991 and 1992, at the conception of which I participated. Initially, propulsion was intended to be only by pedalling a large rear propeller, so as to correct the general motion given by the benevolent trade winds and arrive in the Antilles. Propulsion by the Seadog was to be experimental. I had constructed new mock-ups and prototypes for the partially-immersed system. For sailing on starboard tack or on port tack, the tube of the underwater tailfin was placed by hand on one trailing edge of the skeg or the other (Fig 6). A single cable was used, the initial shock reducing itself automatically thanks to a piece of elastic to limit the strength of the forces. Laminated carbon-fibre at last allowed sufficient rigidity to avoid the loss of hooking in the water under heavy load.

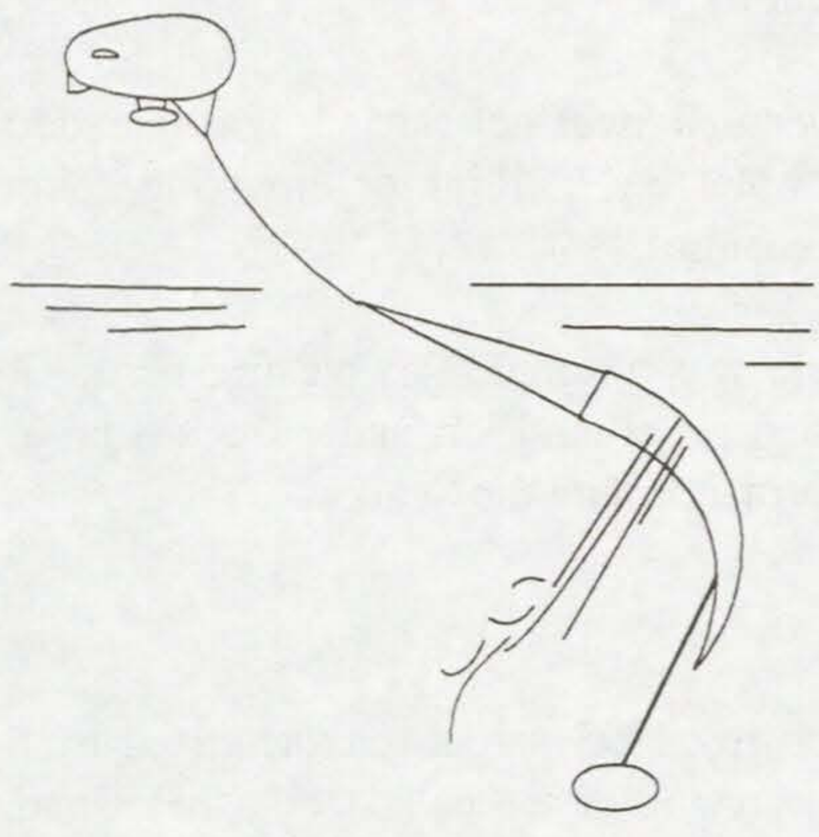


Figure 6. Le Zeppy-2 1992

Various models have been tried for pulling sideways from a motor boat. In calm water, one could reach about 25 knots, beyond which speed violent jumps appeared, initiated by a pitching instability. On a strongly choppy surface, the speed limit was of the order of 20 knots. When tried from ZEPPY-2, the motion of the Seadog was stable, agreeable and effective, in spite of a rather unfavourable airship hull (aspect ratio less than 3) and also of strong parasitic drags. Above about 15 to 18 knots, a speed attained in reaching across the wind, jumps were initiated by the waves. After each jump, the Seadog hooked itself correctly into the water again, but a series of jumps led to a breakage at the attachment of the tailfin, its reinforcement having been unintentionally omitted. The pilots could not use their replacement tailfin; the final shipwreck occurred while they were waiting for favourable conditions.

I had made an equal study of the :pirogue" a Seadog consisting, as envisaged by Burgess, of a fairly long hull, capable of carrying sea water as ballast to prevent the rising of the airship as it is heated by the sun. The skeg attached to the pirogue is curved like the other Seadogs and allows, under strong traction, the pirogue to take off, stabilised against pitching by planing on its flat stern sections. The mock-up seemed to function well, so I constructed a larger mode, which did not behave satisfactorily when towed behind a motor boat. It seems that, for the skeg used, the lengths of the lateral arm and of the hull were insufficient. The actual model "carrier" mentioned later, is analogous but with an elongated tailfin behind the hull.

Other "animals" for a marine airship

ZEPPY-2 made use of other devices related to the water surface:-

The "Mouse" was a little planing hull symmetrical to inversion drawn by a cable and fitted with two scoops for filling with sea water at speed. It allowed the water to rise to ballast the airship when heated by the sun, or to make pure water by reverse osmosis. The name of "Mouse" is inspired by its tail made of rubber tubing which made it plane steadily.

The "Kangaroo", a large mouse that eventually was not carried, was intended to act as a mass of ballast staying at water level, filling or emptying being controlled by a second cable or by radio control.

The "Serpent", meant for the same task, was a simple flexible fire hose. It was eventually filled with water once and for all and left under the airship at the cost of extra drag and a loss of performance with the Seadog.

The projects realised

I built a "Carrier Seadog", according to my 1993 patent, characterised by a symmetrical hull carried by the skeg, carrying either ballast or a helmsman (Fig 7). A long underwater tube, orientable in one direction or the other, assured stability against pitching by a planing surface at its extreme end. The apparatus, with a pilot, was tried with a kite, the tractable "Wipika", which seeded to have too small an area; these trials should be followed up using a modified hang-glider of 25 sq metres. I am also preparing a device to couple to a classic piloted hang-glider, or to a little airship, in particular the "Planostat".

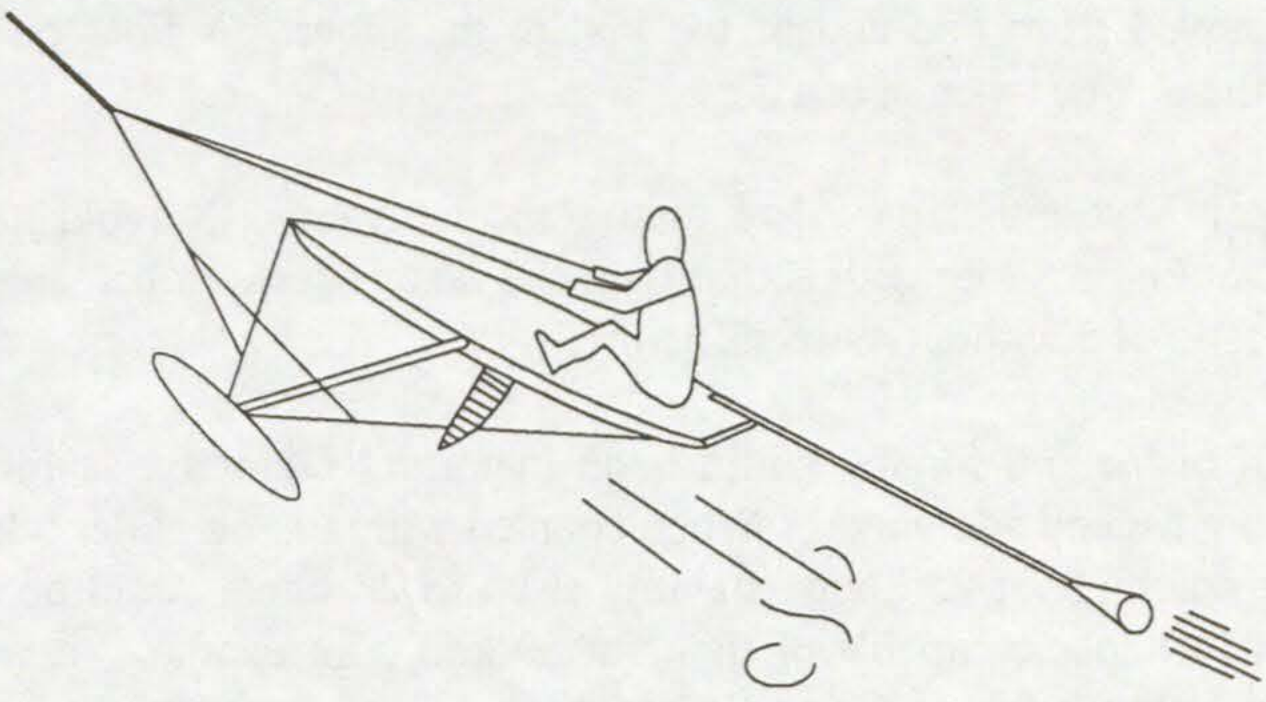


Figure 7. Costes, 1993 Chien-de-Mer porteur

The actual evolution of the Seadog proceeds from the following ideas:-

The partially immersed curved skeg with a symmetrical profile is satisfactory and in calm water can reach a Lift/Drag ratio of the order of 10.

For stability against rolling, the attachment of the cable is to a lateral arm whose length should be 1.5 times the length of the skeg.

Stability against pitching is produced by a planing tailfin at the end of a rod 5 times the length of the skeg, and orientable ether by hand or free to rotate in a vertical axis so as to allow the device to change tack (achieved in a model).

The angle of attack is optimised, with a single cable, by adjusting the point of attachment to the end of the arm, or by allowing it to turn a restricted amount on a vertical axis beneath the skeg. A length of shock-cord allows the angle of attack to be reduced when the pull increases.

To control the angle of attack and to tack successfully, one can use two cables fixed to the ends of a transverse bar on the arm.

In the case of the "Carrier Seadog" with a pilot, the latter can optimise performance by adjusting the point of attachment of the kite to the lateral arm. He controls the direction and angle of attack of the kite by three cables (one fixed cable and two adjustable). This allows him to slow down without hauling the kite down to the water, and to avoid completely a sudden jump in height of the device as a result of a squall. To change tacks, the rod for the tailfin is moved from one end of the hull to the other. A float on an arm stabilises the device when at rest.

The kite can have either partial or total aerial buoyancy, to avoid having to launch a wet kite. A kite with equilibrium buoyancy seems to be capable of a Lift/Drag ratio of 5 without much difficulty.

The length of the rod for the tailfin is an important factor for stability with regard to both speed and waves. When coupled with a hang-glider whose air-speed can reach about 25 knots, stability at up to 20 knots could be enough, but with a Deltaplane capable of flying at 50 knots for example, it would be necessary to stay stable at 35 or 40 knots. A 1/7 scale model seemed to be stable at 12 knots in calm water, this would correspond to 31 knots at full scale. The speed record for a boat (or device classed as a boat!) is not close to being broken by this system, but records for the ratio of speed to wind speed could be, in view of the excellent Lift/Drag ratios for sails and keel.

With a small airship flying only in moderate winds, stability up to 30 knots could be enough. With the maximum stable speed increasing with the square root of the dimensions, there are possibilities open for marine patrol airships. Contacts have been established with the US Navy project

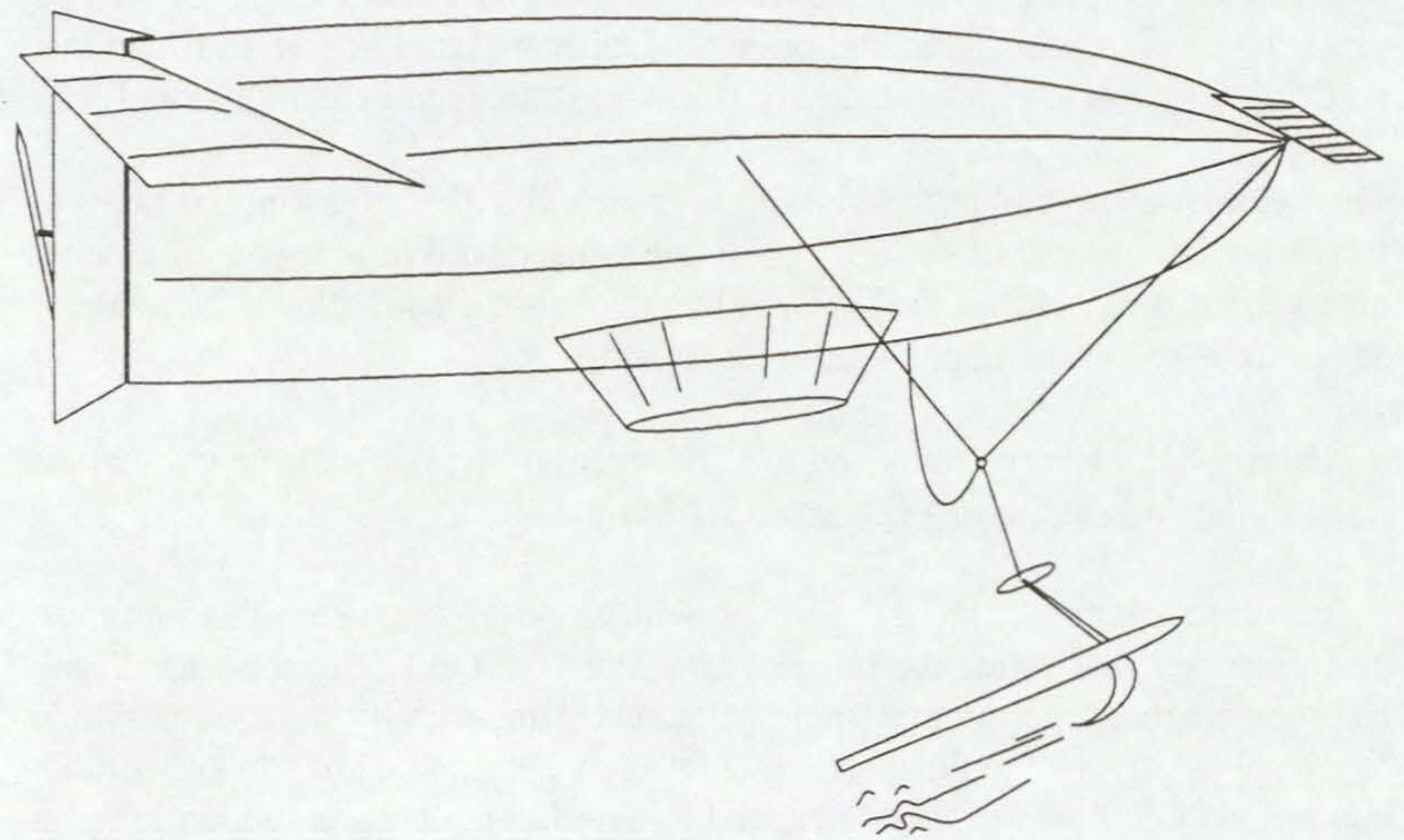


Figure 8. Costes 1994 Project Planostat

The Planosatat Project

I have designed (Fig 8) a single seater airship of 250 cubic metres, adapted for coupling with a Seadog, and which should lie quietly head to wind when docked, which was not the case with zeppy-2. a motor of 18 to 30 hp is fixed high up on the rudder, to protect it from contact with the sea and to get good horizontal manoeuvrability, requiring the point of attachment to have the ability to rotate about the vertical axis. Fore and aft trim is obtained when static by means of small balloons forward and aft, and when moving by means of ailerons at the bow or "moustaches". Ailerons at the stern would present the disadvantage, on a stable machine at a slow speed responding little to trim controls, of giving a vertical force opposing the angle of attack, whereas for the moustaches the effects would be added.

Research on a good method of attaching the Seadog's cables or when docked led to the choice of a nose with a depressed point. The stern is shaped like a fish (derived from Couzinet). The general aspect of the "Planostat" looks good. The cutting out pattern of the panels and the internal partitions has been confirmed by a shaped model. A flying model 4.5 m long is being prepared, especially to check on the coupling with the Seadog. Financial support would be welcome, for media-oriented activities and for short flights.

Zeppy-2 Project

Conclusion

A new lease of life for airships can be imagined only for low-altitude missions, that exploit its high load-carrying capacity, and with plenty of missions over the sea, for which propulsion by wind is seductive. Beyond the little "Planostat", one can envisage, for example, an ecological airship carrying tourists above dolphins and whales, without disturbing them in the slightest, with the sole risk of seeing them play with the Seadog, as that seems to tempt them to fly the Atlantic! The Navy could mount patrols over the oceans of long duration with a low fuel consumption.

There has been much said here of boats and gliders, but one must think of global aspects of the problem, and a regatta for boats, gliders and airships would be really interesting!

Ed. I am grateful to Richard Lyster for translating this from the original French version sent to us by Didier.

Hagedoorn, Glencross and the Hapa

by Theo Schmidt - 11.11.94

Hagedoorn's concept of "Ultimate Sailing" using a kite and a hapa, or sea-dog, has been described previously. Whereas unmanned kite-hapas have been used by the author and others, Hagedoorn's proposal of supporting a person from the kite while under way has probably not been accomplished yet.

Although many have been working on hapa and kite development, including Didier Costes, Richard Neumark, Simon Sanderson, Keith Stewart, Andrea Kuhn, and Theo Schmidt, none of these has been sufficiently motivated to actually attempt manned kite-hapa flight. One man who does have the perseverance to be the first "aquaviator", or at least to be instrumental in seeing the feat performed, is Roger Glencross. Since ten or so years, Glencross has dedicated most of his holidays to the development of the system. Never having previously flown, sailed, or built things, he has had to rely on others to provide help and components. In particular, Didier Costes has provided a hapa or "chien-de-mer" as he calls it, which, although unfinished, seems to work sufficiently well. Theo Schmidt has procured a "Sky-Wing" swivel-bar from Andrea Kuhn, a vital link used to connect the pilot to the kite in such a way that he can control it while facing in any preferred direction.

Now at the 1994 Weymouth Speed-Week, Roger has come very close to a first success. All components were tested separately and shown to work. The kite, a fairly modern 25 m^2 paraglider with a best L/D of 5.5 was capable of lifting people in 12-15 kts of wind at the end of a short tether (hand-held for safety). With the kite unstalled, the force on the tether could be as low as 25 kgf. The hapa was towed from a motor boat and produced 25 kgf at speed of 4 kts with an L/D of 4-5.

Thus it can be stated that the system would work in a 12-15 knot wind with the kite suspending the person directly downwind, causing the hapa to go on a broad reach at a speed of about 4 kts. It can be predicted that the pilot can steer the kite slightly away from downwind, increasing the apparent wind and going on progressively finer reaches or even upwind. With the increased force, speed increases further. The author has used such kites with skis on snow (L/D 5-10) and could reach at about twice the wind speed.

What hasn't yet worked is getting the pilot into the steady state conditions described above. The severe handicap of the present system is the total incompatibility of the kite with water. It cannot be started from water and must be almost completely dry to be usable. Thus the kite must be launched on land. In just the right wind the pilot could walk or run downwind into the water and perhaps release the hapa from a backpack. With the present arrangement, the pilot requires at least one person to hang on to the tether and another to carry the rather unwieldy hapa into waist-deep water. The wind and tide have not allowed a successful launch this year, but it is a safe prediction that someone will achieve the first ever kite-hapa flight in 1995. Whether this person is Roger Glencross or not, it will be his glory for shear dogged persistence against all odds and showing that it can be done in the face of disbelief and occasional smirking faces.

After the first successful flight, the next step will be to shunt the hapa while under way, allowing reversal of direction, and to make the system more practical. The proof of Hagedoorn's ultimate goal, the launch of the hapa after jumping out of an aeroplane, preferably without even getting wet, is of some secondary interest but we will gladly leave it to James Bond to try out.

