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AMATEUR YACHT RESEARCH SOCIETY

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ULTIMATE SAILING II

Kite Traction

Edited by
Tony Kitson

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Buggies, Boats and Peels

State of the Art Kite Traction

by Peter Lynn

Traction Kites

Commercial and Home Made

by Chris Sands

Sands '4-Liner'

Design for a 4-line Traction Kite

by Chris Sands

Edited by Tony Kitson

Amateur Yacht Research Society

BCM AYRS, LONDON, WC1N 3XX

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Introduction

This is the second publication in the 'Ultimate Sailing' series. In the first, AYRS 114, we republished the 1971 article by Professor Hagedoorn proposing the use of a parafoil and a paravane (which he named a 'hapa') to convey a person across the water, and an article by Paul Ashford describing the recent development of effective hapas. In this issue we consider the development of traction kites and their use over land and water.

In the last few years kite flying has enjoyed an enormous upsurge of interest and this popularity has resulted in a great variety of new designs being produced. A visit to any kite festival will reveal the wide range of creations produced by the fertile imagination of today's kite designers. Another effect of the increasing level of interest is the development of specialised kites for particular purposes. The two line Delta kites dominate in the 'stunt' flying arena, but even here there is sub-specialisation; you will probably want a more responsive kite for single person stunt flying but something a trifle more docile for use in team displays. The development of the four line stunt kites which provide even greater control, for those who can use it, is yet another specialised route for the future..

For those of us mainly interested in kites as a means of traction for watercraft it is the development of the power kites that holds most interest. The introduction of the Flexifoil kites was probably the start of modern kites suitable for traction (with the exception of the few brave souls who were prepared to risk life and limb flying parafoils as kites, see Peter Lynn's article). Flexifoils have been used successfully on a number of watercraft, in particular Jacob's Ladder, in which Ian Day obtained the C Class record with 25.0 knots at Weymouth in 1982 and Cory Roeseler whose 19.89 knots on waterskis took the 10 sqm prize at Weymouth 1988. We shall be covering the work of Billy and Cory Roeseler in a future publication. These kites are still used by many flyers as traction kites, but in recent years more specialised kites, less suitable as stunters but more stable as traction platforms have been developed. Peter Lynn describes his Peel kites and their use for traction both on water and on land, for the new sport of kite buggying, which he invented.

There is a major problem associated with kite traction for watercraft; dry kites fly better than wet ones. Even worse, relaunching from the sea is not easy, and, when you are learning the skills necessary for kite traction, relaunching is a major consideration. This is where, for the aspiring kite-sailor, buggying becomes

useful. Buggying can teach you many of the skills that you will need to kite-sail, but your relaunch assistant will not need a wetsuit and fast motorboat.

As well as the Peel kites a number of other specialised traction kites have been developed and are being used in buggying. Chris Sands describes some of these and provides his observations on their use in buggying in the UK. Chris makes his own kites and buggies, which his son, Andrew races. We also include his plans for the Sands 4-Liner, a 3sqm four line traction kite which represents his latest thinking on traction kite design.

Finally, I have produced a list of sources (of information and materials) which I have found useful and which others have recommended. Undoubtedly there are many useful sources that I have missed and I would be pleased to receive any which readers think I should know about for inclusion in later publications. In the meantime I hope that there is enough here to get you started.

Acknowledgements

AYRS member, Peter Lynn has generously allowed us to reprint 'Buggies, Boats and Peels'. This was previously published for him by the Aeolus Press. Thank you Peter.

Thanks also to Chris Sands for his article on traction kites and the design for the '4-Liner'. Chris is not (yet) an AYRS member but, like Peter, he supports the AYRS aims of sharing knowledge to promote progress.

The remainder of the publication was completed with help from Andrew Beattie and Roger Glencross.

The mistakes are all mine.

BUGGIES, BOATS AND PEELS

State of the Art Kite Traction

by Peter Lynn

In the last 18 months sales for Peels and Buggies have been growing at an almost unmanageable rate. Interest in Kitesailers is also strong. I have to confess that I'm surprised at this level of demand. Obviously kite buggying and kitesailing are going to be major new sports.

Initially, enthusiasts are coming from the ranks of kitefliers but already there are signs that the extra dimension offered by moving the flier as well as moving the kite is attracting people who previously probably would not have become involved in kite flying.

As with all new sports, this is a period of rapid development for buggying and kitesailing. Predictably, many things we think or do now will prove to have been incorrect. New ideas, and probably some that have already been wrongly discarded, will eventually take centre stage - it's an exciting time.

Many people ask me for 'How to get started' information. This is it, but I am assuming that readers have basic skills. Things like how to launch and control the kites are not comprehensively covered. Assembling buggies and kite boats is also fairly self evident and will not be covered.

KITE TRACTION

Some theory. For kitesailing and especially for buggying (because of higher speeds) the important determinant is apparent wind not actual wind. Apparent wind is the vector sum of true wind (speed and direction) and buggy/kitesailer speed and course, but only when the kite is in steady state flight, and not turning or weaving. Interestingly, when the buggy/boat speed is much higher than the speed of the true wind all courses become upwind courses. If you find this relationship hard to understand, consult any reasonable book on yachting for a more complete explanation. The consequence for buggying/kitesailing is that for good performance (except when going downwind slower than the wind) the kite(s) you use must be able to get well 'around the edge' and technically the angle 'around the edge' that a kite will hold in steady state flight is determined by

its Lift to Drag Ratio (LDR). Eighty degrees corresponds to an LDR. of 5.7. This is at the high end of what currently available kites can manage and still compares unfavourably with the sails of yachts, land yachts and wind surfers.

High LDR is, unfortunately, not the end of the story. For good buggy/boat velocity the kite must be able to get well around the edge and retain good pull when it is there. A simple way to get more pull at the edge is to use a bigger kite but this approach is severely limited by the tendency for larger kites to generate uncontrollable pull when not 'at the edge'. What we need is a big kite with 'MMR' approaching 1.0. 'MMR' stands for Maximum/Minimum pull Ratio and is the ratio of the maximum pull (for a given wind speed) that a kite will generate (usually occurring when the kite is climbing at maximum velocity and is directly downwind from the flier) to the pull available when the kite is hovering at the edge. The future of buggying/kitesailing is hostage to our success at developing traction kites with LDR above 6 and MMR much better than available from existing kites.

To confuse things further there is an exception to the requirement for low MMR. Another way of thinking of MMR is the rate at which line pull increases with increasing apparent wind. For most buggying and kitesailing we can best use a kite that develops usable, close to maximum, pull at low apparent winds but with, ideally, negligible increase in line pull as apparent wind increases from that threshold. For out and out top speed, high MMR is acceptable provided long run-ups are available. Theory predicts, and I have often experienced this in buggying, that smaller kites or kites with high MMR (e.g. Flexifoils) will eventually enable high top speeds. This will also occur in kitesailing when we start accomplishing speeds above 1.5 times windspeed, as the apparent windspeed component generated by buggy or boat speed becomes the significant part of total apparent wind. Of course the kite's available top speed is a limiting factor, as discussed later.

BUGGY HISTORY

Using kite power with wheeled vehicles has been around for a while. Probably George Pocock started it all in and around Bristol, England in the early 19th Century. His use of kites, with controllable angle of attack, to haul carriages was carefully thought through, sophisticated and, fortunately, predated overhead electricity and telegraph lines. Aiming to supersede the horse, his innovations never became established, presumably because of the unreliability of wind speed and direction. His systems would have had minimal, if any, upwind capability

and although the square rigged ships of his day were little better in upwind VMG (velocity made good) than this, at sea you can drift around and wait until the wind is in approximately the desired direction (world trade developed along the 'trade' winds). On land it is quicker to walk. Also, tacking upwind is easy on the broad reaches of the open sea but it is a little difficult tacking up a 10m wide roadway into the eye of the wind!

Practicable land based kitesailing had to await the development of buggies that can hold high upwind tacking angles, but when the wind is parallel to the road, tacking upwind on that road is still tricky, even without trees, fences and powerlines along the borders. It also demands the total absence of other road users.

George Pocock's dream of scheduled road system kite powered passenger transport is not, then, currently foreseeable but practicable recreational kite land sailing is now a reality for all normal sailing courses and doesn't even require high skill levels. Speeds in excess of 50 km/hr are easily attainable as are VMG's upwind of 25 km/hr. Current practicable wind range is 8km/hr - 100km/hr. Interestingly, downwind is the most difficult course direction for kite buggies but more about this later.

At many other times during the last 200 years kite traction has undoubtedly been used to move wheeled vehicles. I can remember, when I was 11 or 12 years old, using a kite (single line) to pull me on my bicycle across our school playground. I still bear the neck scar from when I ran into another kite line while so doing.

I confess that my kite buggy development was an offshoot of kitesailing development which had been taking all my efforts since 1987. By 1990 I had made considerable progress with kitesailing, sparked off by the first practicable steerable parafoil (a converted jumping chute) acquired from John Waters at Lincoln City in September 1987. John is one of the giants of 20th century kite development, unheralded and almost unknown because he does not travel the circuit. Thank you for this timely gift John - look what you've started.