Figure 1. Roger Glencross with Parafoil at Speedweek 1996

Kites and Hapas
at Speedweek 1996
by Roger Glencross (November 1996)

There were two hapas at Speedweek 1996, both designed and built by Didier Costes. Mine was the older, shorter one. Didier's latest model has a much longer surface-skimming pole and is designed for faster speeds than mine. Both were successfully tested from Phil Gollop's new jetty with the help of Didier, Bob Spagnoletti and Sue Lewis.

I made three mistakes at Speedweek.

The first was that I thought a lot of development was needed before easy control of the hapa could be achieved. In fact Didier solved the problem in one session! As a result, I was not ready for the next stage, which was the actual flight. The problem was the three lines which join the hapa to the pilot. He has to manipulate these lines while his hands are full flying the parafoil. The lines always got fearfully tangled when testing the hapa along a jetty. Didier shortened the lower wing tip line until it ended at the centre of a horizontal pole which rode well above the water's surface but well a way from the pilot. The two ends of this pole were secured to the other two bridle lines. Instead of these two lines being separate lines, Didier made them in a loop, so in effect the pilot has to deal with one line instead of three. The two top bridle lines were secured further apart on the surface skimming pole than heretofore. This made control less critical.

This is the last problem which I anticipate the hapa will face. The other problems have already been solved. The hapa is efficient, having a drag angle of 10-20^0 and sufficient speed range while remaining efficient to satisfy the paraglider's requirements (6 to 10 miles per hour). The stability problem was porpoising, This was solved by a deep running trailing tail plane on a boom. Waves are no problem because it is a low speed, low wind machine which will not encounter waves. No doubt it could not cope with big waves. Changing tack is achieved by the hapa shunting, with the tail plane swivelling through 180^0 automatically, whilst the pilot moves the towpoint aft a few inches manually. This swivelling tail plane is my only personal contribution to the experiment! All else was supplied by Didier, Theo Schmidt, AYRS publication and many helpers!

Didier's longer hapa has a three metre surface skimming pole to my one metre. Its efficiency seems to equal mine. Didier achieves longitudinal stability by two skimming surfaces, one fore, one aft, on the pole. When going forward the fore one exhibits a positive angle of attack which prevents diving, whilst the latter one flops down to a nil angle of attack. It has to cope with waves because it is designed for high speed and does so admirably. It has been tested up to 35 knots. For tacking, it simply shunts and the tow point is altered as in mine. It has no swivelling tail plane to cope with. Control is easier than with mine because there is no lower wingtip line and the top two lines are in a simple loop. The line attachment points are 3 metres apart (as compared with one metre), thus improving control by greater leverage. Well done, Didier!

My second mistake at Speedweek occurred on the last Friday. The wind was perfect, 5 to 10 knots offshore and we decided to tow Fred Ball's Dory downwind by man-lifting parafoil, in order to get some airborne experience. Then we discovered that the water was only ankle-deep for half a mile out from the shore.

My third mistake was thinking that I could get useful information by flying the parafoil on the spot on the beach. This is equivalent to learning to ride a bicycle by cycling on the spot, very difficult and not a true likeness to real cycling, when forward motion will add stability.

I see the future for this project by means of breaking down the problems into stages and learning to cope with them one at a time, as follows:-

1. Fly my parafoil from a kite buggy on land.
2. Tow Fred's Dory downwind slowly by man-lifting parafoil.
3. Parafoil kite bum-skiing. One's legs have the necessary side area (half to two sq. ft) to provide leeway resistance as demonstrated by Andrew Beattie at an earlier Speedweek.
4. Fly man-lifting parafoil downwind dragging a drogue anchor. This is like (3) but provides airborne experience.
5. Try the complete hapa/parafoil combination.

It was a great Speedweek and the best yet from the point of view of value for money. Many thanks to Bob Downhill and all who helped him!

Comments on
'Buggies, Boats and Peels'
Letter from Dave Culp - March 24, 1995

Congratulations on AYRS 116. Great stuff. I'd seen excerpts from Peter Lynn's brochure, but never all of it. Now, what about an update? What's he done since '92?

That's the way to ensure your letter gets published! Thank you for the support.

I find a need to throw my 2 cents worth in on a couple of issues. First, shame on you for stating that Peter "invented" kite buggying, when George Pocock put it into the public domain over 160 years ago!

Thanks for drawing attention to George Pocock. I hate to be pedantic but I will anyway. In the introduction to 116 I wrote, regarding Peter Lynn '...for the new sport of kite buggying, which he invented.' I have not had the opportunity of reading Pocock's book (The Aeropleustic Art, or Navigation in the Air by the Use of Kites or Buoyant Sails, fully referenced in Sources, AYRS 116), but I understand that he proposed the use of kites for transportation rather than sport.

Second, as regards building knock-offs of patented kites (or anything else): In the U.S. it is illegal to build a single copy, even for one's own use. The courts have found that denying a patent holder even a single sale damages him. It's unlikely that a patent holder would sue over a single infringement, but an organization that proposes such actions to its members? In the name of fair play, isn't it just to pay the inventor his royalty, anyway? If money is an issue, second hand kites are cheap and available. If a member thinks he can improve on an existing patent, then that's no infringement.

Thanks again for this. It may hold also for UK and other parts of the world. Readers and constructors, please note.

To my main subject: I'm not at all sure that Peter is on the right track with his "low MMR = good traction kite" approach. First, let's investigate lift coefficients "near the edge" vs. "in the maximum power zone." (Which is diving, not climbing, directly downwind. Not only is gravity assisting, but the kite is accelerating, and the true wind angle of attack is increasing; all contribute to greater and greater pull, right down to impact--trust me.)

It stands to reason that as the kite nears its "edge," angle of attack is minimal and lift coefficient (C_L) is also at minimum. At maximum dive downwind, angle of attack will be at or near the kite's maximum and C_L will also be at its maximum. Thus a kite with fundamentally high performance (able to fly without luffing or breaking up both at maximum and minimum angles of attack and C_L's) will have a fundamentally high MMR (ratio of maximum pull to min pull). The only way to reduce MMR is to narrow the kite's performance envelope, either by limiting minimum angle of attack and thus reducing the distance attainable "around the edge," or to reduce the maximum CL at maximum pull or through reefing, etc. It seems that Peter's work is in both these directions.

Though he mentions kite performance approaching 80° "around the edge" (indicating L/D close to 6), he later says his buggy is able, occasionally, to cross tacks at 90° on firm surfaces. He doesn't say at what fraction of the wind speed this occurs, though he does say that "lower and faster" courses result in greater VMG to windward. If we presume the craft is pinched in order to sail 45° to true wind, we can presume low Vb/Vt, certainly not over 1.0. Given that a land buggy "on firm surfaces" has negligible leeway, $e_H = 0°$. At Vb/Vt of 1.0, we see a b of approximately 22.5°, and thus also $e_A = 22.5°$, not the 10° Peter thinks is possible. This translates to a L/D = 2.5, not the near 6 envisioned. Peter is clearly sacrificing high L/D for lower MMR. With this performance, and adding e_H of any waterborne hull, b will be so high that no Peel powered sailboat is likely to approach the wind's speed on any course, let alone exceed it.

In addition, Peter is advocating reefing his kites when overpowered. Again, this is apparently done since the low MMR kite cannot otherwise be de-powered; it always pulls hard. With a high MMR kite, the flyer simply manoeuvres the kite closer to its "edge" (typically overhead). Absolute pull drops off by 80-90% and what's left is nearly vertical, effectively stopping forward motion. This concept of de-powering by flying near the edge is a basic one and absolutely necessary for safety. Peter's is not the only story I've heard of stable, powerful kites pulling wreckage over hill and dale.

It seems I am now going to defend Flexifoil kites. First a disclaimer; though I own several dozen Flexis, I have never received any promotional consideration from the manufacturer. Except for customary trade discounts for volume purchases, I buy my Flexifoils from dealers at retail, just like everyone else.

First, to their high MMR. It's true that a Flexi flown at its edge, statically, has far less pull than at its maximum dive, on the order of 10:1. However, nobody ever sails with them like that. The kite likes to fly, and pulls hardest, at 3-3.5 times the wind speed. It does so very close to its static "edge." Thus, skilful flying and a typical figure 8 or sawtooth flying pattern yields usable pull "at the edge" of something close to that obtained at maximum dive downwind. This is pretty much irrespective of boat speed, which never approaches 3 times wind speed. Thus, the Flexifoil kite behaves both with high and low effective MMR, as needs and flyer skill dictate.

As to apparent wind (AW) luffing, I had some difficulty understanding what this was, until I went back to conventionally bridled kites. You see, Flexifoils have no bridles and set their own angle of attack, thus they cannot become back-winded. Also, they have a spar at the leading edge, so they do not collapse when angle of attack is small, or there's a lull in the wind. There's no dreaded "over the top and down to the ground" flight pattern typical of both rigid deltas and parafoils.

As an aside, I do not understand Peter's comments that "Flexis would be OK for high speed, given a long run-up." In hundreds of hours of full scale sailing, at all wind speeds, my boats typically accelerate to full speed, often 1.5-1.7 times wind speed, in ***2-3 boat lengths.*** Acceleration forces sometimes leave me "sitting on air" with no boat underneath!

Let's go back to basic precepts; Why sail with kites at all? It seems that the answer breaks down to two areas: 1) simply for fun, to prove it can be done. Or 2) to attempt to sail faster than other craft, on water or land, either in a given set of conditions, or absolutely, period.

If trying to sail under the first precept, then no particular performance is needed (except perhaps some windward ability in order to sail home), and the cheapest available kite is sufficient for great fun. If sailing for performance is the issue, than performance it is, and arguing in favour of any kite or technique which reduces it is pointless. Cost effectiveness, or "bang for the buck" is another issue.

My own goals are simple: I want to beat all comers, period. Top speed and no holds barred. Cory and Bill Roeseler's are also simple: to beat comparably priced and abled craft (typically sailboards) at what they do best, and gain market share. Both these goals are clearly performance oriented, and I believe Peter's are, too. Clearly, for any wind condition, his flyers want to go the fastest. This requires not just survivability, but also efficiency.

Overall,
Flexifoils:

1) can pull at very high line tensions/unit area of kite, whether in their maximum dive regime or near their "edge" due to dynamic sheeting,
2) can pull at very low tensions/unit area, and thus need no reefing,
3) manoeuvre and fly faster than any other power kite (except for stacks of deltas),
4) have no bridles to tangle, and
5) largely do not suffer from AW luffing.

Major disadvantages:

1) Wet flying and launching are very difficult (to paraphrase L. Francis Herreshoff, "Such a kite should be kept away from the water."),
2) the kites must be flown in stacks of from 2-15 to get best power and speed (this sacrifices some theoretical efficiency, and makes launching and untangling tougher),
3) they require some skill to fly well (little skill to fly, only to fly well).

Conventional large parafoils (such as Peels),

1) pull hard always, but require reefing,
2) are easier to fly without the need for dynamic sheeting, but demonstrably do not reach high efficiencies,
3) have inertia problems--not due to the kite's mass, but to that of the many cubic feet of air inside--such as AW luffing and slow manoeuvrability,
4) have speed limits. This is subjective, but I've never witnessed a large parafoil, or even a large delta, flying faster than 50 kts. Flexis are perfectly happy to fly at 60-80 kts, and have been clocked at over 100 kts.

This last is more than a speed issue. While it seems obvious that a fast kite is needed for fast sailing, a fast kite is also needed for slow, but safe and efficient sailing as well. Kite speed, as related to wind speed, is directly related to efficiency. A kite capable of higher L/D simply <u>will</u> fly faster than one capable of lower. As with any sailing structure, wind due to the kite's motion will reduce the kite's angle to the apparent wind. The kite able to produce usable pull at the lowest angle of attack will fly fastest. Reason dictates that a craft with a kite able to pull hard with the lowest angle of attack (thus the highest L/D) will be the first to windward, or the fastest for conditions, or fastest overall. In any language, it will be the winner.

As to safety, the very fast kite, flown in figure 8's will have the highest pull/unit area of kite. Thus for any design requirement, smaller kites may be used. Also, the quick manoeuvrability of fast kites often allows the sailor to fly out of trouble or danger. Last, the very fast manoeuvrability and lack of static stability in Flexis provides an automatic "deadman" feature. Any inattention at all, let alone falling off the boat, results in the kites happily flying into the water, stopping all pull.

Peter repeatedly advocates hand holding kites, both on land and on water. While this is clearly the safest of all courses, and may be necessary with very stable and hard pulling kites, it negates two of kitsailing's strongest advantages over conventional sailcraft. These are the ability to design complete anti-heeling and, coupled to that, the ability to carry very large sail forces in relation to boat size. Once again, this may be perceived as a speedsailing issue, but performance is the name of the game in winning races at all levels. Even in lower performance boats, it is still necessary. Peter himself makes it clear that without anti-heeling, a kite boat's design is seriously compromised. A simple conversion of an existing dinghy or catamaran (an excellent way to "get wet" with kites) can barely be accomplished with hand-held kites; the forces are simply too great. Also, how could one contemplate kite powered rescue of sailboats, particularly yachts of any size, with hand held kites? I'm all for well designed deadman controls, however (except with Flexifoils, where they're not needed). Also, along with deadman releases, some thought should be given to heavy gear coming to earth downwind (We're careful not to sail to windward of bystanders, but this compromises our venues).

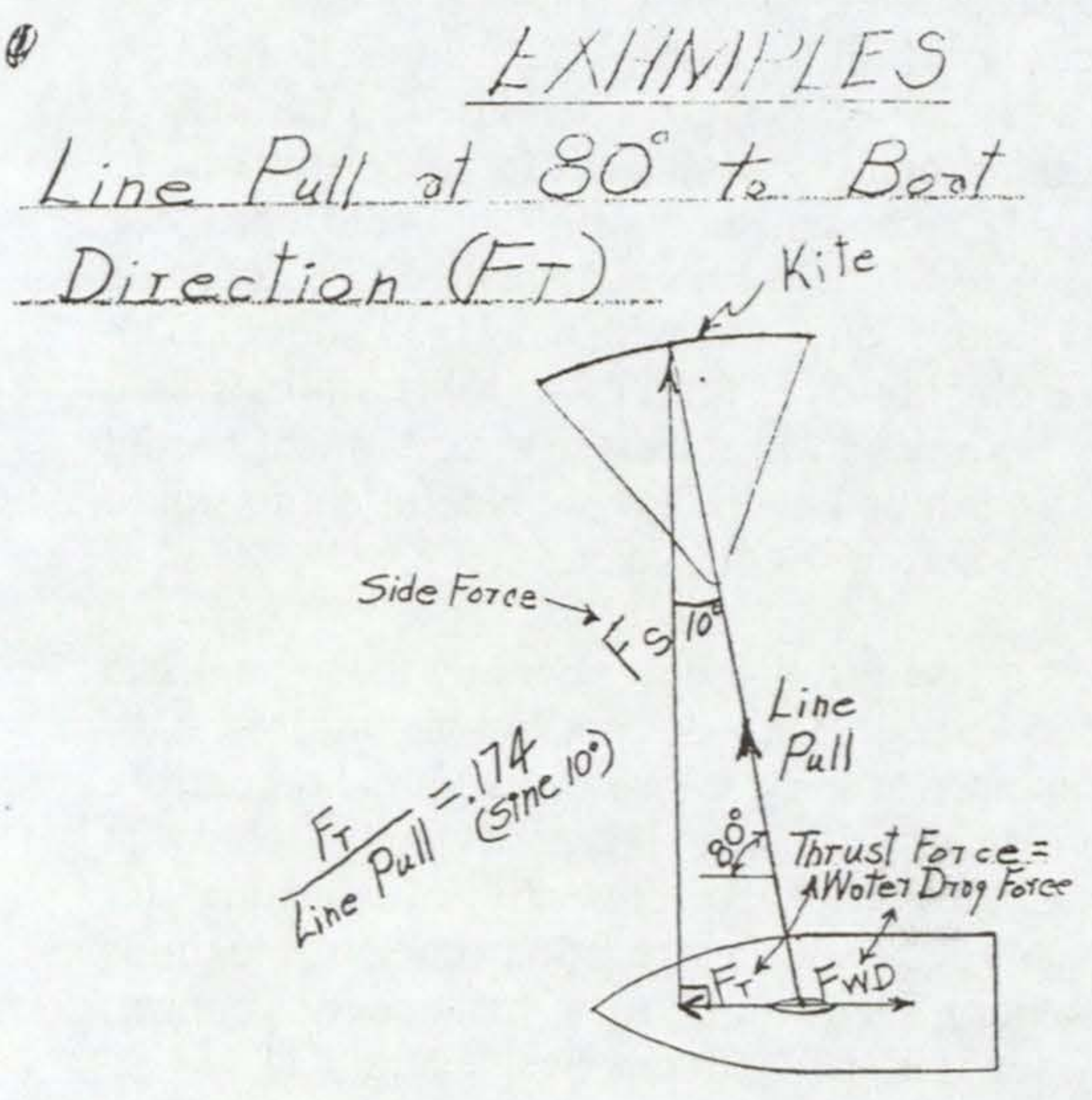
I believe some thought needs to be given to line drag. For any theoretical kite efficiency, line drag adds 3-10° to e_A. This is catastrophic at low e_A's. Solutions may be reducing the number of lines to one (through radio control), shortening lines (though this negates utilising higher velocity winds at altitude), and reducing line drag, an avenue I'm presently investigating. It's unfortunate that the high speed and requisite fast reaction times of Flexifoils favour a long line length. The solution seems to be more practice, or younger, faster operators. I'm open to any suggestions, both practical and radical.

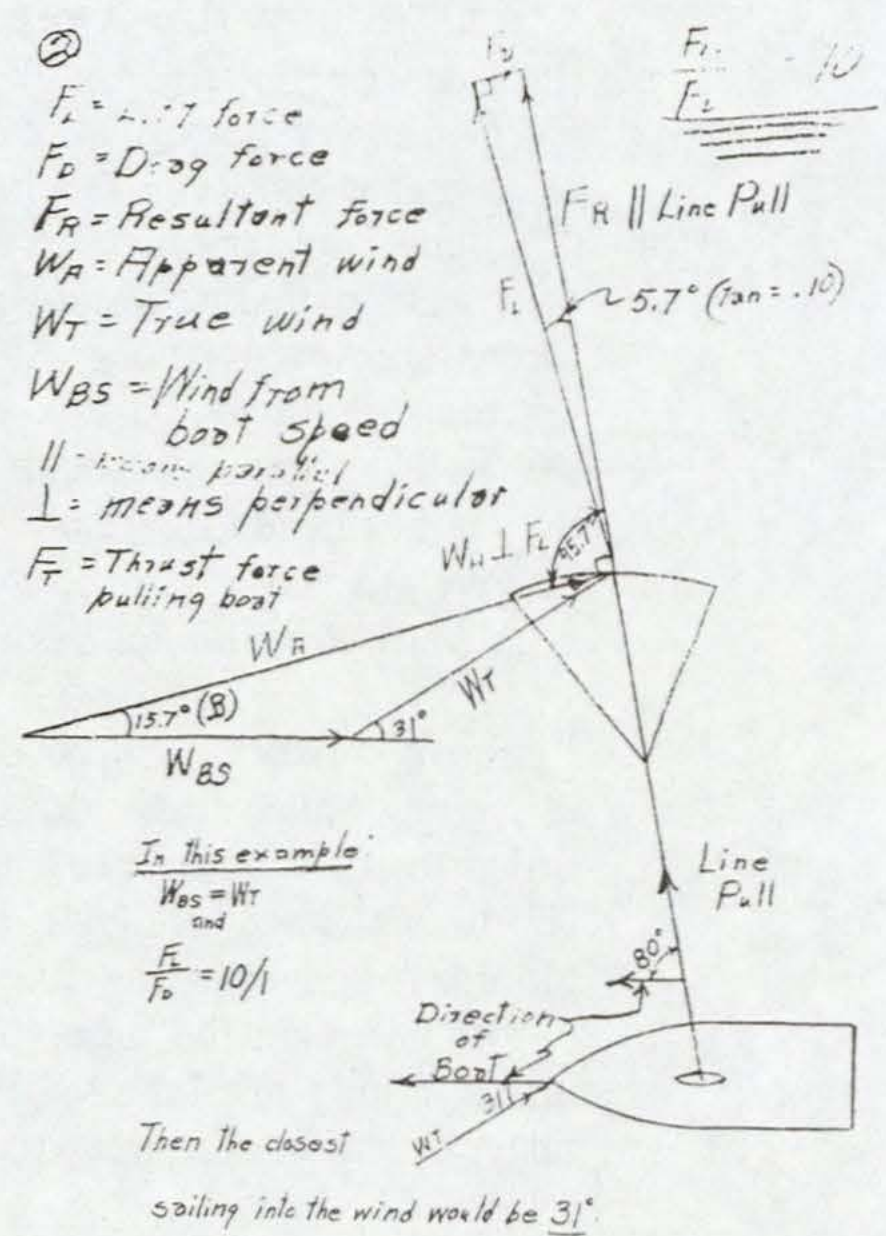
Dynamic Sheeting

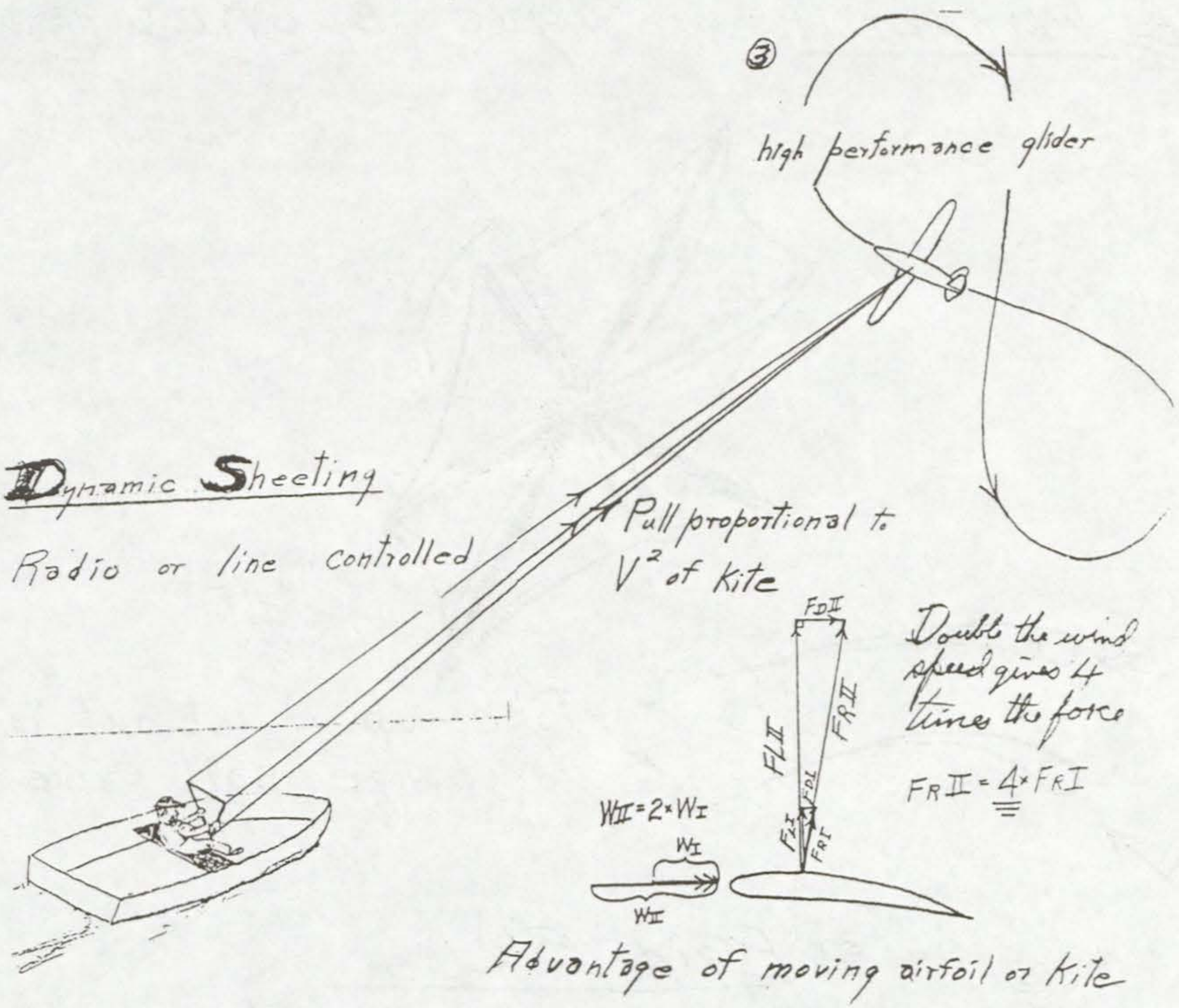
by Bill Sherts (1993)

Ed: I received the following illustrations for a lecture on 'dynamic sheeting' from Bill Sherts around the time that I was compiling the material for US III. At the time I was unable to include anything more in that issue, so I adopted the usual lazy editor's line. I put it in the 'deal with later' pile, with a note to consult Bill for some words to go with the pictures. Sadly, events have defeated me, with the death of Bill last year, I can no longer do that.

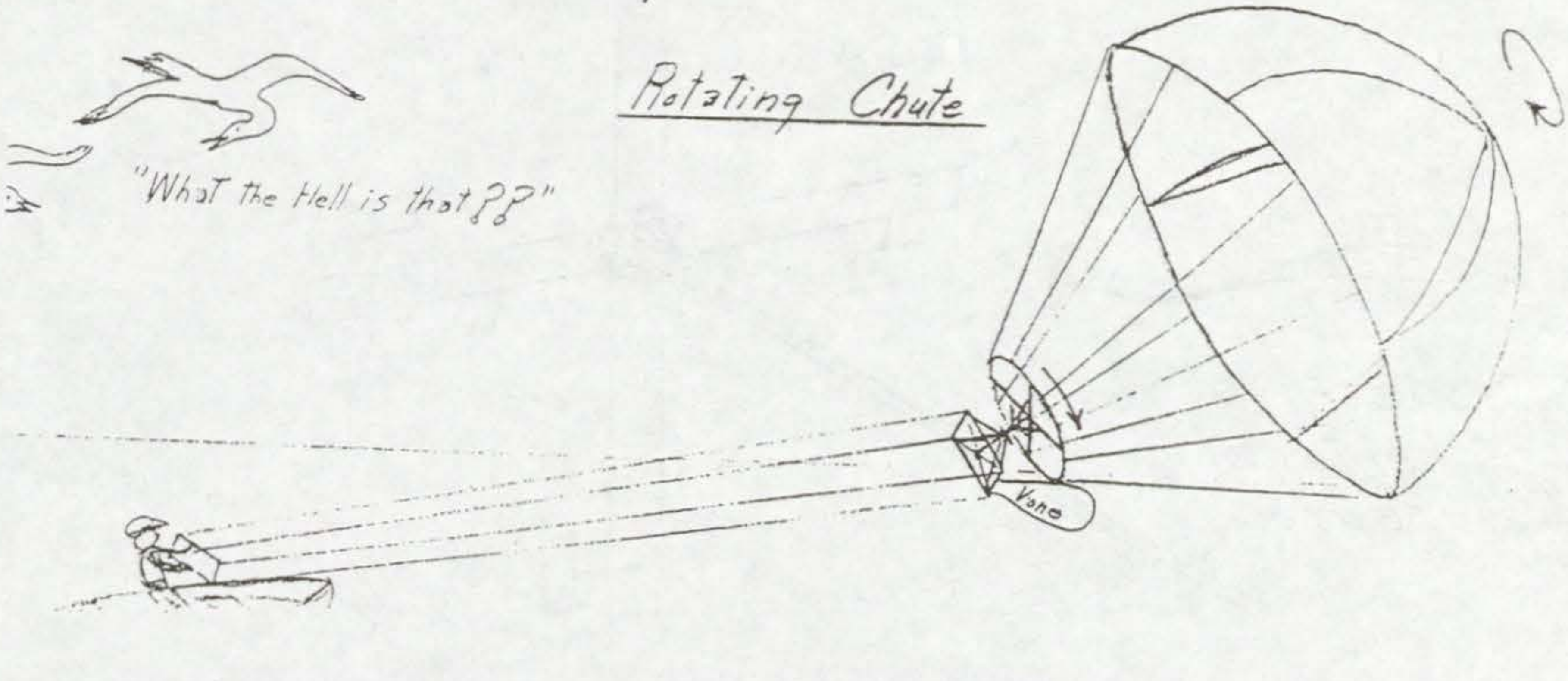
In his letter to me Bill said "I think the notes on the figures make them self-explanatory, but please add any notes you want to". I don't think there is anything for me to add, so here are Bill's figures as received.



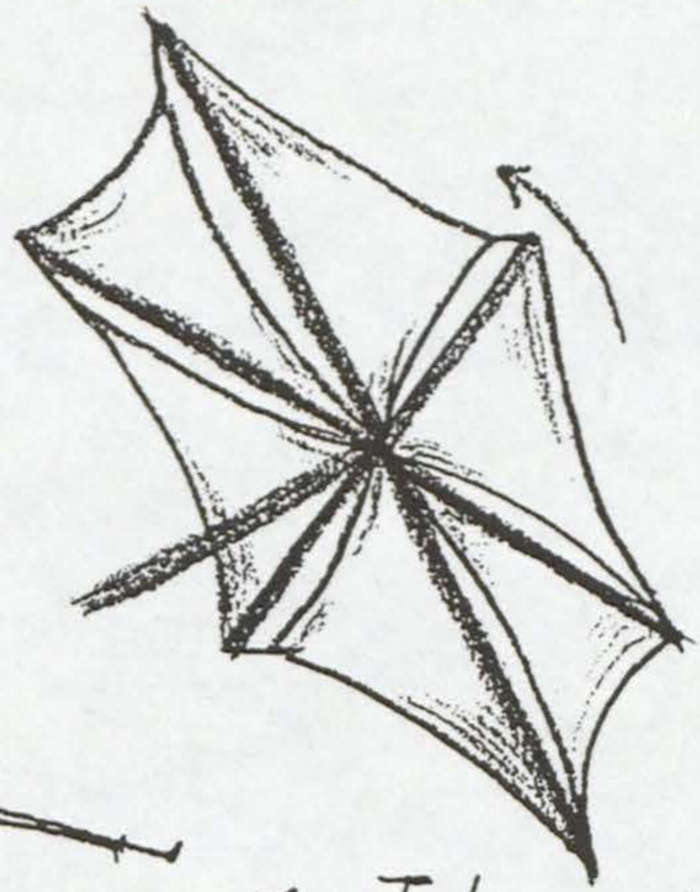


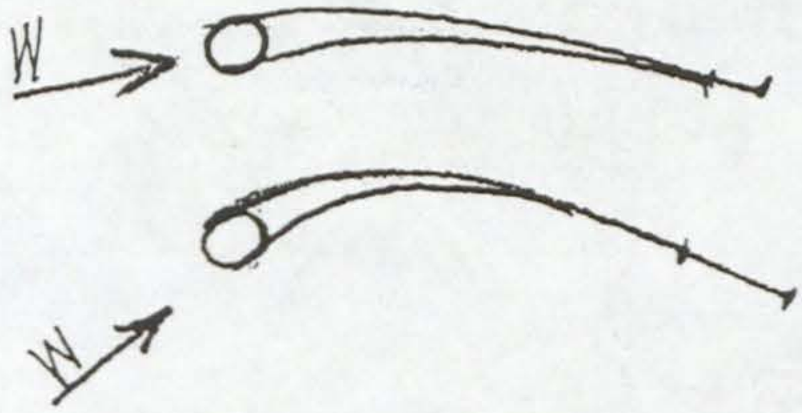


④
"SHERTS" Sheeting



or Windmill - ridgid spokes 5

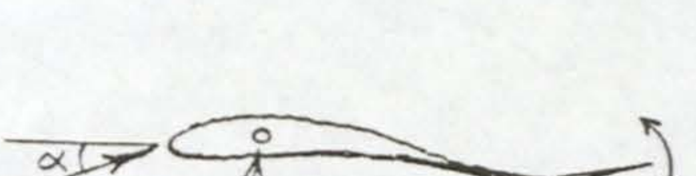




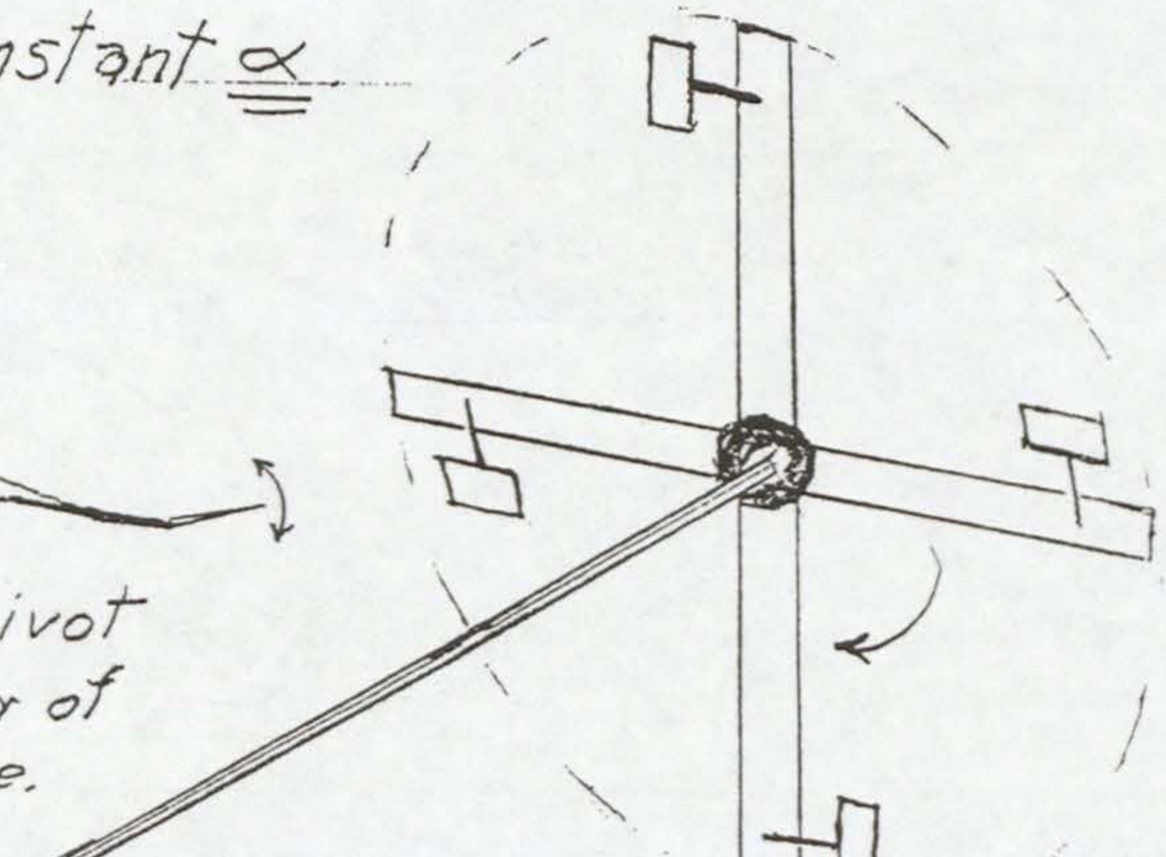
Take up or let out tai[l]
to change sail curve.

6 or Rigid Blades

Adjustable tail trimmers on each blade
for constant α



Blade pivot
at center of
pressure.



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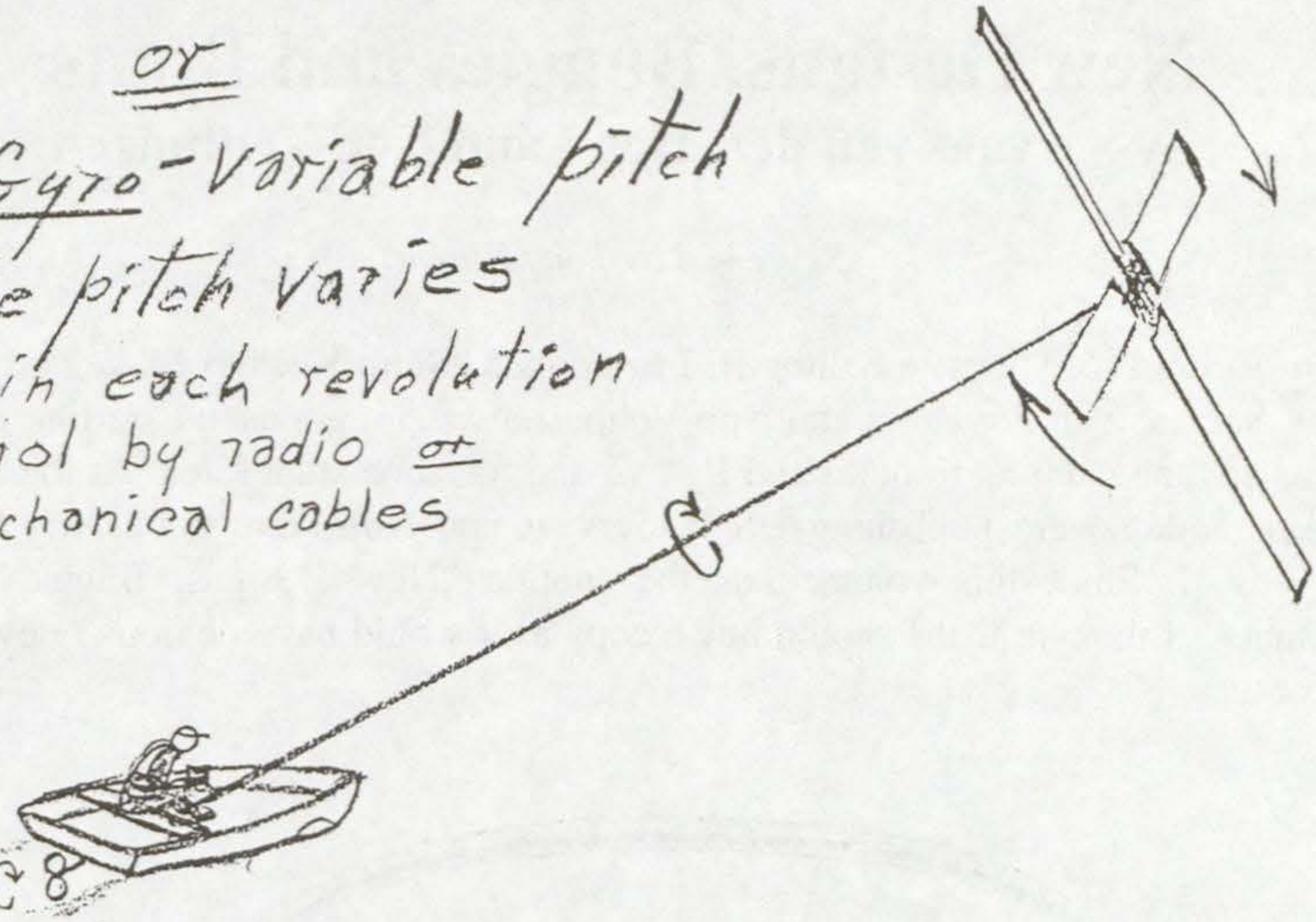
or