In 1990 Ron Spaulding, organising the 1990 Thai International Kite Festival, asked if I could bring something a bit different to help their publicity and suggested kite powered trolleys. Fortunately I had a kite powered tri-hulled boat which was suffering from instability (hulls too small). Replacing the hulls with wheels and shifting from the lake to the park soon cured the problem and buggying was truly born. In late 1989 I had bought a land yacht base and powered it with a 5.5m span S55 Delta Form stunt kite to check the practicality of the conversion.

Fran Gramkowski of High Fly Kites bought this first model - Hang on to it Fran, it's a collector's item.

After the Thai Festival, development proceeded rapidly with the next three (the first stainless steel tube frame models) going to Masaaki Modegi in Japan, Martin Lester in England and Andrew Marnie in Australia. These all had larger wheels and remote steering. Although there have been many subsequent, but minor, modifications, the first current layout (0.4m diameter wheels, direct steering) went to Jurgen Lienau in Germany after the 1990 Berlin Festival. I am indebted to these people, and others who, by taking these early models off my hands created an incentive for rapid development. By September 1992 I was very content with the state of buggy design worldwide. As befits a new sport, every imaginable layout is being tried out. The direct steering tricycle buggy remains the best all round performer and the industry standard. There are now kite buggies in at least 16 countries.

HOW TO BUGGY - GETTING STARTED

Kite powered buggies are already well developed as regards portability, strength, manoeuvrability, light weight, longitudinal and lateral balance, high speed handling and lateral 'bum support'. No doubt improvements can still be made but I am quite satisfied with current designs and believe that big performance gains will now come from better kites. Assuming you can already fly the kite and have some idea of how buggying works -

first: Choose a clear area, moderate, smooth wind and a kite with pull that you can comfortably hang onto when flying statically (i.e. while standing with your feet planted firmly on the ground).

then: Set the buggy to face slightly downwind, put the kite up, park it overhead, then jump in and take off by dipping the kite cautiously down into then out of its power zone. As you start moving, steer the buggy up to a reaching course (cross wind). Repeating this 'dipping' system, hold your reaching course until you are ready to turn. Turning is almost always downwind. The basic rule is to turn the kite just before turning the buggy and to turn the buggy tight.

a tip: Keep your feet to the outsides of the steering bars. Head back on a reach to your original starting point, turn again and practise this until you can comfortably get back to your starting point. Another tip, if you find yourself going backwards put the buggy immediately on full lock (either way works but one way works best - turning upwind). This will turn you around allowing you

to try again without relaunching.

How to stop. No! You don't need brakes. Except on very grippy surfaces (eg sealed roads) the buggy is very difficult to tip over and you shouldn't be on such a surface until you're experienced. Full lock either way, at almost any speed, will cause a spin out which will stop you very quickly. Turning up into the wind will also stop you very quickly. The wimp-out way is to put your feet down. This works to some extent but you can't steer without having your feet on the bars. The fastest and most dramatic braking method is to use the kite as a brake, fly the kite back behind you. This can stop you very rapidly because stopping force is not limited by tyre grip coefficients as wheel brakes would be.

Once you get the hang of reaching, practise upwind courses. There is a balance to be struck between going low and fast or high and slow, the essence of upwind sailing. Your success in finding the optimum is measured by VMG, 'velocity made good', the component of your velocity directly to windward. Quite high courses are possible. I have registered tacks to windward that cross at less than 90 degrees, which is better than most yachts can manage, but the optimum for buggies is definitely to go faster and lower than this with currently available kites. The physics of kite sailing tells us that, for the best upwind course, the kite should be as close to the edge as it will go and as near to the ground as possible. This theory must be modified a little because the wind is unfortunately somewhat less near the ground and by the LDR versus MMR relationship of currently available traction kites, but it is still a good rule to keep in mind.

After upwind courses comes the most difficult buggying course - downwind! Surprised? The explanation is quite simple, going directly downwind you can quickly accelerate to more than wind speed at which point your kite will fall out of the sky! Actually if you're on a softish surface (appreciable rolling resistance), are using a smallish kite and the wind is light/moderate, downwind buggying is no problem. Hard surface, large kite and stronger wind and you'll have all sorts of problems. The accepted technique is to 'tack' the buggy and the kite downwind. This means heading the buggy off at about 45 degrees from directly downwind with the kite out the opposite side then to turn the kite back to your course, turning the buggy to the opposite 45 degrees downwind course just as the kite passes the centre of the wind. Turning the buggy very sharply (a minor spin out) at each change of course will help control by scrubbing off a bit of speed. I believe it is possible to attain downwind VMG (velocity made good) higher than the wind speed! It is definitely theoretically possible and, having often felt wind in my face when going downwind, it may actually be happening! Now you know how to buggy it's racing time!

ADVANCED BUGGY HANDLING

Experience grows, but it's disappointing that the general level of proficiency is improving so slowly. I hear comments from interested observers like 'That looks great, but far too difficult for me'. When these same people can see true state-of-the-art buggying proficiency they will often instead say 'That's for me'. Practice, hours of it, is the key, and not boring long run reaching either. Frequent turns (especially when you have to and not just when you want to!), racing, variable terrain, various surfaces and tricks are what you should be putting the time into. It is generally accepted in yachting that a day of racing is worth a month of cruising.

Talking specifics, there are two emerging problems. One is understeering and this has been caused by changing to fat tyres. With the original 50mm tyred spoked wheels understeer/oversteer balance (which is absolutely the key to buggy handling) was perfect. The problem can be reduced by going to a very short front stem setting. Redesigning frames to move the rear axle back could be the solution or perhaps we may be able to find front tyres with a tread pattern that will give more lateral 'bite'. The second problem is the situation familiar to anyone who has buggied on a super smooth (tarmac) surface. During turns the lines can suddenly go slack, sometimes 10m or more slack! The result may be an embarrassing kite collapse or worse, drifting followed by unsustainable pull and unpredictable direction as the kite re-establishes itself. The cause is obvious; sudden imposed loss of apparent wind; the solution is not so obvious. Slowing to a stop, parking the kite then turning is a very unsatisfying palliative. After a couple of days playing on the vast tarmac at Munich's old airport I see a glimmer of hope in better technique and skill even with two line kites. In a reversal of established practice it seems necessary to turn the buggy (momentarily) before turning the kite. This is akin to standard turning techniques for kite skating (although jump turns also work for kite skating). Quicker turning kites also help and the use of four line kites is a substantial but not total answer. In the long term this and other apparent wind change problems can be avoided by developing the ability to pull in or let out lines as we fly.

BUGGY RACING

Buggy racing is the most fun there is to be had in this world! (Sorry Eros!)

There are currently three types of racing:

1. Pursuit Racing A course, usually directly cross wind, say 100m long, is set up using two 'dunces hat' type marks. It's one on one. Start one buggy at each mark simultaneously and race either a left or right hand circuit or figure eights. One point to the leading buggy if the kites tangle causing both buggies to stop. Two points to the buggy that manages to catch the other. Pursuit racing is great for grudge matches and knock-out competitions.

2. Circuit Racing For three or more buggies almost any layout of circuit is possible but we've found racing to be best on an 'L' shaped course with the long leg of the 'L' along the wind direction and the short leg across the top or upwind end. Racing starts along the reaching short leg followed by the directly downwind leg and then tacking back up to the start. We will quite often race with up to 5 buggies and usually keep going until the winner laps every other buggy.

This is serious stuff and can take up to an hour! Any more than four or five buggies and there tend to be too many tangles but this problem seems to occur much less often as the participants gain experience. Remember that there is a very strong incentive not to get tangled up with someone else because this will likely put both of you out of contention! Using this 'L' circuit it is the downwind corner that requires the most skill. In a stronger wind getting around this corner and settling quickly into an optimum upwind course can be diabolically difficult. Doing this with an adjacent buggy doing its best to spoil your line is even harder.

To add interest we often set our course through a part of our park that has scattered trees, up to 6m high. Being able to do all standard buggying manoeuvres is one thing, doing them when you have to rather than when you want to is another matter entirely.

Don't discard the challenge of light wind buggy racing. In many ways, winning in marginal wind is a greater test of skill than strong wind racing. Operator weight obviously is a big factor in light wind but then again a heavy flier can handle a larger kite. Operator weight has a significant effect particularly on soft surfaces - wider wheels required?

3. Cross Country Racing I surmise that there is exciting potential in point to point cross country buggy racing. Beaches, deserts, even hills are okay (you can go uphill downwind, downhill upwind but you can't easily go uphill upwind or downhill downwind). What about a race across 2,000km of the Australian Nullarbor Plain? Good wind, adequate surface and very few obstructions!

4. Timed Laps. Although lacking the spectacle of having multiple buggies

vying wheel to wheel, competing against the clock avoids all possibility of line tangles and is especially satisfactory when race entrants have widely different kites and skill levels - factors which exacerbate the likelihood of tangling.