Auto Gyro-Variable pitch

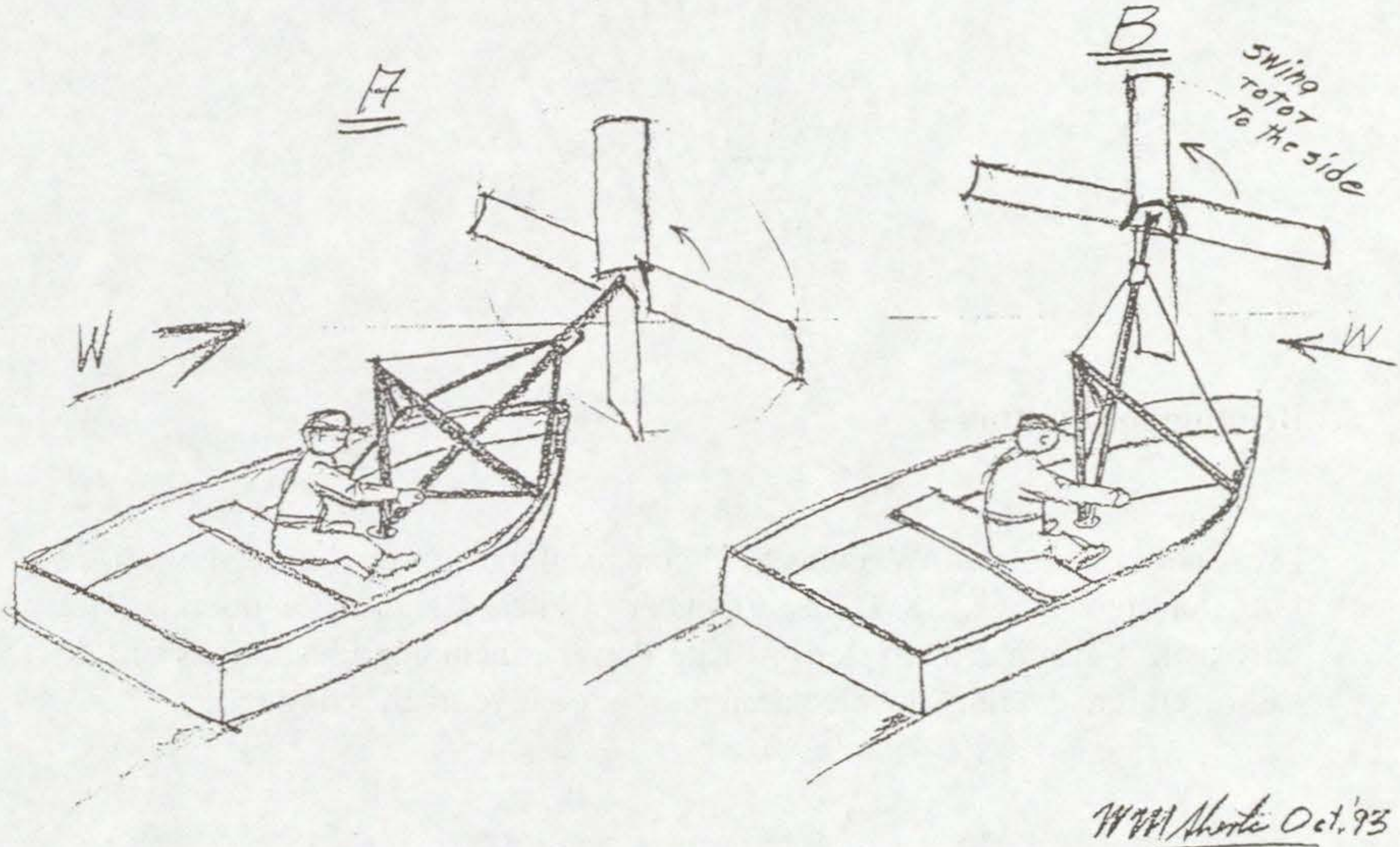
- blade pitch varies within each revolution
- Control by radio or by mechanical cables



⑧

or

Mounted Rotory Kite



WM Shortt Oct.'93

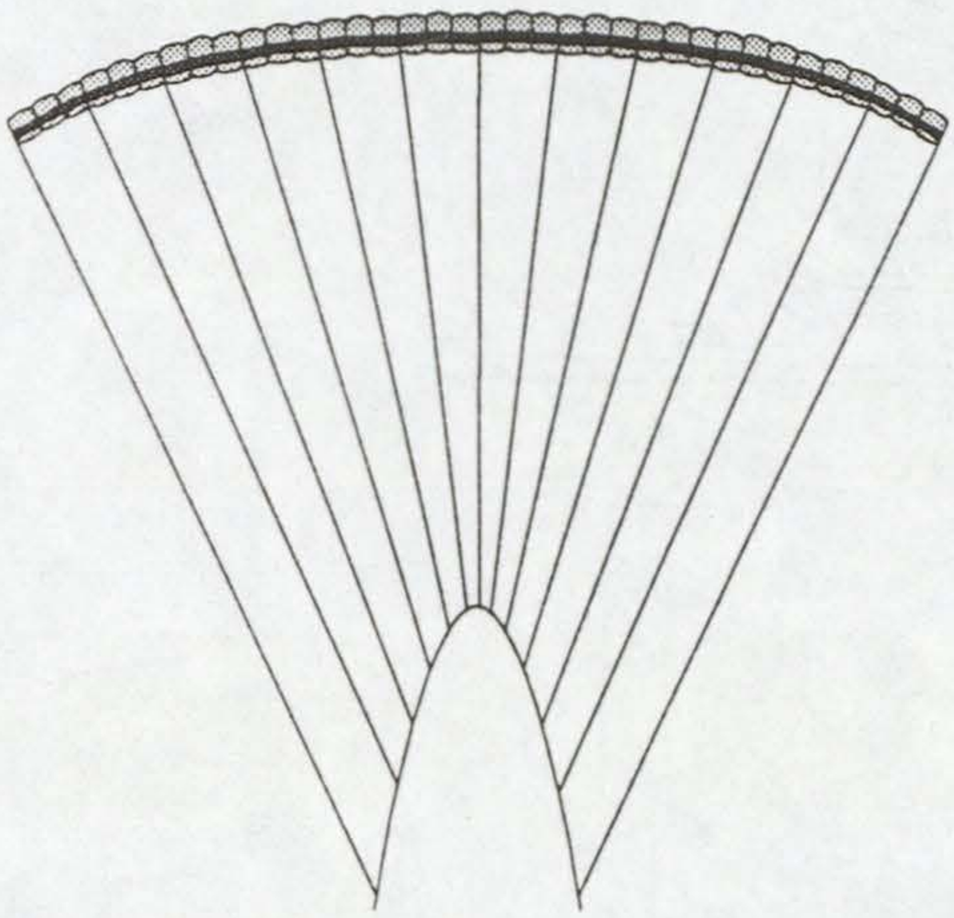
Stunt Kites II

New Designs, Buggies and Boats

by Servaas van der Horst and Nop Velthuizen

Reviewed by Tony Kitson

In AYRS 116, Ultimate Sailing II, I mentioned "Stunt Kites to Make and Fly" by Servaas van der Horst and Nop Velthuizen as being a useful starting place for anyone wanting to build and fly two and four line stunt kites. At the same time as we were publishing US II, Servaas and Nop were publishing Stunt Kites II. Since this volume has the subtitle "New Designs, Buggies and Boats", I thought that I should buy a copy as it would have obvious relevance for us.



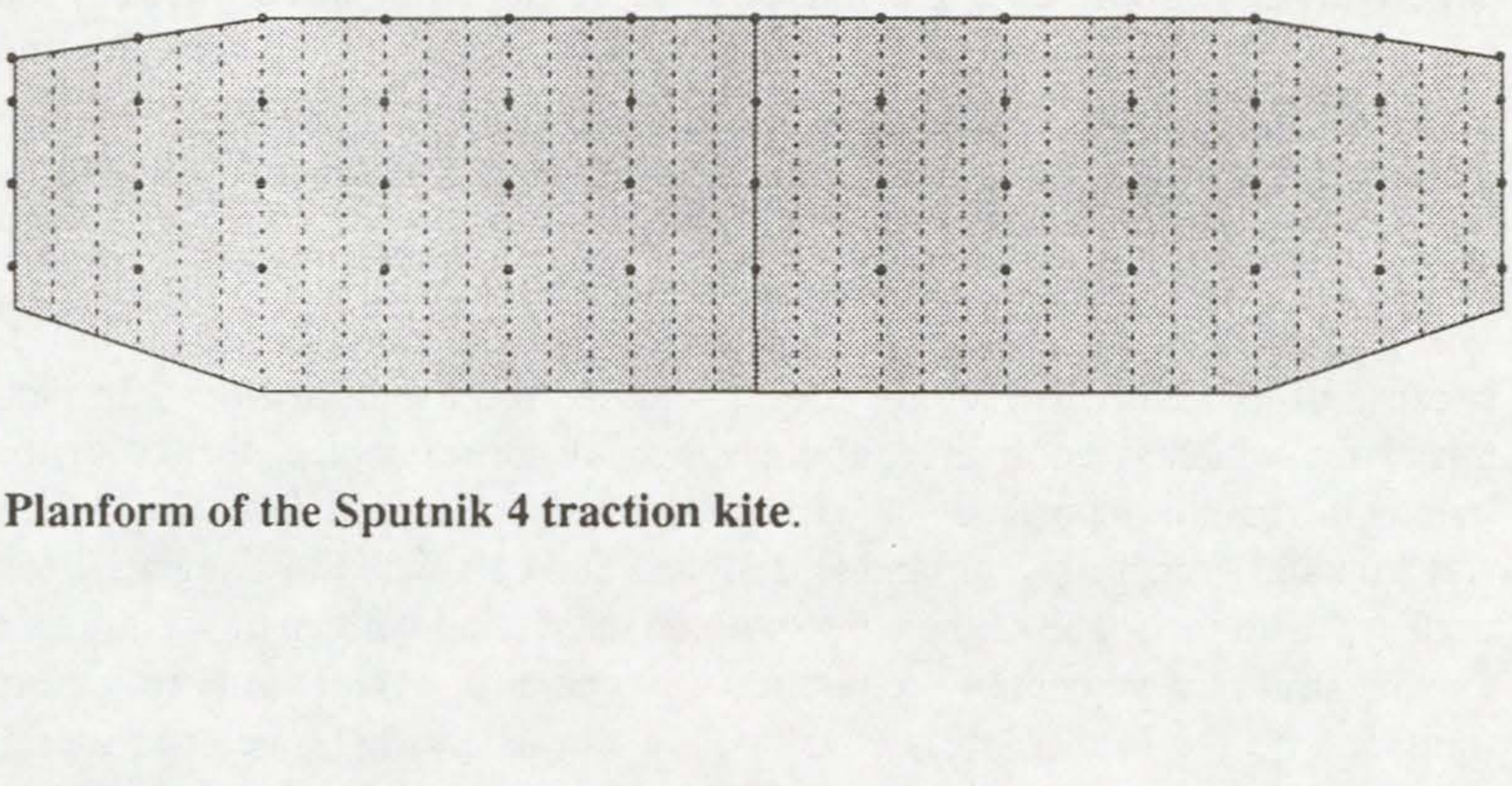
Bridling for Sputnik 4

I was not disappointed. Whereas SK I contained mostly small to medium sized kites for stunt flying, SK II has a number of kites designed for traction. Not only that, it also has a chapter on 'Kite Power', including illustrations of kite sailing craft and a fully detailed design for a 'do it yourself' buggy.

The star of the show for kite traction enthusiasts is the Sputnik 4 development from the Sputniks 1 and 2 of SK I. Sputnik 4 was designed as a DIY alternative to the Peter Lynn, 'Peel', traction kites. The basic design is for a 4.68 metre wingspan, 5.17 square metre soft kite. Details are also provided for adapting it to the smaller, 2.8 square metre, and the massive, 10 square metre, versions.

Published separately is the computer disc Kite 1.0' Kiteflight and Plotter by Peter van den Hamer and Peter Ruinard. This contains some useful programs for scaling and plotting at full size many of the designs in the book and for altering and recalculating bridling.

Whilst the book is now over two years old and things have moved on, for instance Andrew Beattie's Chevron design, it is still 'required reading' for anyone with aspirations to traction kiting with home made equipment. With SK I and SK II you are ready to tackle Hagedoorn's challenge.



Planform of the Sputnik 4 traction kite.

'Stunt Kites II: New Designs, Buggies and Boats' by Servaas van der Horst and Nop Velthuizen is published by THOTH Publishers, Netherlands.

'Kite 1.0: Kiteflight and Plotter' by Peter van den Hamer and Peter Ruinard is also published by THOTH.

Wipicat Patent

European Patent No B1 0202271 - 24.05.89

by Dominique and Bruno Legaignoux

This invention concerns a propulsive wing whose profile has an aerodynamically efficient curvature, linked by ropes to a body generally to be pulled or lifted, comprising an inflatable stay and an envelope made from a thin and flexible material.

The known propulsive wings, because of their generally plane shape, impose great strains to the structure which maintains them deployed. Schematically, this necessitates the use either of rigid stays which are heavy and cumbersome to carry and stock, or of airtight inflatable or wind inflatable stays which, because of their insufficient strength, are always maintained in position by a large number of ropes ending at the body to be pulled or lifted. This is the case with the wing described by the patent DE-A-2 933 O5O. Ropes and wind inflatable stays, besides being very harmful to aerodynamic qualities, make awkward the use of such wings, for example ropes have a tendency to become entangled and these stays to give way.

The propulsive wing according to this invention, as described in claim 1, because of its refined shape, provides a solution to these difficulties. In fact, this wing, which is configured like a spherical gore, enables, thanks to the minimum strain it imposes on the structure, the use of an inflatable stay. This stay contains compressed air and is designed and calculated to integrate itself perfectly with the shape of the wing, without interfering with air-flow. It has a leading strut of a perceptibly semi-circular shape and several struts which are transverse to the former. It is enveloped in a resistant, light-weight material arranged in such a way as to give it an aircraft wing profile of maximum efficiency. This wing is therefore of great lightness and very reduced dimension, once deflated and folded. Each end of the wing takes a long control rope fixed to the load to be pulled, thus enabling the wing to be steered. In order to adapt the win to the different wind strengths, it is possible to reduce the sail surface by removing the rear part of the material by some appropriate method, such as a zip fastener.

Finally, both by the considerable buoyancy provided by the stay and by the simplicity of the control system, take-off even on water being extremely easy to effect, this wing can be controlled by a user mounted on one or two skids, using pulley attached to his harness and through which is passed a single control rope linked to the two ends of the gore.

The propulsive wing is described in detail in the annexed drawings, provided as examples and on which:

- Figure 1 shows, in perspective, the wing according to the invention,
- Figure 2 shows, in section, the wing profile,
- Figure 3 shows, in front view, the wing according to the invention,
- Figure 4 shows, in perspective, the inflatable stay,
- Figure 5 shows in section, a variant of the profile with a system for reducing the sail,
- Figure 6 shows, in side view, the wing according to the invention.
- Figures 7, 8 and 9 show the three stages of the graphic method of tracing the sail pieces.
- Figure 10 shows the most sporting use in a nautical context.

The wing is always shown inflated by the wind. Its size can vary enormously according to the use, from less than half a square metre in a child's toy to several dozens or even hundreds of square metres for heavy loads. The shape of the profile can also vary.

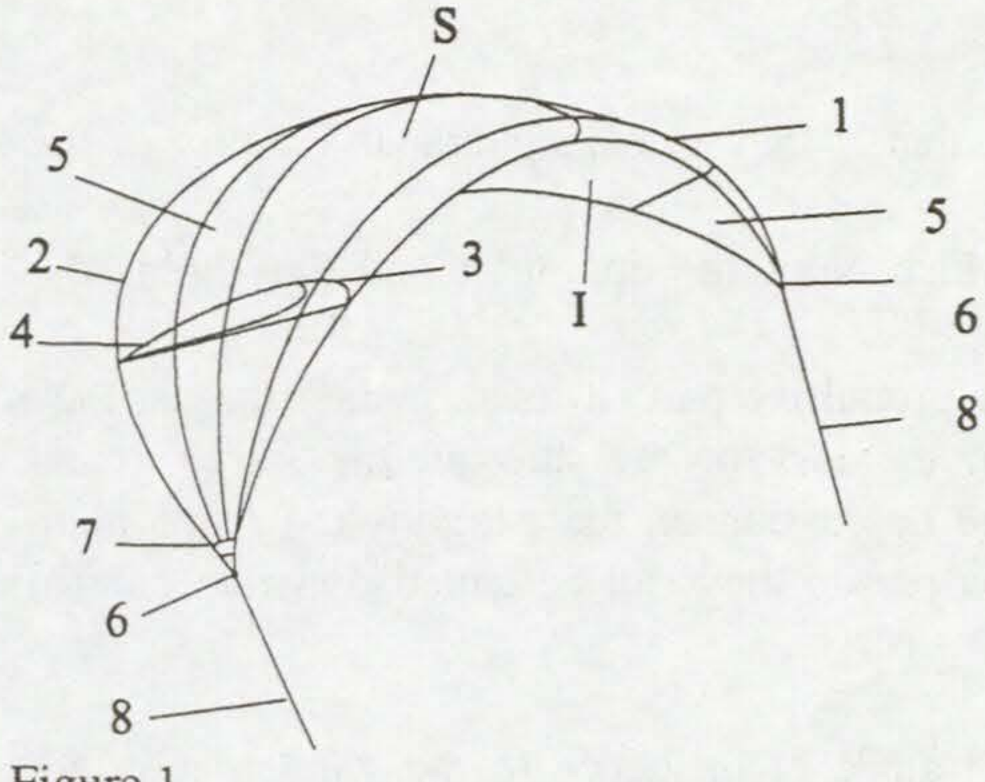


Figure 1.

Figure 1 gives an overall view of the wing. This is in the form of a spherical gore comprising a leading edge (1) and a trailing edge (2) and is embodied by an inflatable stay (3 and 4) covered by a flexible envelope (5) both in the intrados (I) and in the extrados (S). Each of its tips (6) receives through an adjusting plate (7) a control rope (8) linked to the load.