Kite Selection for Buggy Racing

There is always one kite that will win on any given day. As yet there is no kite that is sufficiently broad winded to be all conquering in a range of conditions, (but we haven't yet raced seriously with the new reefing Peels). The reason for this is that, unlike some classes of yacht racing, bigger sails don't necessarily give better performance. If your kite is too small obviously a buggy with a more powerful kite will have the advantage. If you choose a kite that is too large then sideslipping will so affect performance, especially upwind, that a smaller kite will easily beat you. There is a very narrow window, in fact on some gusty days a given kite can be too big and too small all during one race! To ram home the effect of kite selection we have found that, even when using apparently identical 5m Peel kites taken straight from stock, one kite will win every race almost irrespective of who uses it. Buggy racing with widely dissimilar kites is not much fun for participants or spectators.

Tricks

I guess it's just a beginning but here are some of the tricks we're learning.

Hanging the tail out When turning at the end of a reach, by good coordination of kite and buggy it is possible to do beautiful controlled tail sweepers. This is not necessarily the fastest cornering technique when racing but it sure does impress the locals!

Reversing For how far and fast can you travel (under control!) while going backwards flying the kite over your head?

Tacking Upwind turns are possible by bringing the kite up to the apex and down to the other edge while turning up through the wind. You must have good velocity before starting this manoeuvre. I confess that this is generally beyond me and I usually end up executing a somewhat inelegant 'three point turn' but I have seen it accomplished often enough, even occasionally during racing. Upwind tacking is immensely easier on low rolling resistance surfaces. On runway tarmac it's almost easier to turn up through the wind than to execute the usual down wind turn which on fast surfaces carries a strong risk of overrunning the kite - AW Luffing.

360 Degrees It is possible to do a 360 degree spin while at speed and continue the course basically uninterrupted. Actually it's more a matter of courage than skill, the skill comes in getting it right every time.

Two Wheeling In suitable conditions this is quite easy, even for runs of 150m's and more with at least some directional control. The technique is to start from a downwind course on a hard surface and simultaneously hook the kite into some pull, turn across wind and force your downwind thigh against the side frame.

Upwind Courses Not really a trick, more an advanced technique. When you're going upwind and right on the limit of tyre adhesion, lean forward to put the kite pull nearer to the front wheel. This balances the side pull more evenly between all three wheels and will improve upwind performance significantly.

Two Up You can buggy two up. Get your passenger to sit in front of you, feet on the steering bars inside yours. Be very careful especially with children, make sure they wear safety gear, keep their feet out of the front wheel, and watch you don't fold their legs under the buggy frame or wheels.

HIGH SPEED BUGGYING

More than one Buggier now claim speeds above 90 km/hr and although these speeds are a little scary the basic handling is sound at these and, I believe, the higher velocities that will come. As is the case with speed wind surfing, the highest speeds come, with strong winds and with downwind courses at about 120 degrees from the true wind. Axiomatic for high speed buggying is that your kite must be capable of high speeds (except for straight downwind courses in 80 km/hr plus wind!) There is no way a buggy can reach 75 km/hr plus if your kite tops out at 85 km/hr. Interestingly, kite MMR is not a problem for speed runs because as buggy speed approaches and exceeds wind speed the kite's apparent wind when at the edge rises to what it would normally only experience when at the centre. A consequence of this is that for very high speed buggying sometimes the fastest runs will come with a slightly smaller kite than the maximum size that could be handled when flying statically. As the apparent wind rises, the larger kite becomes overpowering. An important assist to high speed buggying is a firm surface. Even on the hard sands of Fano, sideways grip becomes a problem when reaching at 75 km/hr plus. I'm not sure I would have the courage to max. out along say an asphalt airport runway in a 30 km/hr wind! At the old Munich Airport during August 1992, I recorded 40 km/hr buggy speed while my

'Skywatch' was only showing 5 km/hr true wind. Of course, the true wind at kite altitude would have been more than this, but I think that speeds of 4 times true wind are now being realised. No doubt as higher speed records are established, timing and verification will get to be more formal but I find the best current system is to use a digital bicycle speedometer attached to the front wheel.

BUGGY SAFETY

The high attainable speeds are dangerous for buggiers and innocent bystanders. You are responsible for your own safety and the safety of others you may impact with. Some safety guidelines for all buggying but especially for speed buggying:

- keep clear of other beach users,
- don't attempt winds, speeds or tricks that are beyond your ability,
- check your buggy at intervals for structural integrity, loose bolts, loose wheels etc,
- stay clear of other vehicles,
- stay clear of overhead wires etc,
  (Remember you may have to let the kite go sometimes - use quick release handles, with wrist restraints, so at least there aren't handles flying through the air to damage people, possessions or worst of all, loop around electricity lines.)
- make sure you have a safe downwind recovery landing area for released kites,
- wear safety gear, helmet, boots, long trousers and jacket, etc, shoulders and elbows especially can collect grazes,
- keep fit - fit people have less crashes and less injuries when they do crash,
- running into other kite lines - necks and arms - is something to be vigilant for.

For all this, buggying is proving to be a very safe sport. I'm sure injuries will occur, maybe have already, but with over 400 buggy's in use that I know of, I'm not aware of any significant injuries having occurred. Personally I've spent perhaps 500 hours buggying for a minor line burn and less than half a dozen elbow grazes. Bicycles are more dangerous! To convince the wider kite world that buggying is safe, maybe we should institute a Certificate of Proficiency, the possession of which could be mandated for buggiers doing demonstrations at Kite Festivals. This is the most difficult buggying environment, because of close proximity to scattered crowds, other stunt and single line kites and lines and often limited space. If existing kite organisers (wrongly in my opinion) choose

to withhold insurance cover from kite buggying, this Proficiency Certificate could be a lever for persuasion. It will be unfortunate for the wider fraternity of kite flying and for buggying if the two sports go their separate ways at this time.

BUGGY DATA AND CARE

Standard buggies are 1.5m long by 1.05m track, weigh 8 kgms and are all non corrosive except for spokes, rims, front hub and rear wheel bolts. You must check regularly that the wheel bolts remain tight. A tic-tic noise usually indicates a loose bolt. If these bolts are run loose they can bend off or break inside the hub - very difficult to get out - or they can bend the back axle tube. Also check other bolts regularly but don't overtighten the rear frame bolts. Use the shortest front tube setting if you can as it will allow tighter turning. Having the headstem fairly tight will assist high speed handling - replace bushes when necessary. Tyre pressure; too low and you can roll the back tyres off. Buggy rolling resistance (75 kgm occupant) can be as low as 1 kgm (hard surface) and sideways resistance varies depending on surface but usually in the range 35 kgm to 55 kgms.

Some users add non slip coatings to the steering bars - a good idea I think - don't fit toe enclosing straps unless you are happy to break legs or ankles. But why not try velcro straps. Also no seat belts please! You will sometimes want to part company with your buggy in a big hurry! The reason for not tilting rear wheels outwards as for some wheelchairs is that it increases rolling resistance. Wheelchairs do this for armpit clearance. We do not use larger diameter wheels because they sometimes catch your flying lines on upwind courses. Fat tyres DO work better for softer sand, in fact amazingly better. Tyres of standard outside diameter but 75mm wide extend the range of ground conditions suitable for buggying to a very significant extent. I now think that balloon tyres over 150mm wide will allow upwind (just) buggying even in dry soft sand. I confess to having initially been mistaken about the efficacy of fat tyres, mislead by the results of my first attempts to use them two years ago. Keeping an open mind is obviously VERY important!

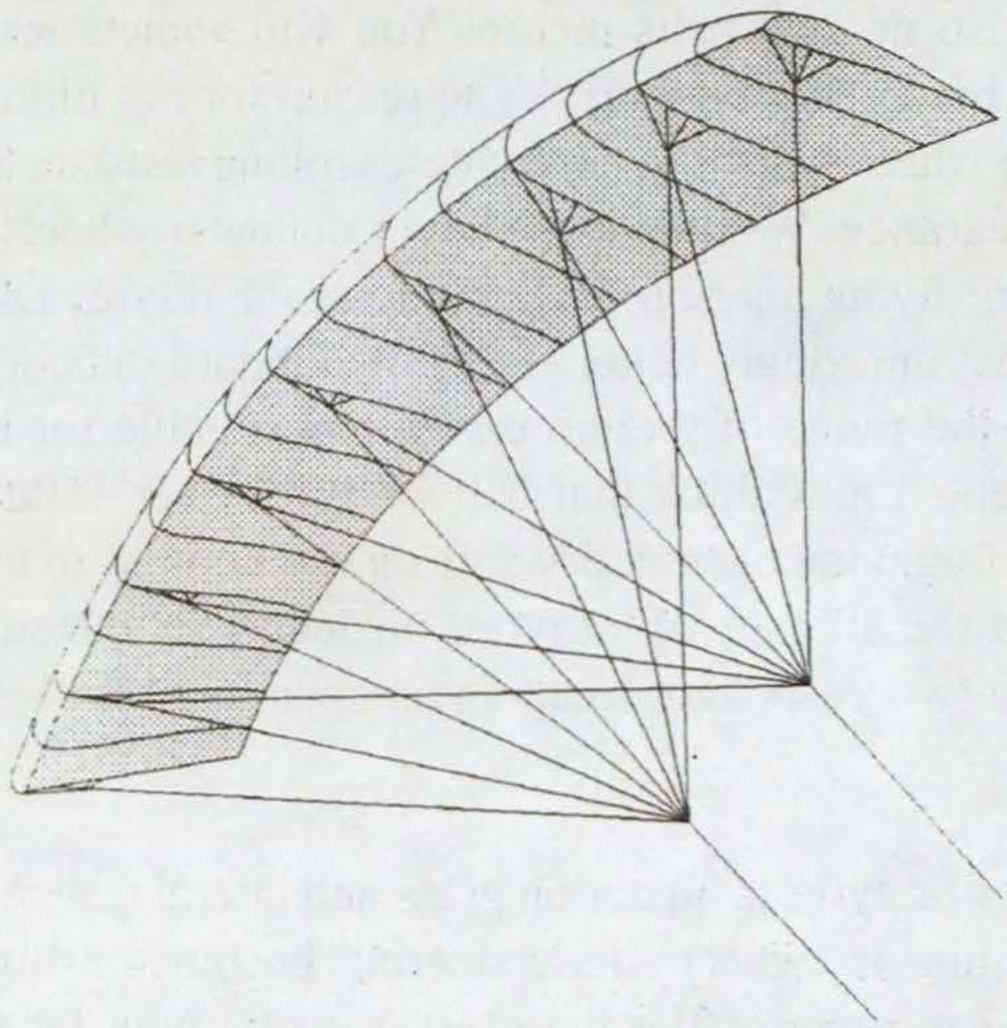
Rolling resistance for fat tyres is higher on grass and lateral resistance is slightly lower, (but tail hanging is easier). Understeering becomes a bigger problem. Tarmac performance is superior (let the pressures off) with fat tyres, and the improved ride derived from the bigger air cushion is most welcome. For multi surface use, fat tyres with high crowns work well, keeping the contact patch small on hard surfaces but allowing a bigger contact patch progressively as surfaces soften. Fat tyres on plastic wheels have also eliminated all of the remaining

corrosion susceptible buggy parts except wheel bearings. Double lip stainless steel bearings are available at greatly increased price for those buggying in salt water environments.

THE FUTURE OF BUGGYING

Of course buggies can and are being improved: wider wheel options, all non corrosive components (buggiers love beaches!) and lower prices through volume manufacture, but the big short term gains in buggying will derive from better kites, development of which is now the subject of much serious thought by various kite designers.

I look forward to regular organised racing; local, national and international. Buggying's considerable novelty and spectacle is generating extensive media exposure. Some international kite festivals now include formally organised buggy events and a number of speciality buggy-only events have been and are being organised in many countries.



KITE BOAT HISTORY

Using kites to pull boats has an even longer history than land kite sailing. 17th century illustrations show kites rigged to extract even large sailing ships from wind shadowed harbours. It seems very likely that kites would have been used much earlier than this to pull smaller boats, canoes or even swimmers.

I define practicable kite sailing as the ability to safely handle all normal sailing courses (upwind, reaching, downwind) in a reasonable wind range. Kitesailing took a huge step forward with the development, in 1978, of Jacob's Ladder, a pair of extended Tornado catamaran hulls powered by a winch controlled Flexifoil stack. This setup held the C class sailing speed record at 25 kn from 1982 to 1988. Later specialised speed record kite sailers have contributed extensively to theory and practice. Much more work is needed but kite traction for boats now seems to have an exciting future, certainly in the quest for speed and for one-person, specialised, enclosed water kite boats (occupying a similar recreational niche to windsurfers) and probably as emergency or auxiliary sails for blue water yachts.

My own kite sailing experiences started relatively recently (November 1987) but by 1992 had covered 26 purpose-built prototypes encompassing many (mostly crazy) forms: monohulls, planing boards, specially designed waterskis, catamarans, trimarans, hydrofoilers, etc. To the extent that negative data is as useful as positive results in the innovation process I can report solid progress! In retrospect I am lucky to have survived at least a couple of the spectacular crashes I incurred on the kitesailers that had the kite lines rigged to their structure rather than being attached through the operator. Being dragged, submerged while tangled in the structure of a capsized kite boat hauled by 20 square metres of two line kite that unaccountably decided at that time to fly stably, in a 50 km/hr wind could be regarded as a necessary pioneering risk but I am now very firmly of the view that quick release systems must be of the 'dead man' type that release automatically when you stop doing something. (I fortunately became disentangled after the first 100 metres or so, the boat continued for some kilometres up the lake, through a swamp, through the fringing willow trees and on up the rising ground till jamming in a rocky crag from which its remains were retrieved, kite still flying, an hour or so later).

Having taken as a goal aims quite different to those of the specialist speed record attempt kitesailers I am very pleased with the 'state of the art'. Protypes 22 to 26 meet all my criteria of air travel portability, 8 kmh - 100 kmh wind

range, all courses, safe, easy to use and not too expensive to make. Some of my prototypes are now in use in Germany, Australia, Italy, and Holland. A concern that remains is speed. Upwind VMG on current models is quite satisfactory being about up with windsurfers. Downwind VMG is, I think in general, superior to windsurfers but reaching speeds are only half that for windsurfers (maximum so far over 30 km/hr). The smaller (mk 26 style displacement/planing) hulls give superior speed but have problems getting out upwind through breaking surf (say 1m or more) without capsizing. Tests seem to be pointing to technique rather than design changes as the solution. I observe less problems as experience builds.

Using our quick release handles system there is now no great physical strain in holding a course. I have easily held a tack for more than 5km and would not hesitate in taking on an ocean passage as the craft are positively buoyant. Using an Argos or GPS system the worst that could happen is a call for rescue. An on-the-water kite launching/retrieval system is essential however and not yet available. I have now the precursor of such a system that works most of the time for 10-30 km/hr on flat water. It is being improved all the time.

My greatest insecurity is that one or more of the radical approaches which I tried may have been rejected because of insufficient perseverance or absence of some trivial modification. Analogously, the search for successful innovation is equivalent to blundering around in a fog-bound landscape comprising various hills of unknown attitude. The innovator's task is to find and ascend the highest hill. Arriving at an incline the innovator, if well organised and disciplined, may eventually attain the pinnacle of that particular hill. Unfortunately, there is no way of ensuring that an adjacent or more distant hill may not be higher! For kitesailing does it matter? Any hill that's high enough will get the sport started. Optimisation can come later.

KITESAILING: THEORY AND HOW TO

Getting skilful at buggying is of great assistance for kitesailing but kitesailing poses a whole new set of problems. On the plus side, underwater foils can withstand huge sideways forces, even at quite low speeds. In fact there seems to be no practicable limit on resistance to side pull - the limit is capsizing or leaving the water. This is not as bad as it seems. It's when you come down that the big problems occur!

My 1992 model kitesailers are quite versatile - under 20kgms packs to 2.15m

x 0.6m x 0.2m. (3.3m x 1.75m x 0.6m assembled), capable of sailing upwind in the wind range 5 km/hr to 100 km/hr (in the extreme limits). I tried many different layouts but, against theory, the one hull in front, two at the back seems to work best. Two hull layouts don't turn fast enough. Two front, one back is too complicated (steering), has a wave drag problem (bum clearance), is heavier and seems to tip easier. Monohull layouts are just not satisfactory at this time. Kite pull varies so much that they behave like Pooh Bear's honeypot, being much more interested in floating with them on top and you underneath than in the conventional air breathing relationship. Nothing is settled yet though. A practicable zero heel system for attaching the kite to the boat structure would re-open the layout options. One thing I think I know for sure is that for kitesailers the rudder must be at the front. Having the rudder at the front effectively eliminates the otherwise frequent occurrence of 'getting caught aback' - the 'nose into the wind, kite pulling over the stern' scenario which generally precedes the 'big turnover'!

I believe that planing hulls are a must for high speed but we are not yet attaining speeds using kitesailers that can be easily maintained using kite powered water skis. Also I am awed that a Flexifoil stack powered Tornado catamaran (displacement hulls) has averaged 25kn for 500 metres. I can't get anywhere near this average yet, couldn't even do this speed momentarily and certainly regard the 38kn for 500m reportedly attained by the Durand kitesailing team in France as being from an alien universe! Of course, I have been aiming at developing an easy to use, safe, inexpensive, all normal sailing courses, broad wind range kitesailing boat to be widely available and I have not yet had the privilege of sailing along the especially constructed, flat water, high wind, downwind, 'French Trench' speed sailing course! But, kitesailing is now practicable and accessible. The big problems, interelated, are: absence of a usable on-the-water kite relaunch system (I'm trying!) and apparent wind luffing kite collapses which are a much more serious and intractable problem for kite boats than for buggies.