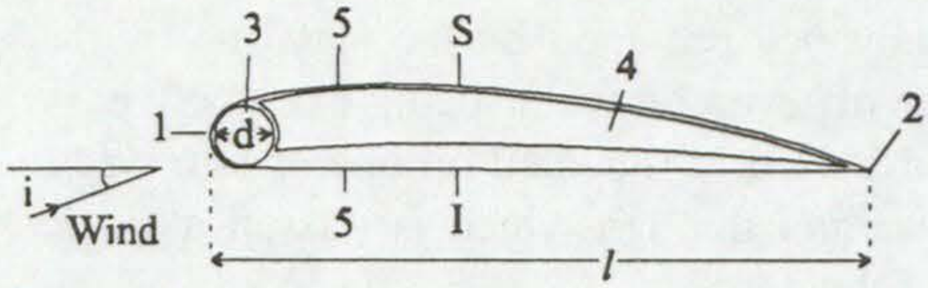


Figure 2.

This wing functions aerodynamically speaking as an aircraft wing as Figure 2 shows, that is, it attacks the wind with a small angle of incidence (i) creating a pressure on the intrados side and a depression on the extrados side (S), the wind moving from the leading edge (1) towards the trailing edge (2). The essential difference from an aircraft wing is that the latter is a flat surface seen edge on and the wing in accordance with the invention is clearly semi-circular, as shown in Figure 3.

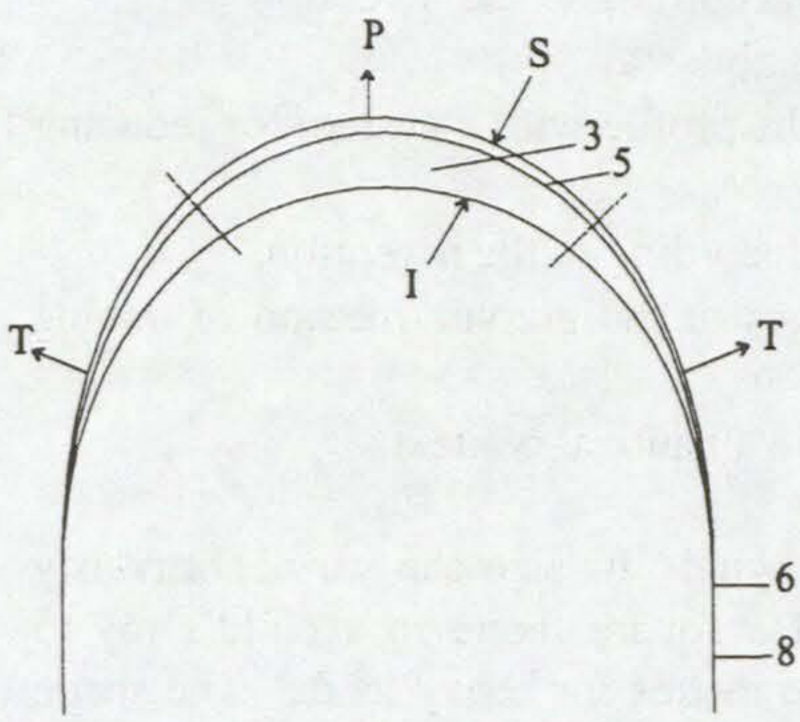


Figure 3.

The main advantage of this shape lies in the fact that it imposes a minimum of strain on the stay. Moreover, the shape is self-sufficient, that is, it needs no auxiliary structure. In fact, the surface can be broken down diagrammatically into three parts: a central part which develops the propulsive force (P) (the wing properly speaking), and two end-pieces. These latter rep-resent about a third of the total surface and have three functions:

- They act as control surfaces, that is they give longitudinal stability to the wing.
- They generate a force (T) which holds the tips apart and thus holds the structure deployed.
- They act as end-plates for the propulsive part (P) of the wing, that is, they impose a maximum limit on the loss of pressure on the intrados and therefore the filling out of the depression on the extrados (S) (a problem with standard sails). For this reason they can be called dynamic control surfaces.

But no sail can present a small angle of incidence to the wind if it is not maintained on the desired shape by an appropriate stay.

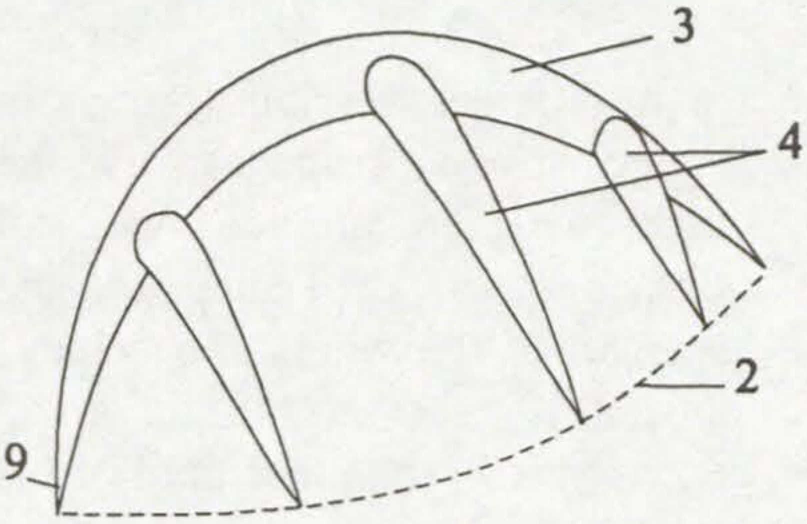


Figure 4.

The stay of the propulsive wing shown in Figure 4 is inflatable, using an inflatable boat pump, for example, through one or several orifices (9), provided with stoppers and (secondarily) non-return valves. The pressure required is relatively weak and air can be replaced by a lighter gas to facilitate flight in weak wind conditions. The struts are of round section and their shape is calculated for maximum integration into the profile. They can be made in two ways: either as a duct plus an air chamber, or as an inextensible air chamber alone. The material must be flexible and stand in suitable fashion to the pressure and to repeated foldings. Finally, the struts can be linked together, requiring only one inflating orifice, or separated, in which case several orifices are required.

The leading strut (3) is equal in length to the leading edge. Its diameter (d) (Fig. 2) varies according to location along the wing leading edge (1) as a function of the length of the profile (L). This strut therefore becomes thinner towards its end to finish in a tip, which gives it, seen edge on, the shape of a crescent (Fig. 3). Its role is to prevent the leading edge (1) from moving away and the whole wing from becoming deformed, something which would greatly disturb flight control.

The transverse struts (4) have a length equal to the length of the profile at the position where they are placed less the thickness of the leading strut against which they abut. Their number varies in relation to the size of the wing, and the thickness and flexibility of the fabric. Taking the example of a surface of 4 m^2 and fabric of 100 gr/m^2. there would be three struts regularly spaced. Their role is to prevent the fabric from creasing and they therefore work above all in compression.

As shown in Figure 2, this armature bears an envelope (5) made of a flexible, light fabric made from a synthetic material or plastic sheeting, which does not lose its shape easily or absorb water and is as resistant as possible to wear and tear. This envelope totally surrounds the stay hiding it completely. The envelope and the stay are fixed together at their points of contact. A layer of fabric covers the upper side of the stay and forms the extrados (S) while another layer covers the underside, forming the intrados (I). They meet at the back and are fixed together.

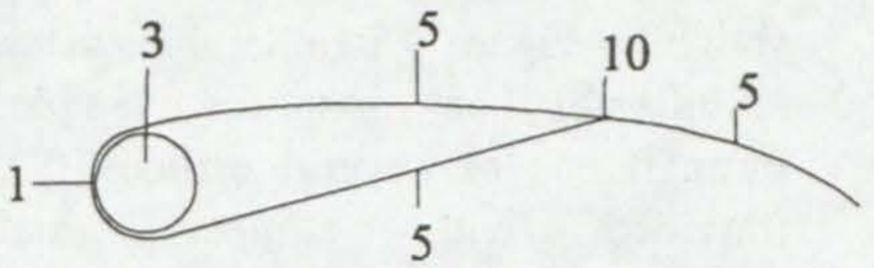


Figure 5.

In a different version (shown in Figures 5 and 6) one can use the same wing to provide two sail surface sizes, depending on the strength of the wind. To achieve this, it is necessary to fix a zip fastening (10) lengthwise across the sail, generally across the rear third of the surface, in order to obtain a narrower wing if needed.

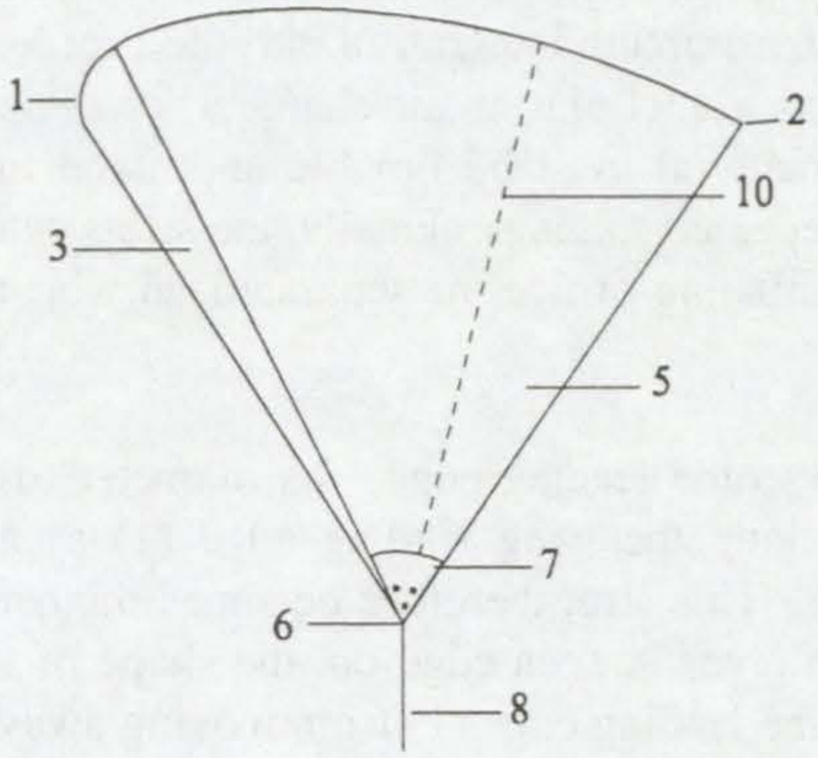


Figure 6.

As an example, a wing of 6 m^2 can be reduced to 4 m^2. This can be a very practical solution on condition that the intrados envelope is fixed at the level of the zip fastening, or removed (although the latter can slightly reduce wing performance). Again it is necessary to ensure at the profile design stage that the reduction in sail surface will not alter the equilibrium of the sail. Finally, to obtain the best flight performance, the wing must have a wing length/maximum profile length ration higher than 2, the length of the wing being the length of the envelope (2) between the two tips.

The wing held at the two tips, is in a position of stable equilibrium in flight when its angle of incidence in relation to the wind (I) provides a laminar air-flow round the profile. The angle (I) must be very small to enable the right direction or angle of lift in relation to the wind. To achieve this result, the tips (O) (Fig. 7) must be an extension of the force (R) resulting from the push and drag forces, (R)being located at 42%, of the length of the profile. This percentage can vary by a small amount, depending on the shape of the profile. The wing surface being curved in both directions, and therefore not expansible, and this percentage having also to be respected, it becomes impossible to manufacture a wing of perfect shape according to old-fashioned methods. It is for this reason that a method using graphic projection (see Figures 7, 8 and 9) has been developed, making it possible to ascertain the exact shape of the sail-pieces, or pieces of fabric which, assembled according to a radial disposition, form the envelope. Using this method the shape of the profile can be respected at all points on the wing.

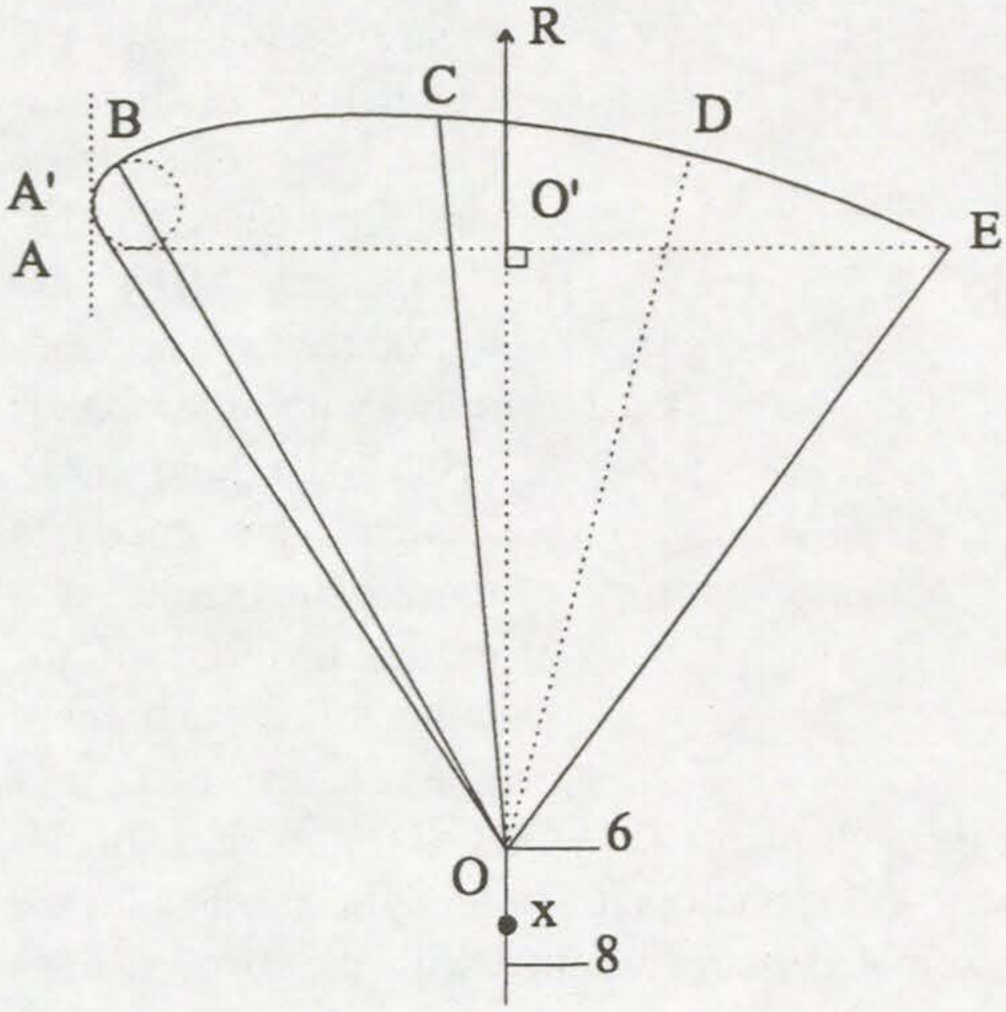


Figure 7.

On Figure 7, the thick line represents the wing seen from the side. The number of pieces and the shape of the profile have been chosen arbitrarily. Let (O) be one of the tips of the sail, (AA') the axis delimiting the front of the profile and parallel to (00'), (AE) the length of the profile. The surface (OA'B) represents the leading strut, (OBC), (OCD) and (ODE) being the sail pieces. The point (O'), the orthogonal projection of (O) on the straight line (AE) is such that AO' = 42% of (AE). The projection is carried out from the imaginary point (X) located on the straight line (O'O) such that O'X>OO'.

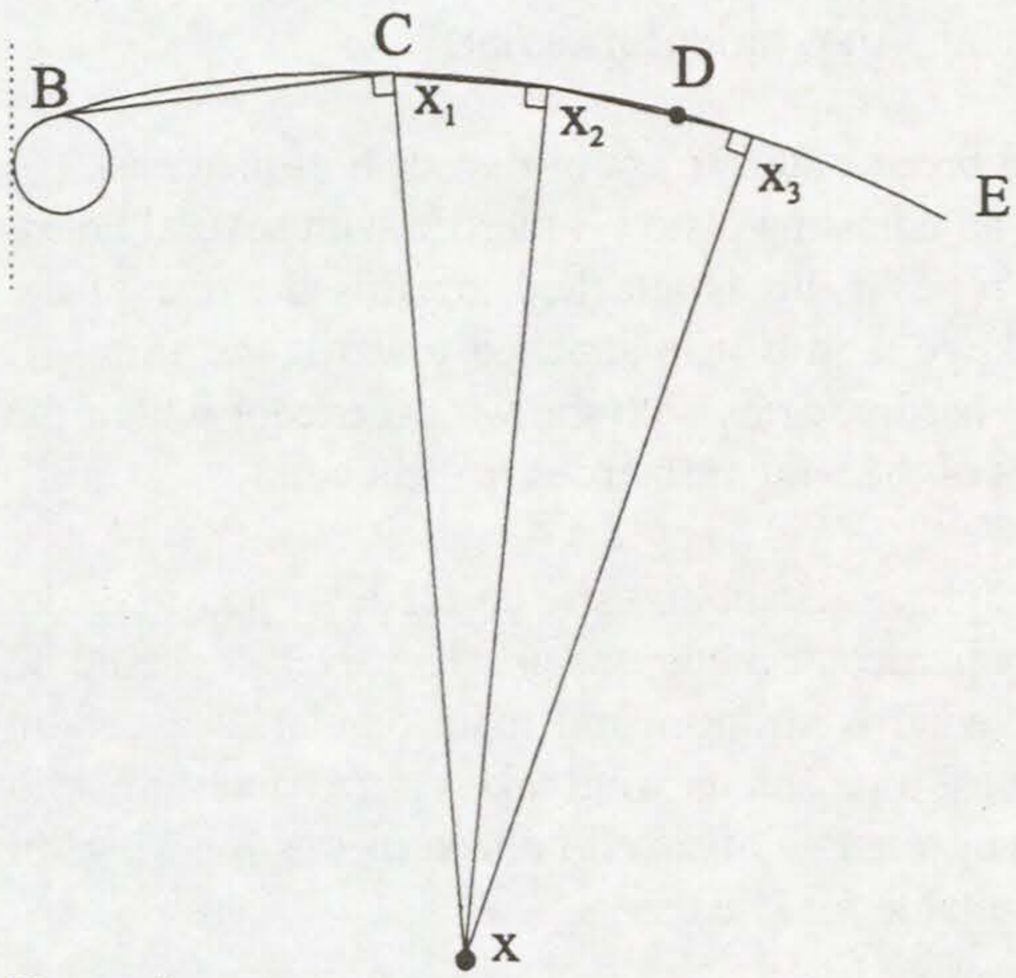


Figure 8.

Figure 8, traced from Figure 7, is a section of the chosen profile (only the extrados in this demonstration). Three straight lines (BC), (CD) and (DE) are traced, representing the profile obtained after assembly of the sail pieces (the more numerous the pieces, the closer the profile obtained is to the one intended). A perpendicular is projected from the point (X) to each of the straight lines. One obtains the intersection points (X1), (X2) and (X3).