The theory for kitesailing is very much as for buggying particularly with respect to kite requirements and flying techniques. Because relative kitesailing speeds do not yet approach the 3 times and more multiplication of true wind speeds available to buggiers, low kite MMR is a greater requirement. Paradoxically, kitesailers manage higher relative speeds in light (less than 10 km/hr) winds than buggies do. Boat drag rises from zero at zero speed, buggy drag starts at about 5kgms but doesn't rise much with increasing speed. Because boats also have to contend with waves and a higher drag penalty for available leeway resistance, their upwind performance is not as good as for buggies.

APPARENT WIND LUFFING (AW Luffing)

The particular kitesailing problem with AW luffing is because, when the operator senses an impending luff, there is rarely sufficient boat velocity - momentum or manoeuvrability - to permit the quick flick to a more upwind course that would save the same luff on a buggy. AW luffing is not the kite's problem as it is caused by suddenly moving the kite into a zone of negative angle of attack wind but good kite design can alleviate the problem somewhat.

Unfortunately, bad kite design can also alleviate the problem! Using a kite with a high drag profile (low LDR) that is incapable of penetrating very far around the edge will remove much of the risk of luff induced kite crashes. There must be a better solution as this also prevents satisfactory upwind sailing. Operator skill is one answer but I've put in lots of hours on the water and am not bullet proof yet. Mind you I'm a slow learner, more cerebral than intuitive as a kite flier and judge myself to be well down the bottom of the skill pecking order. Sailing in smooth wind cures the complaint but is not very often possible.

All kite styles are susceptible, (even four line kites). A simple relaunching system would be a substantive answer but better flier technique will always be necessary. The skill to develop is sensitivity to the kite via appreciation of its position, direction, velocity relative to the wind and line tension.

Impending luffs are always signalled by a drop in line pull. Sensing a luff, turn the kite quickly away from the danger area back towards the centre of the wind. In spite of AW luffing problems, uninterrupted kite sailing jaunts of more than 2-3 hours are now easy enough.

Turning Because kitesailers won't turn as tightly as buggies, the standard technique is always to turn downwind, (I have never heard of a successful kitesailing upwind turn) and to keep the kite lines approximately in line with the boat's axis as you go through the turn.

Surf Kitesailing in surf requires a special technique especially getting out to unbroken water when the wind is directly onshore - and if the wind is off shore should you be going out at all? Being lost at sea may be character-building but is not always survivable and could give the embryonic sport of kitesailing a bad name! To get out through surf into the wind I start with the kitesailer out a little distance with its fins stuck in the sand and set up parallel to the beach. Launch the kite, park it up, wait for a wave to float you off then hook into some kite pull and immediately steer up into the wind as far as possible while maintaining

reasonable velocity. When a breaking wave approaches, steer directly into it, keeping the kite powered up to pull you back on to a reach as soon as you're through the wave. Repeat this process until you're clear of surf - it usually works!

Crashes Attach a surfer's lanyard between you and the kitesailer. In this way, if you get capsized or hauled out you won't lose contact with the boat and, provided you have the presence of mind to keep the kite up, can almost always right the boat and get going again. If you crash the kite, stay on the boat, wind the lines up, place the kite on your lap and, taking the hand paddles you had thoughtfully tied to the seat back before setting off, paddle to the nearest land, relaunch and sail home in style!

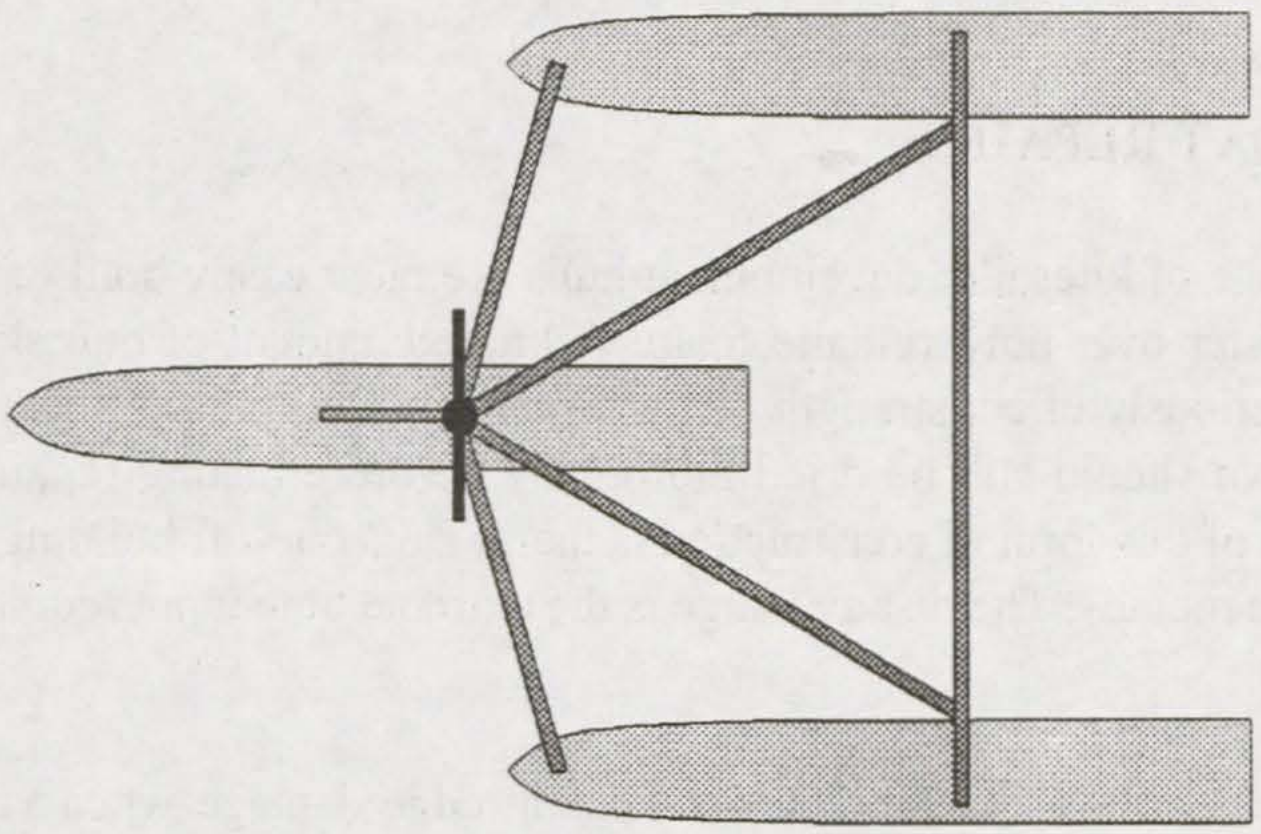


Figure 1. Kite Boat

KITE BOAT SETTING UP

My 1992 kitesailer and replicas can be set up for different conditions by fitting washers or spacers under the hull mounting bolts to change the angles of the hulls. By setting hulls with more 'nose up' they will be more resistant to nose diving (front hull) and capsizing (rear hulls). The boat will then also plane more easily. The penalty is that setting the bows up increases displacement mode drag (low speed performance suffers). Up to about 10 degrees doesn't seem to cause a noticeable low end problem however. Earlier models with pivoted hulls should have eliminated this compromise but tended to suffer from going too 'nose up' at higher speeds. Current thinking is to use controlled flex of the structure to trim the hulls back flatter at higher speeds. Seats should be set as low as possible to keep the pull line low (to resist capsizing) but not to the point that your bum drags in the water.

KITE BOAT REPAIRS

At this stage of kitesailer development hulls are most easily built of glass fibre and polyester over polyurethane foam. A limited amount of hull skin damage will not seriously effect strength or performance. The foam is relatively water resistant but should still be dried thoroughly before effecting repairs. The big advantage of this form of construction is that it suits one-off building, as it does not require moulds. The disadvantage is the extreme time input required to get a fine finish.

Fin Damage Fins inevitably suffer leading edge damage when you run into obstructions. Usually it is sufficient to reshape the damaged area with sandpaper etc. Severe damage requires rebuilding. Leaving the kitesailer fins stuck into the sand in breaking surf can break the fins off. Water forces are enormous.

BLUE WATER

Longish ocean passages are tempting (to me anyway) because getting away from turbulent landwinds is a fantastic buzz. Some suggestions:

1. Use a quick release harness because arm strain becomes unbearable after even 15 minutes holding one tack.
2. Keep an extensive shoreline downwind of your position in case you have to get back by paddling or drifting.
3. Use an escort boat.