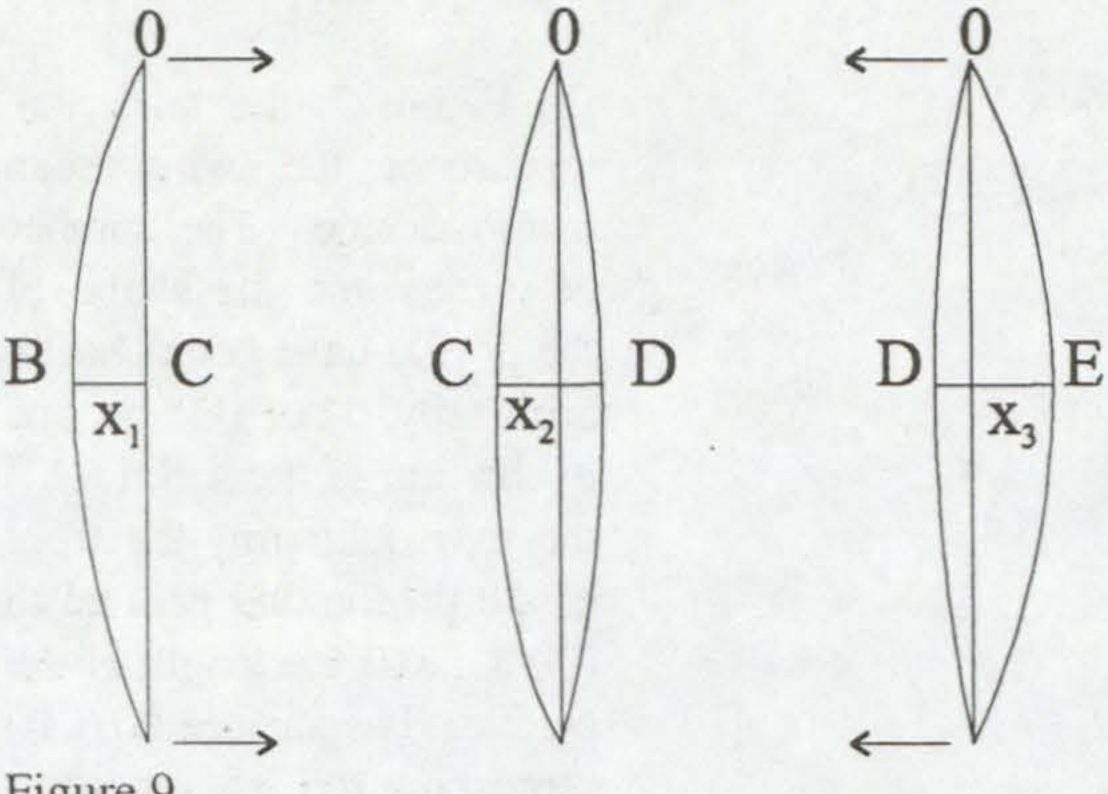


Figure 9.

Figure 9, taken from Figure 8, gives the exact shape of the sail-pieces. The three straight lines (BC), (CD) and (DE) are reproduced horizontally with the points (x1), (x2) and (x3). Verticals are traced to these points which stop at the tips (O) of the wing. For each piece one traces two arcs from the tips (O) and passing through points (B), (C), (D) and (E). In this example, (C) being integral with (x1), one obtains a straight line behind the first piece. The pieces are assembled in accordance with the arrows, edge against edge, in such a way that the tips (O) join at the same point, by glueing, sewing or any other appropriate means. They are then fixed to the stay. This method of manufacture using assembled pieces requires few facilities for production by a craftsman. However, other methods of manufacture can be envisaged in an industrial context, for example heat-forming of flexible sheeting on a wing-shaped mould, using various materials.

Moreover, in order to enable a precise adjustment of the angle of incidence (i), each tip can be provided with an adjusting plate (7) pierced with several holes, to which is fixed the control rope, If this is attached towards the rear of the plate, the angle (i) becomes large, and if it is attached towards the front, (i) becomes small. The angle (i) hardly varies with the winds, except where the wind is weak, when the weight of the wing influences its behaviour.

The control rope (8) must be light, resistant and stretch the least possible. Its length does not depend on any particular requirements. However, it should be borne in mind that while the wind is stronger and more regular at a certain altitude, the weight of the control rope and its wind take-up may interfere with control of the wing. This is why a length of several dozen metres for wings of less than 10 to 20 m ^{2} seems suitable for kite use.

When the load to be pulled is a machine or device, the wing is linked to it by a single control rope passing through one or several pulleys.

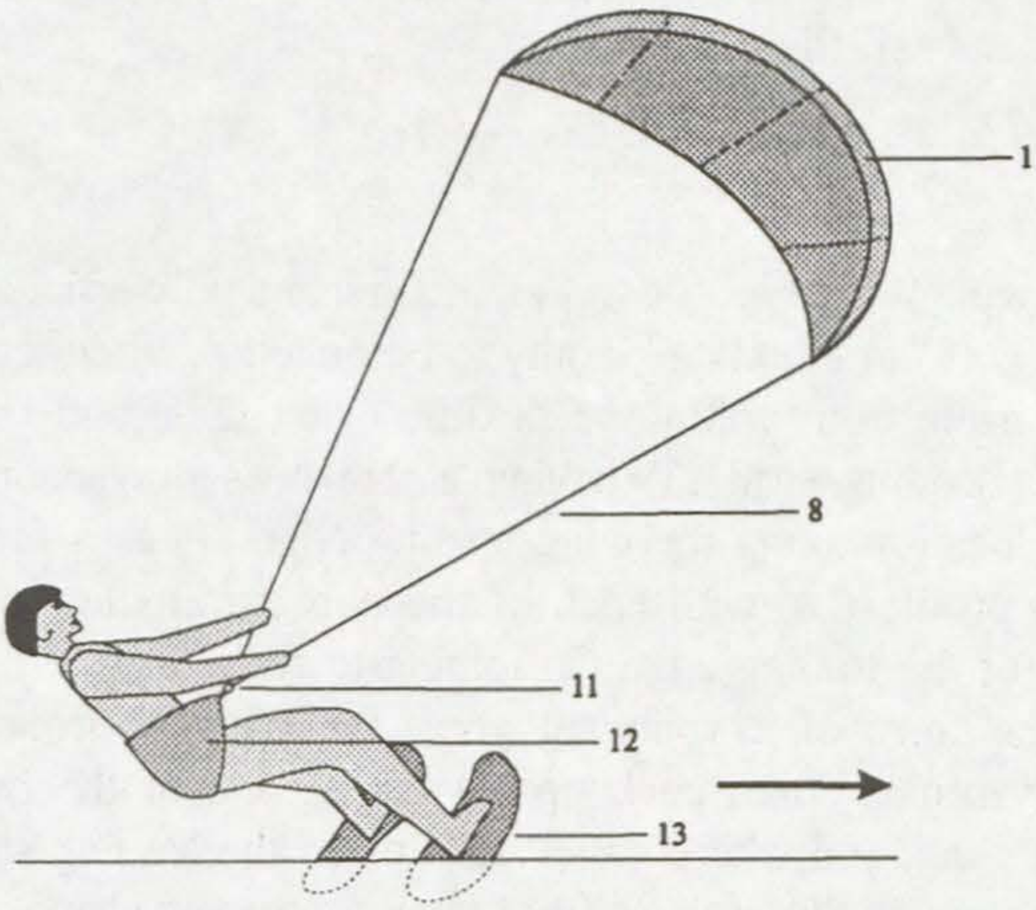


Figure 10.

When the load to be pulled is the user mounted on a small-sized machine, the control rope (8) is used as shown in Figure 10 to adjust the wing in the desired direction. Each of its ends is connected to one of the tips (6) of the wing. It passes through a swivel block (11) which turns freely on itself, fixed to a harness (12) worn by the user. The propulsive force provided by the wing acts through the control rope (8) on the pulley (11) then on the user, but the latter can control the apparatus by only slight effort, because the tensions on the control rope are always equal on both sides of the pulley. The swivel enables the pulley (11) to turn on itself in order to eliminate twists in the control rope (caused notably by take-off manoeuvres.

Using this unsinkable wing and its control system, take-off over water is extremely easy and requires no external assistance. In its most sporting application in a nautical context, the user is equipped with one or two special skis (13).

In a flight application, a person suspended from the wing by means of an appropriate harness, uses the same control system as described above. (Figure 10).

This wing can be used for traction or support of a person, a load, a device or machine on water, on the ground (snow, ice, grass, sand, etc) or in the air.

Among its numerous possible applications the most obvious concern sliding sports, yachting, and sail-flight.

CLAIMS

1. A propulsive wing whose profile has an aerodynamically efficient curvature, linked by ropes (8) to a body generally to be pulled or lifted, comprising an envelope (5) made from a thin and flexible material and an inflatable stay made up of a leading strut (3) having a thickness dimension that varies according to location along the wing leading edge (1) as a function of the length of the profile (L), with each of the two extremities of the leading edge (1) and of the trailing edge (2) joining to form a tip (6), wherein the wing is in the form of a spherical gore, the wing in front view being approximately semicircular, each tip (6) taking one of the two ropes (8) ending in the wing, and wherein the variation of the leading strut thickness dimension confers on this strut, in front view, a crescent shape.
2. The propulsive wing according to claim 1, wherein the pieces of material forming the envelope (5) are assembled together in a radial arrangement from each tip (6), each piece of material going from one tip (6) to the other.
3. The propulsive wing according to claim 1, wherein the rear part of the envelope (5) is removable by the use of a zip fastener (10).
4. The propulsive wing according to claim 1, wherein the rope (8), each end of which is connected to one of the tips (6) passes through a swivel block (11) fixed to a harness (12) worn by the user.

Editor's Notes

Bruno has informed me that they have progressed a lot since this patent particularly with respect to the generating of panel shapes, figures 7, 8 and 9 and the related text. In fact, these shapes are now calculated by computer.

I hope to publish information on some of these more recent developments in a later issue.

For those unfamiliar with the terminology used in this Euro-Patent, I have found the following definitions in the Concise Oxford dictionary;

***Intrados** n.*	*the lower or inner curve of an arch.*
***Extrados** n.*	*the upper or outer curve of an arch*
***Gore** n.*	*1. a wedge-shaped piece in a garment,*
	2. a triangular or tapering piece in an umbrella etc.

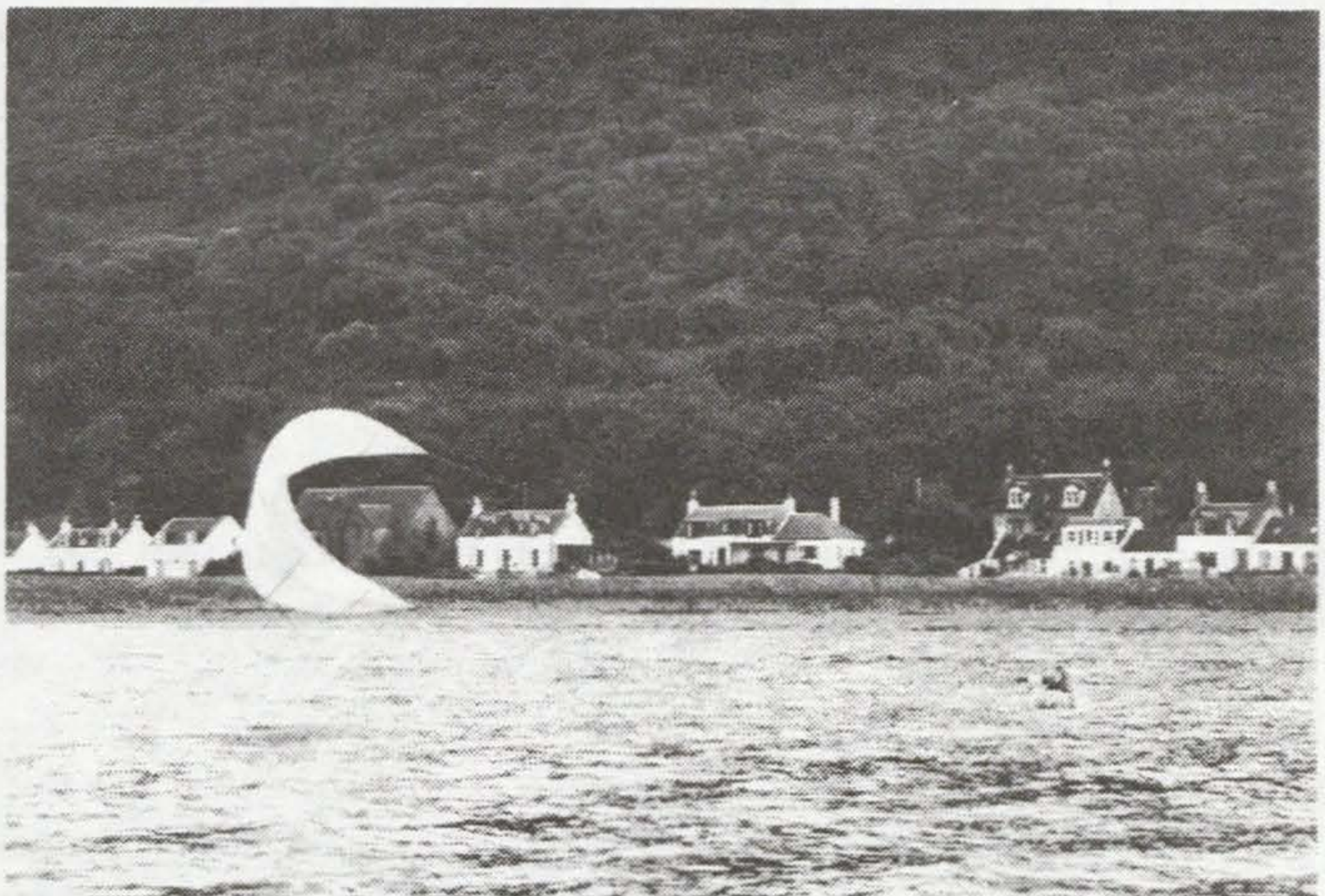
The Wipika

Traction Kite and Inflatable Catamaran

by Robert Biegler (October 1996)

Before I start describing kite and boat I should point out that I only managed to go sailing a few times since I bought them last year. That was partly due to an unexpectedly high workload, partly because there was one thing I overlooked when I chose to buy the boat. What I wanted was a sailboat that is portable by train, bicycle and bus (because I have no car) and that is fun to sail (meaning reasonably fast).

Portability is one of this design's outstanding features. Everything fits into a holdall measuring only 65 x 45 x 35 cm (26" x 18" x 14"). The problem I had overlooked is that I am still left with two bags, one that held the boat, another that contained my wet suit, life vest, etc and now my dry clothes. I have found no good and secure way of attaching these to the boat. It does have a zippered pocket with a few litres volume, but it was never intended to be a load carrier.



The Wipika Kite and Catamaran in action.

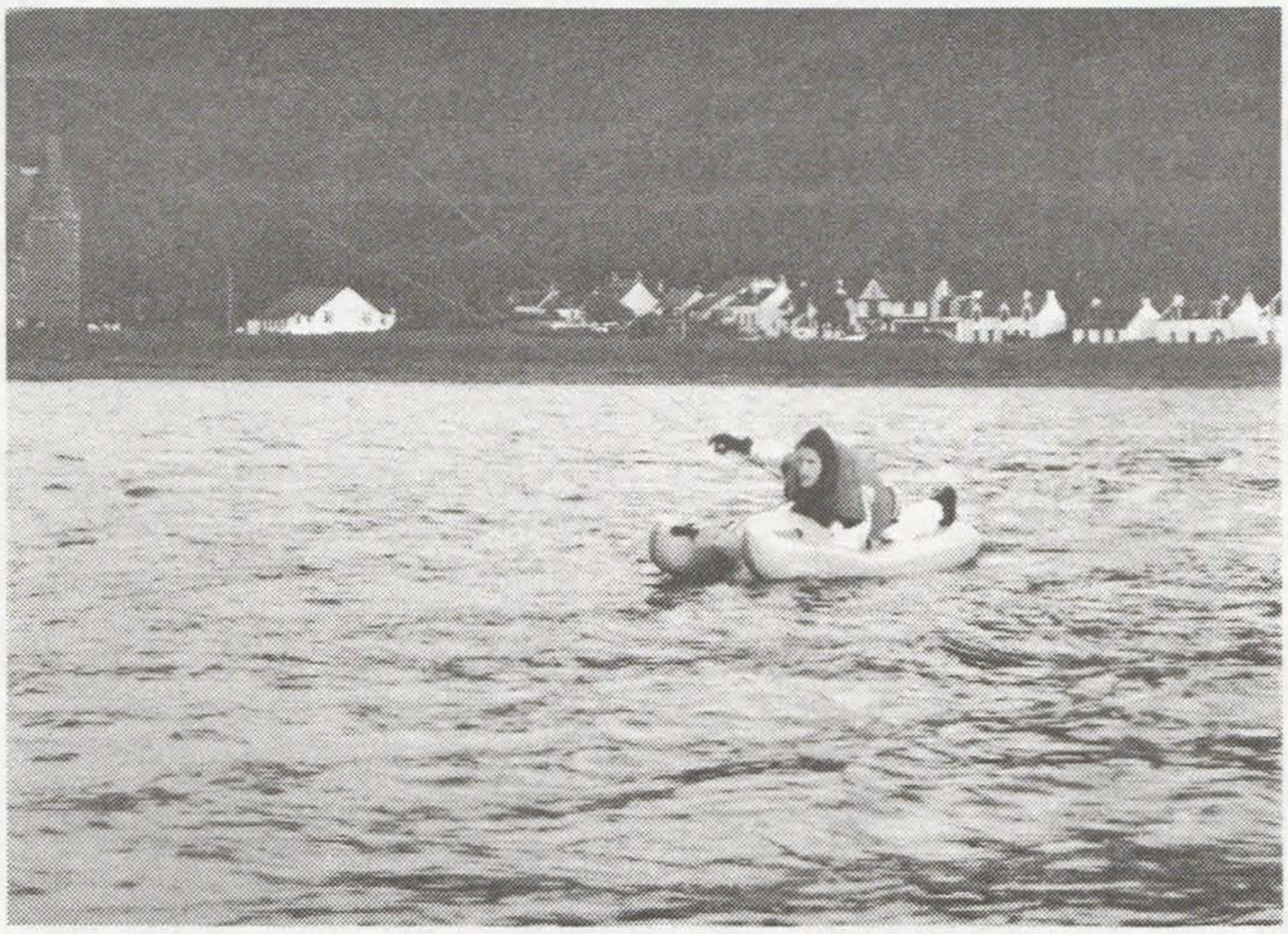
That aside, how does it sail?

First, the kite. As you can see from the picture, it is basically a sled kite with inflatable spars. Two thick lines attach it to a harness worn by the sailor. Two thinner lines are attached to the leading edge of the kite, enter each of the thick lines and exit again close to the harness, ending in a knob. Pulling on the left steering line pulls the leading edge on that side down and the kite turns clockwise, from the sailor's perspective. That is the opposite to conventional two-line kites. If you are used to those, it is no problem to cross the lines.

The kite reacts very slowly to steering inputs when compared to stunt kites. This has two consequences. First, the kite does not require the fast and preferably automatic reactions of quickly turning kites. It means that the kite is fairly easy to keep where you want it, but in light wind, when the kite is very slow, it also needs a bit of foresight. Second, it is a largely static kite. In contrast to most traction kites you don't fly this one in a figure eight pattern to increase pull. Therefore you also don't have the option of decreasing pull by stopping this pattern. I read that this dynamic sheeting can vary the pull of flexifoil kites by up to a factor ten. The Wipika kite pulls all the time. You can only vary the direction of pull, or you can pull the quick release cord to let go of one set of lines. The kite will fly out like a flag, still attached to the other lines, and gently float down to your lee. The inflatable spars will prevent it from sinking once it hits the water. Given enough wind, and if it doesn't fold up completely, it will just fill with wind again and automatically re-launch from the water. If that doesn't work it is often possible to take the two thick lines close to the kite, get it in the air and then pay out the lines hand over hand. This easy water launch capability makes the kite fairly versatile, and it has been used with a variety of boats, including kayaks.