SAFETY

1. Drowning should be avoided. Wear a wet or drysuit, lifejacket, and neoprene cap and boots to protect against hypothermia.
2. Be careful not to get caught up in the kite lines during an emergency. Sometimes kites will luff, fall back downwind then re-engage the wind suddenly and with uncontrollable pull. Quick release handles are good safety insurance.
3. Don't even think of attaching the kite lines and/or yourself to the boat without a 'deadman' type link unless you want to die.
4. Consider other water users. Released handles could easily snare and seriously injure a passing wind surfer.
   I once snagged and tipped over a 4.5 m catamaran this way. Even lines released from Q.R. handles are not 100% safe. Floating lines winding into propellers is a nightmare scenario.
5. Regularly check your boat's structural integrity. A broken cross tube could cause painful injury during a high speed capsize.
6. When kite launching, give yourself plenty of downwind space to slide while you're getting the kite under control.
   I once burnt the soles of my (bare) feet while launching and another time slid into and broke off a substantial roundwood fence post.
7. On the other hand, over water is about the only case when 'kite jumping' can be safe. Bailing out of a kitesailer can be fun!

KITESAILING FUTURE DEVELOPMENTS

I have been concentrating on developing the T.S.P.K.S. (transportable singleperson kitesailer) and this has a good chance of gaining popularity especially if the lack of an on-the-water kite launching system can be rectified.

There are other exciting possibilities for water based kite power:

* Although I consider blasting downwind in a gale behind (what is effectively) a parachute, as cheating, if kitesailers can get the world sailing speed record (approximately 43kn) this way then they'll get my applause.

* Kites could be developed as auxiliary or emergency sails for yachts, fishing boats, power boats, etc. (even big ships?). A simple left or right bias settable single line parafoil could easily be included in most boat's safety inventory. In cases of dismasting or motor failure the kite would get you home. Upwind

performance wouldn't be necessary but might be possible. A choice of course, downwind plus or minus 45 degrees, would always get you to land eventually.

* Trans oceanic kite sailing. Complicated and sophisticated kite launching/ retrieval systems are definitely feasible but don't seem currently cost effective on small single person boats. They would be feasible for 10m and up multi crew ocean going boats (who takes the midnight to dawn kite flying watch? - Robert Loera claims he can fly stunt kites in the dark!). An added advantage of launching/retrieval winch systems is that they can be contrived such that the kite pull is always through the boats hydrodynamic centre of pressure - no substantial heeling forces, hence monohull craft would work fine.

* It is possible to use a kite to pull a windsurfer-type board with the flier standing up and flying the kite through a pulley at deck level (to keep tipping forces within bearable bounds). I've tried this. Getting started is a bit tricky and steering is not as sharp as necessary for consistent course making. What about adding foot operated pressure pads linked to a rudder?

1992 has witnessed some exciting developments in kitesailing. There has been a challenge proposed as a focus for further development, a kitesailing race across the English Channel. I would like to kitesail my entry in this event from New Zealand to England and am convinced now that this is practicable. However, available time and resources should be going into fundamental system development not into grandstanding publicity stunts like this.

* I am now certain that the water launching problem can be solved, soon and in more than one way. Four line kites can usually be relaunched off the water, but winch systems may be the definitive answer.

* Apparent wind luffing problems are now obviously solvable, substantially by using four line kites and totally with winch systems.

* Traction kite development is advancing rapidly all over the world. For example from France, the Legaignoux brothers, after 4 years full time development work, have announced a range of 4 line controllable kites in the 7sq m to 17sq m range specifically for kitesailing. - More about 4 line traction kites under 'Other Available Traction Kites'.

'The future holds more wonderful devices than even our imagination's imagination can imagine'.

PEEL HISTORY

One day in 1988 I sat down and listed the ideal features for a traction kite, attempting to anticipate in advance what the traction kites of 2015 will look like. Some of the listed features, in addition to the fundamentals of good Lift to Drag Ratio and satisfactory MMR (maximum pull/minimum pull ratio - see later explanations) were: ability to scale up to large sizes without deterioration of the weight/area ratio, full options for airfoil profile, robustness in crashes (especially when being swilled around in the surf) and at least a potential for automatic reefing (some way of making the kite smaller automatically as apparent wind increases). Ease of packing and 'soft is safe' were bonus features after I had already decided to attempt a soft stunter. The direct lineage of the Peel design was an evolution from the old 20sq.m. two line parafoil I had been given by John Waters while at Lincoln City in 1987. The problems faced were to dramatically improve LDR and control without causing a luffing problem. Soft kites also have the inherent problems of necessary bridle complexity and a tendency to collapse when flown into wind pockets (their form holds only when there is positive air pressure available from relative motion). After thirty three prototypes and numerous frustrating re-cuts and re-rigs the first satisfactory Peels were coming through intermittently during 1990 and I started using them at festivals during that year.

Chasing those essential characteristics for traction kites LDR and MMR, I tried every possible airfoil profile from a wedge to a Flexifoil clone. At first I could find no window between poor tracking (the ability of the kite to hold a horizontal traverse without 'mushing out', especially in light winds - kites that fail by this measure will gradually require to be pointed more and more upwards even while maintaining a horizontal course) and luffing (tendency of the kite to collapse catastrophically when the angle of attack becomes negative).

I differentiate two forms of luffing. One occurs when air flow sets up a couple with one force lifting the trailing edge while another force pushes the leading edge down. This form of luffing is inherent to the profiles used and to the bridling setup and can occur even during steady flight in smooth wind. It is absolutely unacceptable. I call this form of luffing Centre of Pressure migration luffing, CP luffing for short. The other form of luffing occurs when the kite experiences negative angle of attack. This can easily occur when flying in turbulent winds or even just when high speed/momentum carries the kite out past that point at the edge of the wind where it is, in the limit, able to hold steady state flight. This is a huge problem for kitesailing because unless you can walk on water there's not much you can do to stop it once it starts happening.

When flying statically (i.e. standing on the ground) fliers instinctively, unconsciously take a quick step backwards to hook the kite back into some movement relative to the air - the prerequisite for continuing kite inflation. I call this form of luffing Apparent Wind luffing. AW Luffing for short.

For a while I despaired of usable solutions and went back to developing delta form rigid frame stunt kites. For reasons explained later this kite style has fundamentally good MMR, a feature that I am sure is well understood by Don Tabor from San Diego to whom the kite world owes a huge debt for the development and popularising of this kite style. Building larger and larger delta form kites (up to 5.5m wingspan) I was eventually defeated by a scale effect problem. Lift increases as the square of span but strength requirements increase as the cube of span. Big rigid kites suffer terminal handling problems because they must be too heavy for their area. For all this, large rigid structure kites (carbon) could yet become the dominant traction kites as their shortcomings are circumvented or if the alternatives prove to have worse failings. Likewise for stacks of smaller rigid frame delta form kites which I have, at least temporarily, given up on because of launching problems and their tangle susceptibility when crashed - especially in rolling surf. Also tube breakages can be a nuisance.

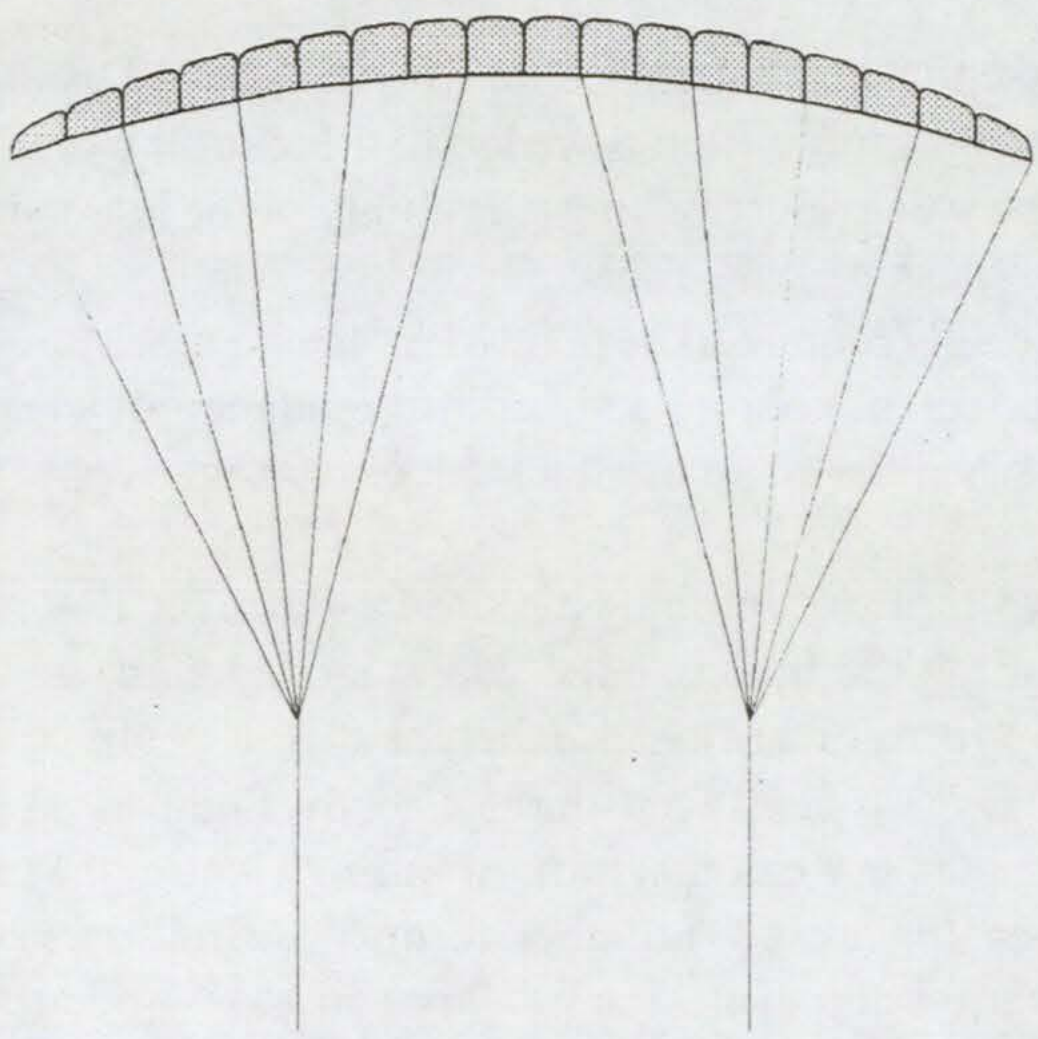


Figure 2. Separate Bridles

Returning to soft stunter development I decided to just put up with poor tracking and bridle the kites back to eliminate CP luffing while I concentrated on control/ steering development for a time. By October 1990 I had tried a large number of systems starting with separate bridles to each side of the canopy, as for the original John Waters parafoil and the Paraflex. This caused a loss of performance through canopy distortion..

The next attempt was to use a semiflexible bar spaced out along which were bridles to the individual cells and below which were various criss-cross or linked 'Y' bridles connecting to the flying lines. This worked very well but was an 'impure' use of a rigid member in a soft kite. Next came the catenary bridle; the flying lines are set up as a continuous loop with individual cell bridles attached to it at various spacings. With this I could not get tight turning without unacceptable canopy distortion and large arm movement. But I have since seen this type of bridle used entirely successfully by Nop Velthuizen in Holland even on 5m² soft stunters.

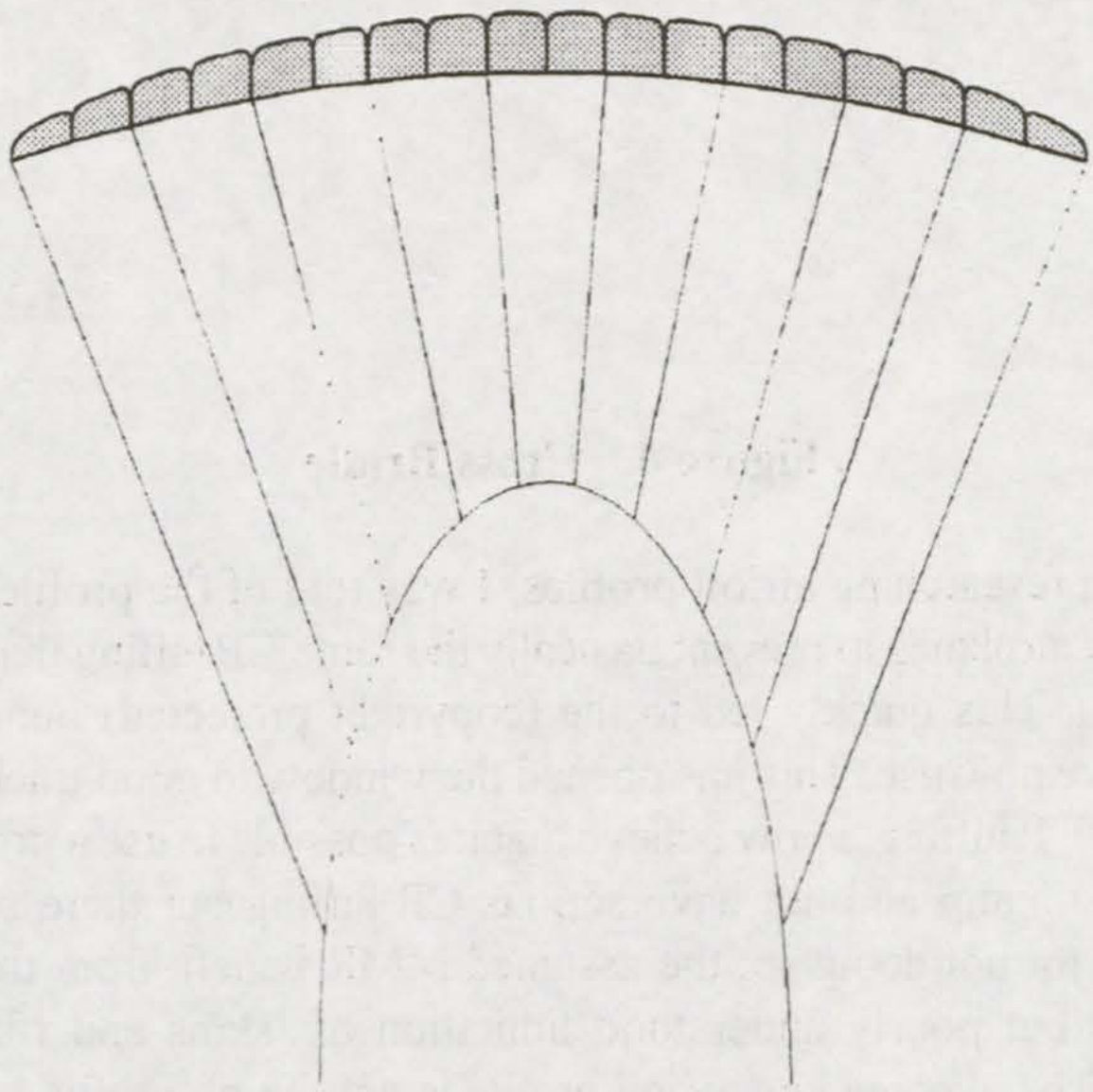


Figure 3. Catenary Bridle

Next I tried a complicated cascading pulley system which worked satisfactorily but then hit on the current (and copyright protected) cross bridle system which is simple, causes minor if any canopy distortion and allows tight turning without excessive arm movement even for 7.5m wingspan kites.