The Wipikat, as can be seen on the second picture, is a narrow inflatable catamaran with not a solid piece in it. Lateral resistance is provided by two shallow inflated skegs. Looking at them I wondered whether the boat would be capable of going upwind at all. It does, but not well.

I estimate leeway to be about 15 - 20 degrees, best angle to the true wind perhaps 70 degrees. I haven't measured that. The boat has no rudder. The sailor lies on the boat and slides back and forth to steer. Though conceptually similar to a windsurfer I have found it, so far, a lot less manoeuvrable. Stay well away from other traffic especially because others may not realise that you can't tack, but must gybe.



The Wipika Catamaran

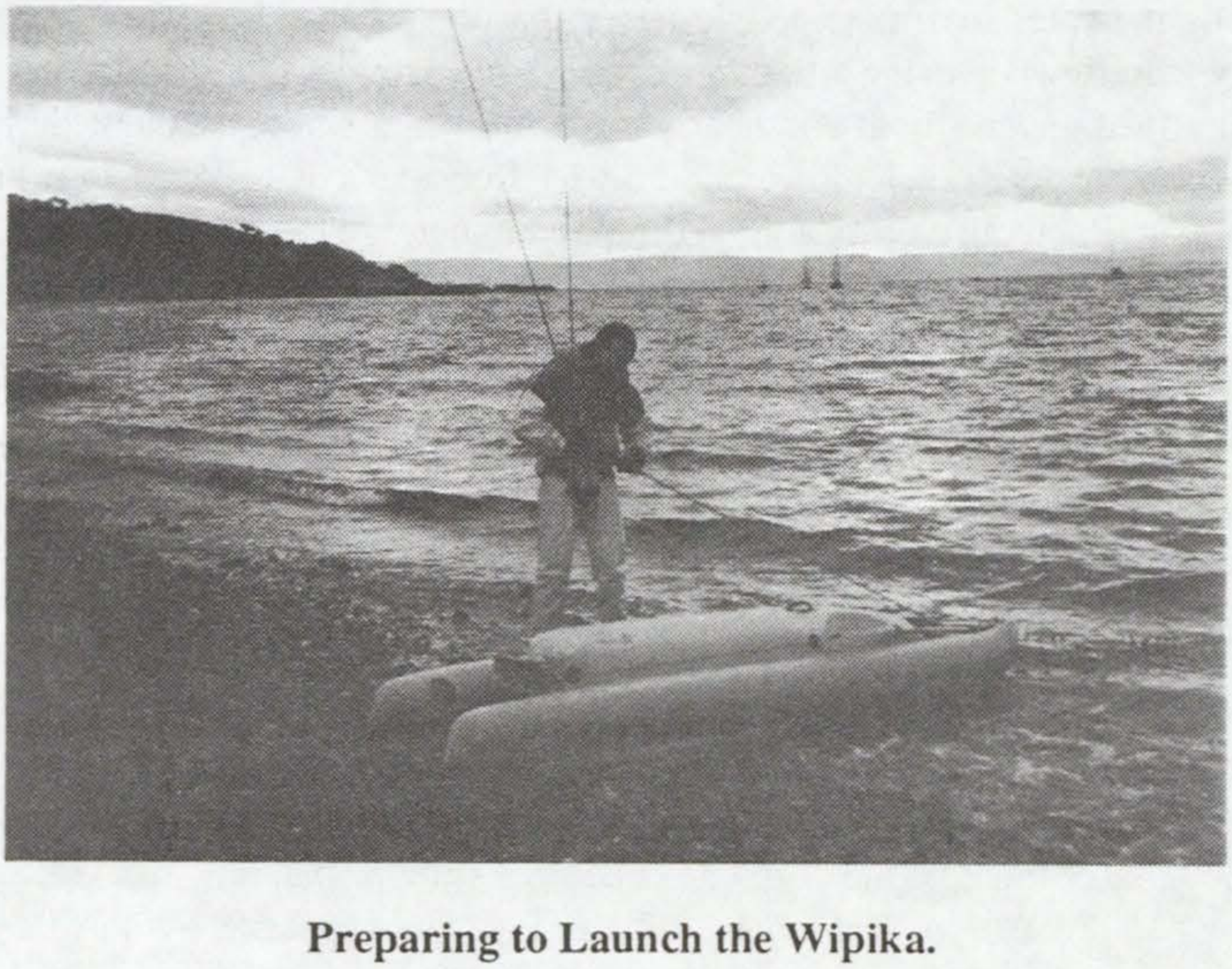
This brings me to the subject of safety. My experience is limited, but my reading indicates that most people agree that deadman release is a necessary safety feature when using a traction kite on solid ground. On water, Peter Lynn was trapped under a boat and nearly drowned when sailing without during an early experiment (see Ultimate Sailing I). Roeseler's Kiteski system has no release at all, but also no boat to get trapped under.

Using the Wipika kite, I have often been pulled off the boat in a gust. Anticipating that, I always tie myself to the boat to avoid losing it. I consider that safe because the boat is very light at 10 kg, has only that short connecting line I could possibly get tangled in and if it gets pulled onto me it has no solid parts to break my skull.

As for the most suitable size of kite, I bought the 8.5 sqm size, and at less than 70 kg body weight I find an estimated force 4 is about all I can handle during launch on the beach, which is the most risky part. If I had had an opportunity to try various sizes, and presently being able to afford only one kite, I probably would have chosen the 5.5 sqm kite. I heard a rumour that a 3 sqm kite will be built when production starts again, which may have happened by now.

In summary, if you want a boat you can mess around with off a beach in an onshore wind, and that can be easily transported on a train, bus, plane, car or a yacht if you have one, then the Wipika kite and catamaran may be for you. If you want to race or sail on a local reservoir crowded with swimmers, surfers and dinghies, chose something else. If you want a traction kite for use with other boats and you are not out to break speed records, the kite is also an interesting option.

As for myself, I am hoping to modify the boat. To secure my bags I need something to tie them to and a method of steering that doesn't require sliding back and forth so I have some space for them. A rudder should also make the boat more manoeuvrable. It should be foot-operated, so I have my hands free for the kite. Once I sit up, I need more stability, because the boat is quite narrow. A pair of foils with some dihedral angle should do the job. All that should fit onto a frame that could be tied to the boat, after creating a few attachment points using some PVC fabric and glue. If I don't like it I can still go back to the original configuration. I hope I can also try the kite on the folding kayak Theo Schmidt has lent me. If I get any interesting results from all that I will write something again.



Preparing to Launch the Wipika.

Kites and Lift to Drag Ratio

Originally published May 1996

by Peter Lynn

Continuing the now established principle of using turn-off titles, this paper is about lift-to-drag ratio, with particular reference to kites. Lift-to-drag ratio is a useful way of thinking about some types of moving objects. It is essentially a measure of efficiency for things that support weight on lift forces generated by fluid flow.

For a powered aircraft in steady-state flight, lift must equate to weight and drag, the total of all the forces attempting to slow the plane, is offset by the thrust generated by the engine(s) through propellers etc. Typically, powered aircraft pay a drag penalty for generating their required lift of about 5% to 15% of their weight; ie they have L/D's averaging around 10 (light aircraft ***and*** commercial jets).

High performance gliders can only maintain steady-speed in non-lifting air by using up some of their potential energy (ie by losing altitude). The number of meters they can fly forward for each meter they sink is a measure of their L/D, and can exceed 50.

What is the L/D for that most efficient of water borne craft, the super-tanker? Because they are so incredibly long, they are not penalised much by wave making drag as defined by Froude's Law, even at respectable speeds of 8m/sec or so. I would guess they manage L/D's of maybe 100.

L/Ds for soft-sail parapents are measured as for gliders, and figures higher than 12 are claimed by manufacturers (but is this for just the canopy, or for the entire canopy and pilot system?)

L/D can also be used as a way of thinking about other things for which we would usually use quite different measures for efficiency when we want to make comparison between these and fluid flow supported things.

the road surface), and drag is the total of rolling resistance and air resistance, exactly offset by the driving force supplied by the engine via the transmission to the tyres. The car's "L/D", if maintaining 28m/sec requires 30kW, is (1500 x 9.81)/(30,000/27.7) = **13.6.**

What is the "L/D" for a person walking? Say it takes 25W of expended "energy" for a 75g person to maintain a steady walking speed of 1.5m/sec, then the "lift" is the force required to support a weight of 75kg which is 75 x 9.81 = 736 Newtons. The drag is 24W/1.5m/sec = 16.7 N. Hence, our pedestrian's "L/D" IS 736/16.7 = ***44.2*** - not too bad!

What is the L/D for a coasting spacecraft at constant velocity, ie when not being significantly influenced by gravitational fields? (Actually this is stretching the L/D concept well beyond breaking point, but it's still interesting to consider). Well, by Newtonian physics, a body continues in its uniform motion unless acted on by a force, so, taking the 'lift' as the craft's mass, and the drag as zero, we get an infinite 'L/D'! Hooray! At last, something for nothing!

Actually, its not infinite, because Einstein came along and spoiled the game by giving the universe a beginning and an end (in fact, Einstein didn't actually believe this himself, but it turned out to be a consequence of his theory anyway.) So, our space craft doesn't quite continue forever unimpeded, even if it manages to mss major things like black holes for a while. But its "L/D" is going to be fairly high - I doubt the world contains enough zeros to enable it to be written down. Continuing to digress interstellar space is **not** empty, in fact there is a whole branch of 'aerodynamics' dedicated to pushing things through the somewhat sparse gas of the great void, using ion motors, Bussard's ram jets, light sails, and so on!

It is easy enough to think of entire craft (powered boats, powered aircraft, cars, gliders etc.) having this measure of efficiency we call lift-to-drag ratio, but it is also useful to consider separate measures of L/D for the different parts of wind-powered craft. C.J.Marchaj uses this approach extensively in his definitive work on sail boats, ***The Aero-Hydrodynamics of Sailing***, and we can usefully adopt this approach when considering kite traction.

An Americas Cup class yacht reaching at 4m/sec supports its weight and a small proportion of sail down force (from heeling), a total of about 35,000 kg, and requires something like 5000 kg of 'push' acting parallel to its direction of travel to maintain speed, at around 4m/sec giving a hull and appendages L/D of about 7. The 'push' is supplied by the sail, which pays its own drag 'price' for generating this push. For a typical high-performance yacht or windsurfer sail, while reaching 'lift' the useful force generated by the sail functioning as an airfoil, is measured at right angles to the apparent wind direction, while 'drag' the 'price' paid for generating this lift, is the total of all the aerodynamic forces acting parallel to the apparent wind. In apparent winds of 5 to 15 m/sec, sail L/Ds are typically about 9.

Here I have used kgs to measure forces, but should have talked in terms of Newtons to be Kosher. The ratios remain the same, and kilograms have the virtue of being readily related to by most people who know how much force it takes to hold a 1 kg mass in 1 gravity (actually it is 9.81 Newtons, but so what!

As an aside at this point it should be noted that L/D's are usually speed dependent. Of course the "L/D" of our space craft s effectively independent of speed, as are ice runners and even wheels on hard surfaces for a useful range of speed. Aircraft L/D's are not independent of speed, being optimum only in a middle range, worse at the very slow and very fast ends. "Boat" L/D's for displacement craft decrease approximately with increases in the square root of the water line length (Froude's "Law").

For planing surfaces, L/D decreases to between say 5 and 8 once planing is fully established and holds at this until starting to decrease again at speeds above about 30m/sec because water flow wont stay attached' above this. Airfoil L/D's can be very high at quite low speeds (e.g. 5m/sec), even as high as 40 or 50 but more usually 15-20 and is very dependent on the angle of attack (the angle at which the apparent wind strikes relative to the airfoils centreline). As angle of attack increases above about 3^0 , L/D decreases inexorably.

Now, to get a meaningful measure of the total system efficiency we first have to convert these L/D ratios to angles. Think of it this way; because, in this imperfect world, there will always be some drag for any lift generated by an airfoil (sail); sails provide a resultant force which always acts at more than 90^0 from the direction from which the apparent wind is coming. How ***much*** more than 90° is determined by the sail's L/D and is, in fact, denoted as χ (in degrees) and equals the arctan of 1/(L/D) - don't worry about what this means if you can't be bothered trying to understand it, just punch the buttons on a suitably empowered calculator, and take the answer as read - for a sail L/D of 9 arctan is 6.3°. This is called the aerodynamic drag angle. Similarly, no matter how efficient a hull form is, you must provide push at a little less than 90° from the direction you wish it to travel in if it's to move forward at all. In fact, how *much* less than 90° the push must be provided at is called the hydrodynamic drag angle - β - and is calculated by the arctan of 1/(hull L/D). For a hull L/D = 7, $\beta = \arctan(1/7) = 8.13°$.

A measure of the overall efficiency of a sailboat is how well it will sail into the wind. In particular, the closest upwind course that the boat can sail is measured as the angle α between the boat's course and the direction from which the apparent wind is coming. Interestingly and usefully:

$$\alpha = \beta + \chi$$

For our America's cup boat:

$$\alpha = 6.3° + 8.13° = 14.43°$$

For a windsurfer, the board typically manages an L/D (planing) of about 4, so:

$$\beta = \arctan(1/4) = 14°$$

Windsurfer sail L/Ds probably reach 9 or 10 , but we need an L/D that includes the aerodynamic drag of the operator as well, so a figure of about 6 seems likely

$$\beta = \arctan(1/6) = 9.5°$$

$$\begin{aligned} \alpha &= \beta + \chi \\ &= 14° + 9.46 \\ &= 23.5 \end{aligned}$$

Smaller values of α denote greater efficiency but α is not the whole story if elapsed time around a given course is important. A craft that doesn't sail quite as close to the wind, but sails at twice the average speed through the water, will prevail in most races, but the performance of all wind powered craft be they small dinghies, ocean racing yachts, windsurfers, land yachts, ice boats, kite buggies, kite roller bladers, kite skiers, kite waterskiers or kite sailors deteriorate very quickly with small increase in α.

All kite traction can be analysed using the above tools.

For a kite buggy, reaching at, say 50km/hr on a very smooth surface, L/D is typically 100 kg/5 g - approximately 20, so:

$\beta = \arctan(1/20) = 2.86°$

For a buggy-based kite sailing boat, reaching at 20 km/hr, L/D is 100kg/20kg or about 5, so:

$\beta = \arctan(1/5) = 11.3°$

Now, you may fairly say: but I don't want to go upwind I only want to go across the wind or downwind. I say far, because the great Age of Discovery during which Europeans spread to all corners of the world, used square rigged sailing ships almost exclusively, and these ships could barely sail upwind at all! They also had a ***very poor*** L/D at any reasonable speed so they had to hoist huge areas of canvass to push along at even 4m/sec (Captain Cook's Endeavour averaged less than 1.5m/sec from England to New Zealand in 1779). They offset their substantial inability to sail upwind by just waiting around until the wind was going in the approximate direction they needed.

Few people today are willing to wait around in this way (we get impatient - even when we have to wait for the next sector of a revolving door!) So, wind powered transport craft for the 3rd millennium require high L/D ratios, both aerodynamically and hydrodynamically to enable good upwind performance. Now you may say, But wind powered craft for the 3rd millennium are not ***about*** transport," we have internal combustion power, gas turbines, even bicycles for getting from A to B. This is true. Today wind power is mainly about sport and recreation, but this is ***always*** about going ***fast***. It ***is*** possible to go very fast directly down wind in a very strong wind using something like a parachute but this type of craft is unlikely to have widespread appeal because it is so severely restricted by direction and wind speed.

To go fast ***relative to the wind speed*** requires very good aerodynamic and hydrodynamic L/D's because at these high relative speeds all courses become upwind courses from the craft's perspective of where the wind is coming from (called the "apparent" wind). This is most easily understood by thinking about ice yachts that (because of the very low friction hence incredibly high "hydrodynamic" L/D of ice runner) can sail at more than 10 times the wind speed. The "true" wind speed is such a small fraction of the "apparent" wind speed for ice yachts that the operator won't notice very much difference, will probably barely have to trim the sail angle at all between sailing upwind and sailing downwind because the wind will always be striking the craft from over the front corner and will never seem to be coming from behind. To a lesser extent, this applies to all efficient sailing craft. Especially to kite powered ice buggies, land yachts, sailing multihulls, wind surfers, and kite buggies on tarmac surfaces because for all of these craft α (the sum of β and χ) is low enough. If kite sailing is to join this group the α for kite sailing must be reduced somehow.

Kites are airfoils so hence to kites as sails: now we get to the nub of the problem! The L/D for current traction kites is usually no better than 5. After adding in the aerodynamic drag of the flier (fortunately, usually in a lower apparent wind environment than the kite is experiencing, which gives kite-traction a small and sorely needed advantage relative to conventional sails) the overall aerodynamic L/D will be about 3 or 4. This is why I have concentrated in the last 2 or 3 years on trying to improve the L/D of traction kites.

We are up against the reality that all courses become upwind courses as speed relative to wind increases, and the even more depressing reality that our competition (conventional yacht sails, including wing sails) regularly get aerodynamic L/Ds greater than 9. So far I'm unable to construct a usable kite that has a useful lift coefficient at L/D greater than 6. Kites with higher L/D can be easily built, but they all suffer from a terminal control problem in that they use their centre of the wind developed speed to build kinetic energy, which causes them to over-penetrate the edges - often by 30° or more. When their speed then dissipates, they are upwind (by apparent wind) of their operator. Many times I have then had these kites fall back down the lines towards me, allowing no recovery. This is not a trivial problem and is, I suspect, inherent to all 'real world' systems using non-rigid connections to sails with L/D greater than, say 5 or 6. I note as evidence that even very disparate kite styles - rigid, inflatable, 2 line or 4 line, - all 'top out', as their development progresses at about the same maximum L/D.

Some of us here have now individually amassed may 1000's of hours on kite buggies and kite sailing and we are getting *very* competent in our ability to keep 'over-flying' kites from doing just that - but all this skill seems only allows an L/D gain of from 5/1 to 6/1. I do notice that using these high L/D kites is an even bigger problem when winds are unsteady and/or less than 5 m/s, but this is for a different reason. I hope I'm wrong about the seriousness of this barrier, and hope that there is a simple solution because any dynamic system to counter this phenomenon will be horrendously complicated (as a minimum, the kite would have to 'know' where and what the true wind - direction and velocity - is at all times, its own speed and direction *and* have the ability to act on this knowledge).

Four-line systems do allow the operator a greater measure of control in over-flying situations, but do not solve the problem except by usually permitting quicker and less traumatic recovery. An early attempt I made at a solution to this (back in 1992) was to fly through a winch system that took up line whenever line tension went below a set limit. The result was generally that the kite ended up at the winch from behind!

As an aside, I also note that the extra drag from four lines is not generally significant for lines of less than 30 m anyway - we are sure about this, as we do lots of one-on-one triangular course buggy racing two-line versus four-line, same kite style, which soon sorts out upwind deficits of even a few degrees.

The L/D for the kite is the line angle where it enters the bridles. Of course this actually measures

(kite lift - kite weight force) / kite drag

but, knowing this, we treat this as convention and derive appropriate coefficients etc. Kite weights are usually insignificant in proportion to line pull anyway.

I really fear for the future of water borne kite traction unless someone can accomplish some serious improvement in the L/D of traction kites. Pessimistically, there has been no real progress in traction kite L/D since Flexifoils (I acquired my first one in 1978!) No matter what we do, we will never match, let alone surpass, competing wind-powered craft unless we can get kite L/D's up to 10 or more.

The situation for buggying is not so serious because their great manoeuvrability, portability and capacity for tricks have created a significant niche market that compensates for their lack of sailing efficiency. It is also true that the buggy "L/D" (especially on a hard surface) is so high ($\chi = 3°$) that α as the sum of β (kite/operator L/D which is very poor) and χ (buggy wheels on a hard surface which s often so good, so small an angle as to be negligible) still grants the ability to buggy well enough upwind (tarmac, hard sand grass) for all practicable uses. Ice buggying, and maybe now snow buggying also work well, if not fully competitive with their conventional sail powered or ski borne brothers. Kite water skiing because it can be very fast, and very spectacular, also seeks to have a secure though maybe small niche, in spite of losing in the efficiency stakes, both from generically poor kite L/D's and very poor water ski hydrodynamic L/D (the drag penalty from using water skis to simultaneously support the skier and provide the 50 kgm's + lateral resistance necessary for upwind performance may push their L/D below 3 ($\chi = 18.4°$, ouch!) Roller blades etc. have O.K. L/D but require very smooth surfaces which are very rarely available for kite traction use. Grass skis seem to have an L/D of less than 4 which is very poor but their "minimalist" form is a significant mitigating advantage.

Ski kiting on snow has an exciting future. Particularly because there are so many huge vacant frozen snow covered lakes out there and because four line kites with skis permit spectacular "aerials". Viable water based kite sailing is what I set out to accomplish in 1987 and at this point I have not succeeded in making it an activity for any but a tiny bunch of aficionados who persist with discomfort and inconvenience for no rational reasons that I can discern!

The two traction kiting developments that have been successful for me; kite buggies and Peel traction kites, were both almost accidental spin-offs from an obsessive concentration on kite sailing. This should tell me something! Either I should give up on kite sailing and work towards a more achievable goal or that I should continue to work on kite sailing as the spin-offs are worth while even if the main goal remains unattained!

I have put most recent efforts (60 or 70) completely different designs of water craft:- hydrofoils, proas, large boats, small boats, strap on body fins, monohulls, cats tris, etc etc etc) into the water end of the problem, trying to improve the "craft" hydrodynamic L/D. A problem is that we start with poor aerodynamic L/D (kites L.D 5/1) so attempting to offset this with superior hydrodynamic L/D is self defeating in the sense that any breakthrough here will likely be adopted by our competition anyway (conventional rigs). Eight years down the track I am a little wiser, having tried some ***really*** strange layouts often with flashes of potential and some that seem to offer across the board virtues. I'm sure that the New Zealand fibre reinforced plastics, stainless steel and aluminium supply industries (to list just a few) will go into serious decline if I ever give up (never!) or succeed!

The measurement systems I use are an analogue cup style anemometer, a G.P.S., for speed measurement, (reliable enough when averaged over time and with the virtue of being easily shifted from craft to craft), an accurate portable load cell system, an inclinometer and a 5 kw Honda outboard. I seriously doubt that hydrofoil L/D's above 10 or 15 are available; less after the drag penalty for creating lateral resistance is added. Also, if our hydrodynamic L/D's (weight support only, not including lateral resistance) are better (as they, currently are) than our kite L/D's, then it is better ***not*** to use kite lift to offset weight (this has been a long standing misdirection from the Amateur Yacht Research Society (A.Y.R.S.) - I think).

In fact every degree of "edge" that is relinquished to get kite altitude to enable some weight offset costs some upwind angle, (although a very soft function for the first few degrees). - The usual increase of wind velocity with height also muddies this a bit. Planing is an interesting phenomenon, but seems to be limited to an hydrodynamic L/D of about 8 for flat water, even less in waves. I've put much time into trying to devise kite powered craft that mimic the windsurfer's very clever facility for decreasing planing area as speed increases - not even available to any great extent on water-skis I think. Of course windsurfer sail L/D is high enough for it to be worthwhile their taking some weight loads aerodynamically.

More and more I've moved away from kite systems that are rigged to the boat and away from larger and more complex craft towards the minimalist and especially towards having the operator as directly connected to the kite as possible. - Mainly we've found that as we tend to higher L/D kites, anything other than direct connection between our hands and the kite line costs control/performance/reliability.

What is the state of the art for kitesailing as at 1996?

I've been working fairly much full-time on kite-traction, with a primary focus on kite sailing since 1987, having been in the fortunate position of having a business and wife that can just about support this level of personal obsession/indulgence. It's great fun and I'm feeling quite pleased with progress in the field to date (mine and others), but are warm feelings good enough? Just how does the world of kite sailing stack up as at the beginning of 1996?

Just to define some terms; I'm considering here only systems capable of upwind courses and that use kites attached by lines only (i.e. not tilt rig sail boats). There may be good things happening in some places that I don't know about but there are definitely good things happening with the Roeseler Team (Kiteski^{tm}) and Bruno and Dominique Legaignoux (Wipicat). Interestingly, there is almost no conflict between Kiteski, Wipicat and us even though we are working on essentially the same problem. The entire kite sailing field has so far seen a very good level of co-operation between researchers with little overt copying even in the absence of comprehensive intellectual property rights coverage of the breakthroughs that have occurred (such coverage is virtually impossible to finance anyway). If blatant ripping-off occurs there will be no rational justification for continuing to do the needed research anyway, so let's hope!

What progress is Peter Lynn Ltd making in kite sailing? As it happens we have been entering an open class sailboat race each New Years day for the last three years and so we have a rather objective assessment of our progress. This race, "The Clearwater Cup", is three laps of an upwind/downwind course with the main marks about 3 km apart. It starts at 2 pm irrespective of the conditions on a New Zealand alpine lake which has become something of a wind-surfing Mecca. The race is open to any sail-powered craft that weights less than 100 kg without crew and has traditionally been won by "A" Class catamarans (single person 5.5m x 2.3m x 14m ^{2} development class multihulls). In recent years windsurfers have been collecting some wins, but we are talking about very hot talent (not quite Olympic gold medalist Bruce Kendal, but some of the very few in the world who can frighten him). The upwind performance of these guys is ***amazing*** - it has to be to stay ahead of the cats.

In 1994, winds 20-30 km/hr Phillip McConnachie on a kitesailer (buggy-based) with a 5m^2 Peel started out confidently enough, rounded the first (reaching) mark but was not able to get to the top mark even once. He was put out by the tough rough conditions, poor upwind performance and being slightly overpowered.

Back again in 1995 with more experience, a new boat with the same buggy layout and a bit lighter wind (7.5 m^2 Peel) Phillip eventually completed one full lap, coming in just as the winner, a windsurfer, finished three laps hotly pursued by the cats.

In 1996 three of us started on kitesailers, wind was lighter (7.5 m^2 to 10 m^2 kites). Phillip McConnachie was on a 3.5m catamaran kitesailer with an 8m^2 4-line Paua. Pete Lynn (junior) was on an outrigger style trimaran kitesailer and I was on a 3.5m long catamaran kitesailer with almost surfboard-like hulls. All of us easily made the top mark. Our upwind elapsed times were double that of the top windsurfers and cats, our downwind times were ***under half*** that of the next fastest craft and our overall times around the course were 1.5 times that of the winner (because of spending far more time sailing upwind than downwind). So now we are half as fast as the competition upwind and twice as fast downwind; progress indeed! This would have beaten any windsurfer in the world 10 years ago. This was the good news. The bad news was that Phillip and Pete ***never*** ,made it around a mark set in the huge wind-shadow of a forested island on the way back up from the bottom mark, even the yachts could be hear cursing this shadow and Phillip with 50m lines just had no chance. I had 80m lines and the benefit of watching Pete and Phillip crash there first. They had a total of about 8 crashes here with much paddling back to shore and re-launching over about 1.5 hours. I had a total of 5 re-launches during the race (though 2 of those were before I even crossed the start line), these re-launches cost me a total of just over an hour. I finished in 4 hours 5 minutes elapsed time, the winner was a Hobbie leading a windsurfer and another cat by about 1.5 minutes to complete in 2 hours 10 minutes.

So what did we learn?

That the 4 line kite was far superior in not collapsing. Phillip's fight with the island was about having no wind there at all; he experienced no other problems with the kite, whereas Pete and I, for all our experience did lose our kites about once per hour on the average during these racing conditions.

That the big gains over 1995 came from ***hydrodynamic*** improvements. Unfortunately, there's no real chance for significant further hydrodynamic gains as the boats we are now using are highly developed. Worse still, we benefited from a break-through hydrodynamic trick which, when applied to other sailboats, will improve their performance and put us back a notch in relative terms.

That the L/D of the kites is ***the*** problem. Of course, we sometimes attain line/kite system L/D ratios of over 5 but our sailboat competitors manage sail L/D's of 9 or more. We have no chance of footing it with conventional sail craft on upwind courses until we can get kite L/S's of 9 or so as well. Unfortunately there is what amounts to a sort of natural law blocking us. This is the subject of a separate article, suffice to say that it is no accident that **all** styles of practical traction kites be they hard, soft, 2-line or 4-line have topped out at usable L/D's of not much above 5. **This is no Coincidence**.

I think our relative performance would have slipped a bit in stronger wind as windsurfers' downwind performances improve rapidly when winds exceed 9 m/s or so. In very light wind (drifters) our relative performance would slip drastically as windsurfers can "pump" and "A" cats get ***very*** slippery fast in the light.

Kite collapses and our lack of water-launching ability don't worry us too much. Both (Kiteski^{tm}) and Wipicat^{tm}) have usable kite re-launching systems and we can develop such a facility when we need to which will not be until I can find an answer to the major problem of kite L/D (if there is one!) because I won't invest the time in developing a re-launching system until I know what our kites are finally going to look like (different systems suit different kites).

I wish I wasn't committed to so many festivals (more than 25 I think) in 1996 so I could have more time for kitesailing!

One last Kite Traction thought - I recall, following a recent comment from Bill Roeseler in an A.Y.R.S. publication, having dreams during the 1970's of tethered ***sailplane*** powered water born craft hitting 200km/hr but do seriously now doubt the practicality of this. Hydrodynamic L/D's always seem to be poorer than we hope for and at 200km/hr I think an overall of 2/1 might be all that is attainable and then there is the manifest problem of controlling overflying if the aerodynamic L/D is to much exceed 5/1 and this has never yet been accomplished even at lower speeds and smaller scale let alone for a (manned?) glider acting as a traction kite and attaining an L/D of >40!!

Both Kite Ski (Cory and Bill Roeseler) and Wipi Cat (Bruno and Domninique Legaignoux) are major steps forward for kite sailing, building on the still awesome performance of the Flexifoil, powered "Jacob's Ladder" in the 1970's but kite sailing is unlikely to break in to the main stream without major L/D improvements.

Another aspect of traction kiting about which there is some misunderstanding in some quarters is size versus "power". Often I her buggiers making judgement about which are the superior traction kites on the basis of pull to area ratio ie C_L is roughly proportional to <A but L/D improves with ***decreasing*** C_l down to <A of 3^0 or so we will see larger and larger softer pulling ***but more efficient*** kites taking over market leadership as traction kiting develops.,

Of course, kite L/D is a very useful concept also for single line kites, and this has already been touched on in "Kites and $1/2pv^2$". The essential relationship is that the kite L/D ratio is defined by the angle of the kites line to the horizontal as it meets the bridles ∅ = arctan L/D. Again, almost mystically, we find that single line kites with an L/D much above 5 are not practicable but this time the reason is that single line kites become inherently unstable at somewhere around this figure. (See forthcoming paper "Single Line kite Stability"). *Editor's note: This refers to a Peter Lynn publication, not AYRS.*

At the other end of the kite L/D scale, note that kites can still fly fine with L/D's of much less than 1. L/D = 1 just defines a kite flying at 45^0 anyway. In fact, all that a single line kite has to have to be ***called*** a kite is an L/D> 0 and some stability. The effect that single line kite L./D has on the altitude a kite can attain is covered in another paper called "A Kite Altitude Model" which is an "Excel" spreadsheet based numerical model of attainable kite altitude as defined by many factors but including such as wind speed profile, kite size, line strength and ***kite L/D***.

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Conclusion

When I produced the first 'Ultimate Sailing' in 1994, after months of lobbying by Roger Glencross, I thought it was a 'one off'. Then more articles arrived and I began to realise what a great deal of interest there was in both kite power and hapas.

Great progress is being made at both ends of Hagedoorn's string, the wet and the dry (see review in Conclusion of AYRS 118), but we still seem no nearer to his goal. Didier Costes has perhaps come the closest to success with the Zeppy 2 project, but he is cheating, just a small amount, by using a lighter than air kite.

As Theo Schmidt pointed out in his 1994 paper, only Roger Glencross is trying for the 'ultimate', and this is still true today. As one of those who must admit to wearing the 'occasional smirking face' at Weymouth, I must also admit that Roger has shown 'true grit' in his continuing attempts at becoming the first 'aquaviator'.

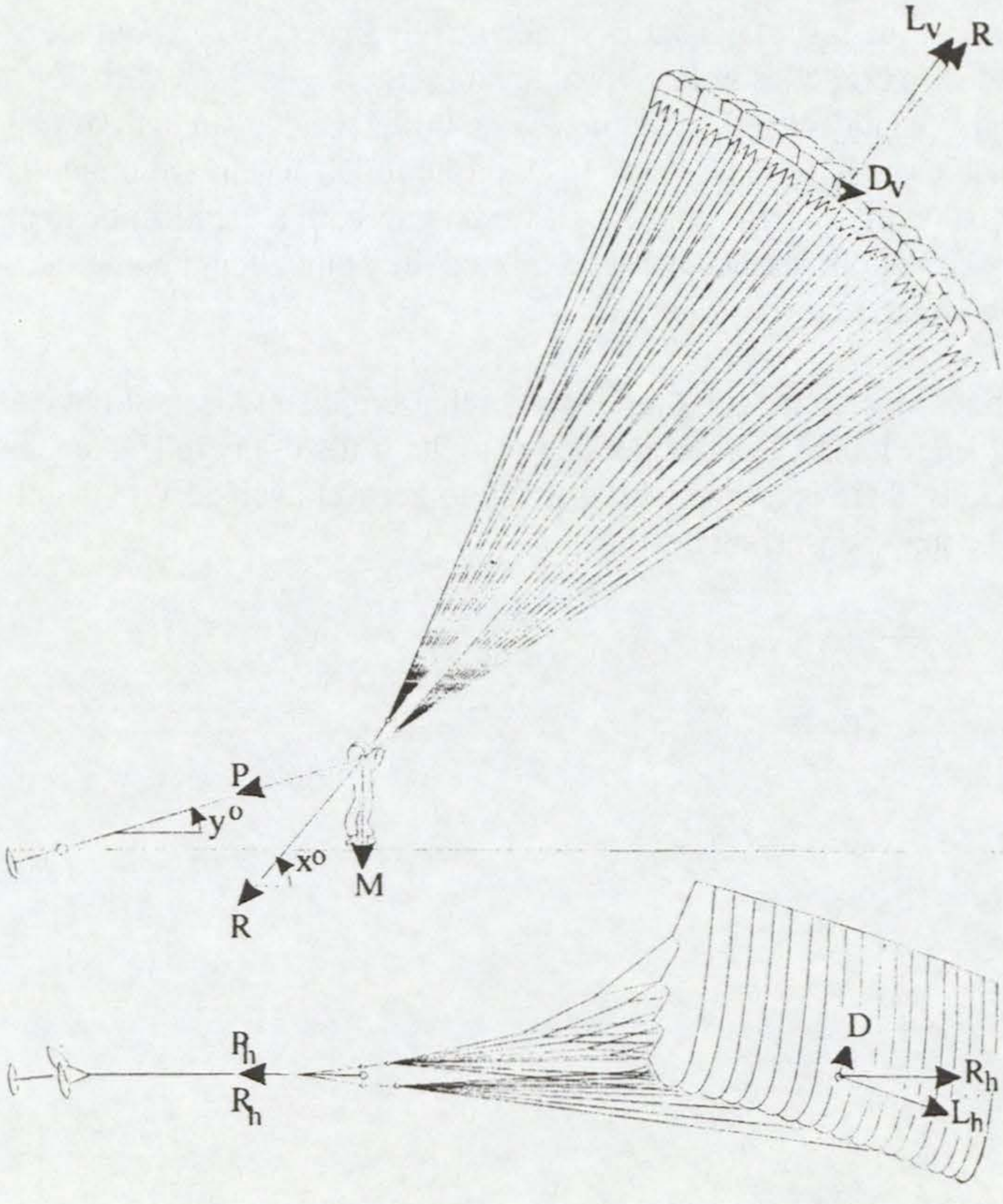
I am surprised that no younger members have taken up the challenge of this potential sport. Or is it necessary to have 'designer labels' on the hapas before any interest will be taken?

It also surprises me that I have still not received any critical review of the original paper. There are some aspects of the paper which seem to me to be quite wrong. For instance does the argument on the behaviour of long slender hulls (AYRS 114, page 13) really mean that such a hull will travel more easily sideways? Have I been paddling my canoe incorrectly! And didn't Edmond Bruce show us (AYRS 82, Page 195) that it is the shorter, beamier hulls that require the steadying skeg, not the longer, slimmer ones?

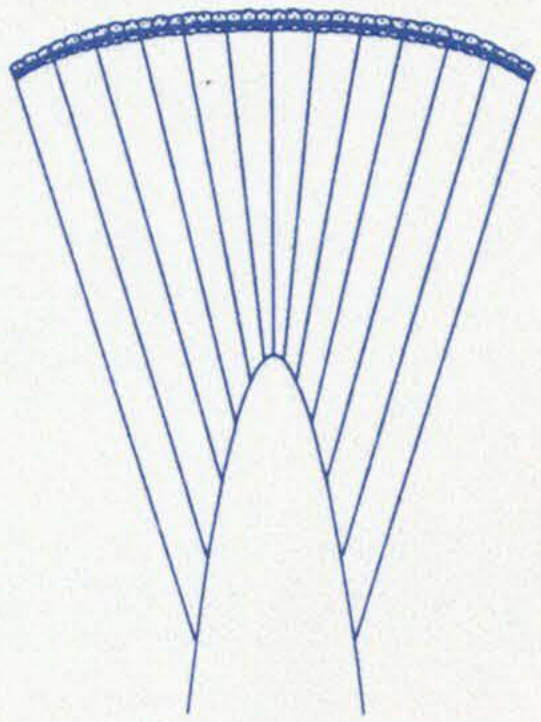
Also the analysis showing how wetted surface can be reduced by using spherical hulls (Page 18 and Figure 5 on page 20), is surely rather naive. The argument is true, but wetted surface is just one factor to consider.

I wonder whether the rest of his paper stands up any better. How about the hapa attached by a bridle leading to a single line (Figure 7 on Page 22). The leeway will presumably change with increasing or decreasing strength of pull, effectively also changing the angle of attack of the foil. This change of angle will also affect the lift to drag ratio. Don't we end up with a very disobedient 'chien' at the end of our leash? Or have I missed the point about getting rid of cramping and unnecessary restraints?

Why has nobody written in with these or any other criticisms? Have I got it wrong or did Hagedoorn? Or does nobody read the fruits of my toil? Come on you theoreticians, there is a chap who is going to get wet again at Weymouth in 1997 and he may be wasting his time.



This is the way to do it?



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