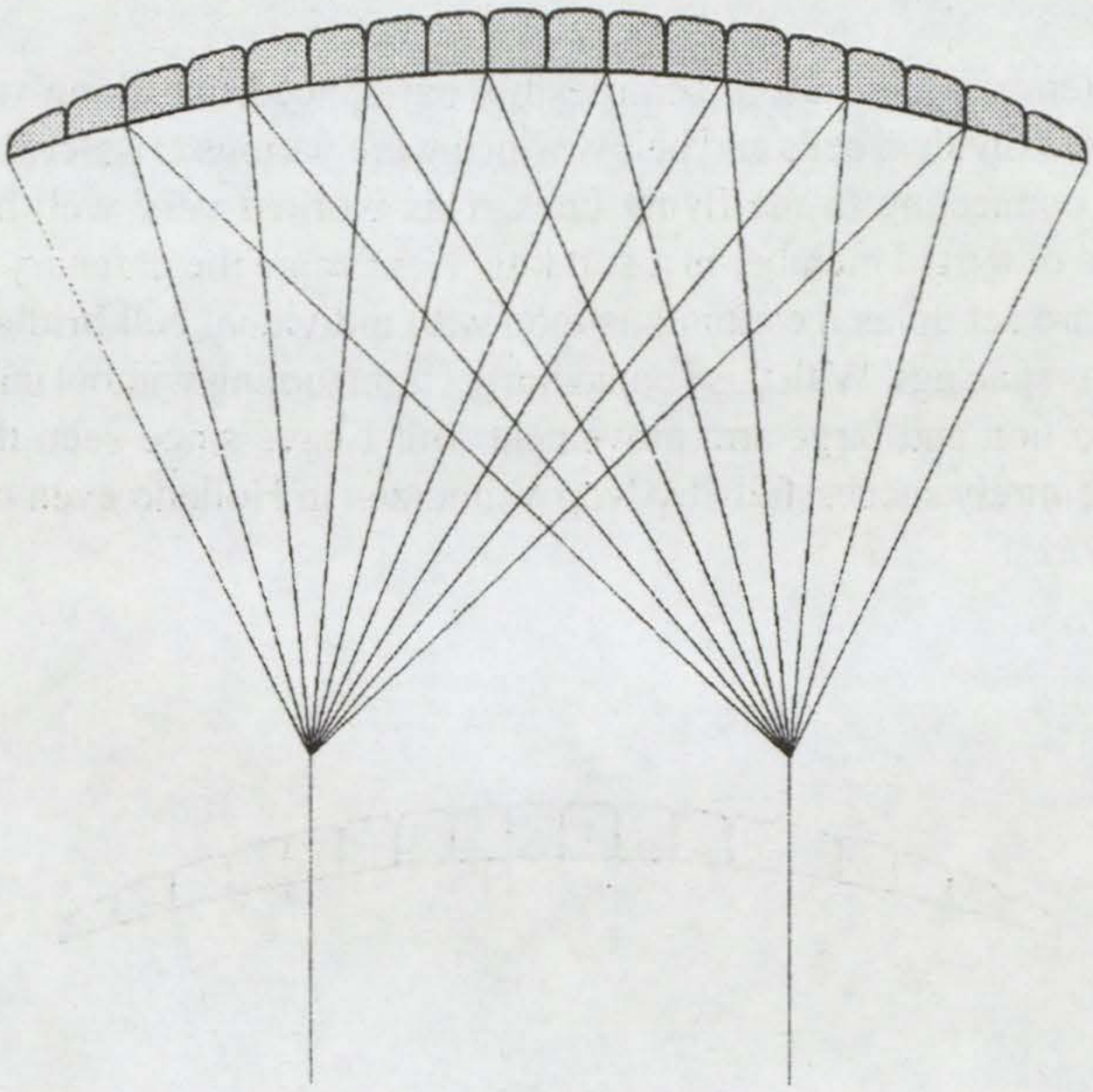


Figure 4. Cross Bridle

In early 1991, researching airfoil profiles, I was told of the profile forms used on flying wing airplanes to prevent basically the same CP luffing that Peels were suffering from. This quickly led to the (copyright protected) humped trailing edge profile we now use. This has opened the window to good tracking and the elimination of CP luffing. I now believe that it is possible to use a profile without a trailing edge hump and not have serious CP luffing but there are currently other reasons for not doing so; the assumed MMR benefit from the hump and also a simple but poorly understood limitation of 'skins and ribs' soft kite construction. The average kite airfoil profile is not the rib profile but is always deeper, particularly at points where the cell width is much greater than the rib depth. I am always much amused by the mega precision and mega computer optimisation that is claimed for some soft kite rib profile airfoils. The rib profile

applies for less than 1% of the kite! To accomplish a perfect wedge shaped trailing edge, an infinite number of ribs would be required. Practicable rib spacings always cause 'coal sack' type distortions along the trailing edge, seriously disturbing airflow exit and placing a limitation on attainable LDR of maybe only 15 or so (good sailplanes manage a wing LDR of over 100 !). The humped trailing edge may cause less form drag than conventional trailing edge forms - think of the wedge shaped low drag shapes currently fashionable in car design. By using the humped trailing edge the window has opened very wide. I can now bridle Peels far forward of the position where the lift coefficient drops out of the useful range without CP luffing becoming a problem.

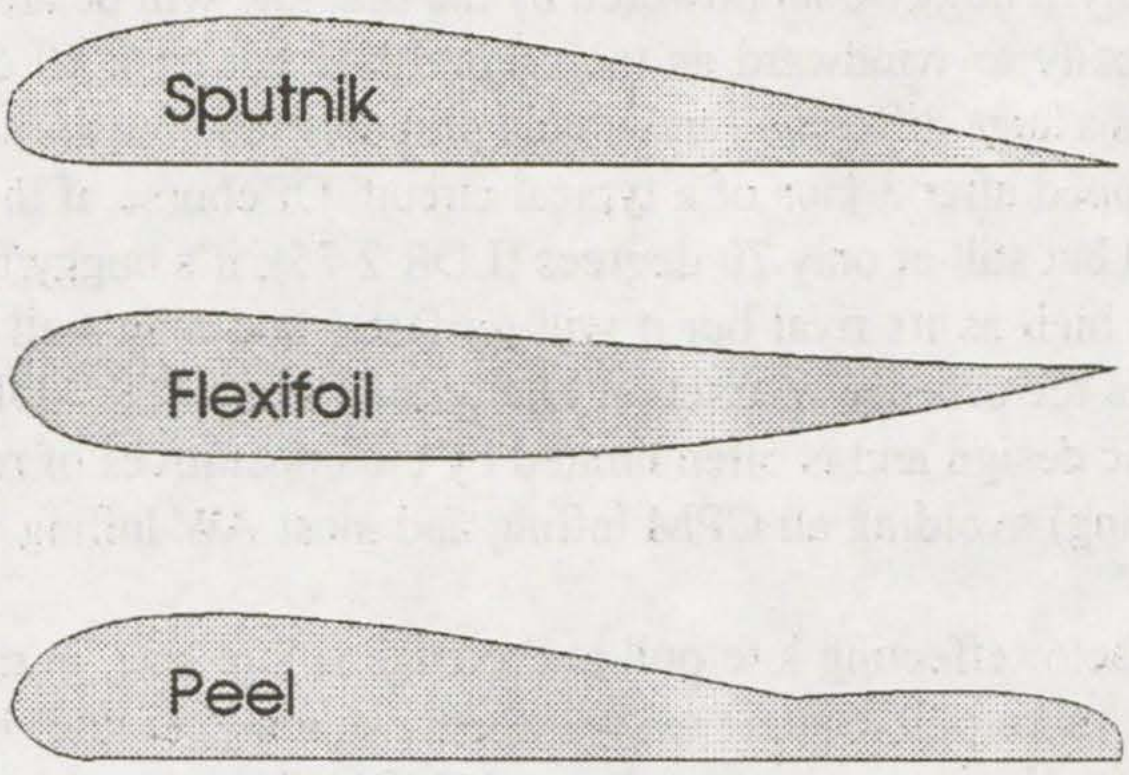


Figure 5. Rib Profiles

There was always a solution to the CP luffing problem. The Paraflex design from Wolfgang Schimmelpfennig and Wolkensturmer uses bridles only in the forward 25% of its chord and an airfoil which seems to be evolving towards the Flexifoil profile. This is an excellent vice free and exciting kite to fly but does not seem to have a satisfactory combination of LDR and lift coefficient to allow satisfactory upwind performance for kite traction application. As for the Flexifoil, it could be quite suitable for speed record use where sufficient 'run up' is available for apparent wind to build. A basic explanation of this limitation may well be to think of only the forward 30% (the bridle supported portion) of the Paraflex as being the effective lift creating area with the remaining 70% just along for the ride, for visual effect (as used in the very effective Snoopy and Big Boss type decorative kites) and to act as a sort of anti-luffing 'whales tail'.

To complete the Peel history requires introduction to the final member of the Peel innovation troika: cross bridle, humped trailing edge and, as from the patent filing date of June 1992, the reefing bridles. First must come a thorough explanation of how the characteristics of LDR and MMR can be combined to make a good traction kite.

Accepting that as buggy/boat speed reaches true wind speed and above (see Kite Traction), all courses tend to be upwind courses from the kite's perspective, it is essential that the kite has good LDR and as much pull as possible when it is 'at the edge' (see definitions). LDR is a measure of how far around the 'edge' is for a given kite and apparent wind. Eighty degrees, representing a LDR of 5.7, is currently a very good LDR for a kite. If a second kite can only manage 70 degrees at which 'edge' it has the same pull as the first kite at 80 degrees then, quite accurately, a buggy/boat powered by the first kite will be able to maintain the same velocity to windward as the second kite but on a 10 degree higher course. This is a huge difference and would probably result in the second buggy/ boat being lapped after 3 laps of a typical circuit. Of course, if the second kite had more pull but still at only 70 degrees (LDR 2.75), it's buggy/boat won't be able to go as high as its rival but it will go faster and may well prevail. This compromise is the essence of traction kite optimisation. Kite LDR is largely a matter of basic design and is often limited by the imperatives of retaining good control (steering) avoiding all CPM luffing and most AW luffing.

The biggest factor effecting kite pull at the edge is kite size, in general bigger kites generate more pull. Simple answer then: use a bigger kite! Unfortunately kite size is limited by its maximum pull (see MMR definition) not by its pull at the edge (minimum pull). Too much pull and you capsize (boat), slide sideways (buggy), or fly into the air (boat and buggy), all of which are highly detrimental to progress! To allow the use of a bigger kite for superior performance upwind we need to also have a kite with low MMR. Of course, for buggying/boating off the wind (apparent wind hitting your back) high MMR is no great disadvantage, but in most buggying and much kitesailing this rarely occurs. There are many ways of improving MMR. The ideal system would retain constant high LDR while holding pull constant at its maximum usable value for all significant wind speeds. There are no available systems on any available kite types which even get close to this ideal.

Now back to Peel development history. In its standard 1991 form Peels have good LDR quite satisfactory MMR, no CP luffing and can, with experienced fliers, avoid AW luffing at least as well as other available traction kites. I have tried very hard for some years to improve the Peel MMR still further. It is now

possible on 1992 peels to use spring bridling that moves the bridle point automatically forward as pull increases thereby decreasing theoretical maximum pull by at least 25% without causing CP luffing. This seems like an ideal solution to better MMR but it has an (expected) side effect. Bridling forward increases the speed of the kite through the air which increases the pull proportionally, offsetting much of the pull reduction accomplished by forward bridling in the first place. Accordingly the best solution seems to be to make the kite smaller as pull increases - a reefing system.

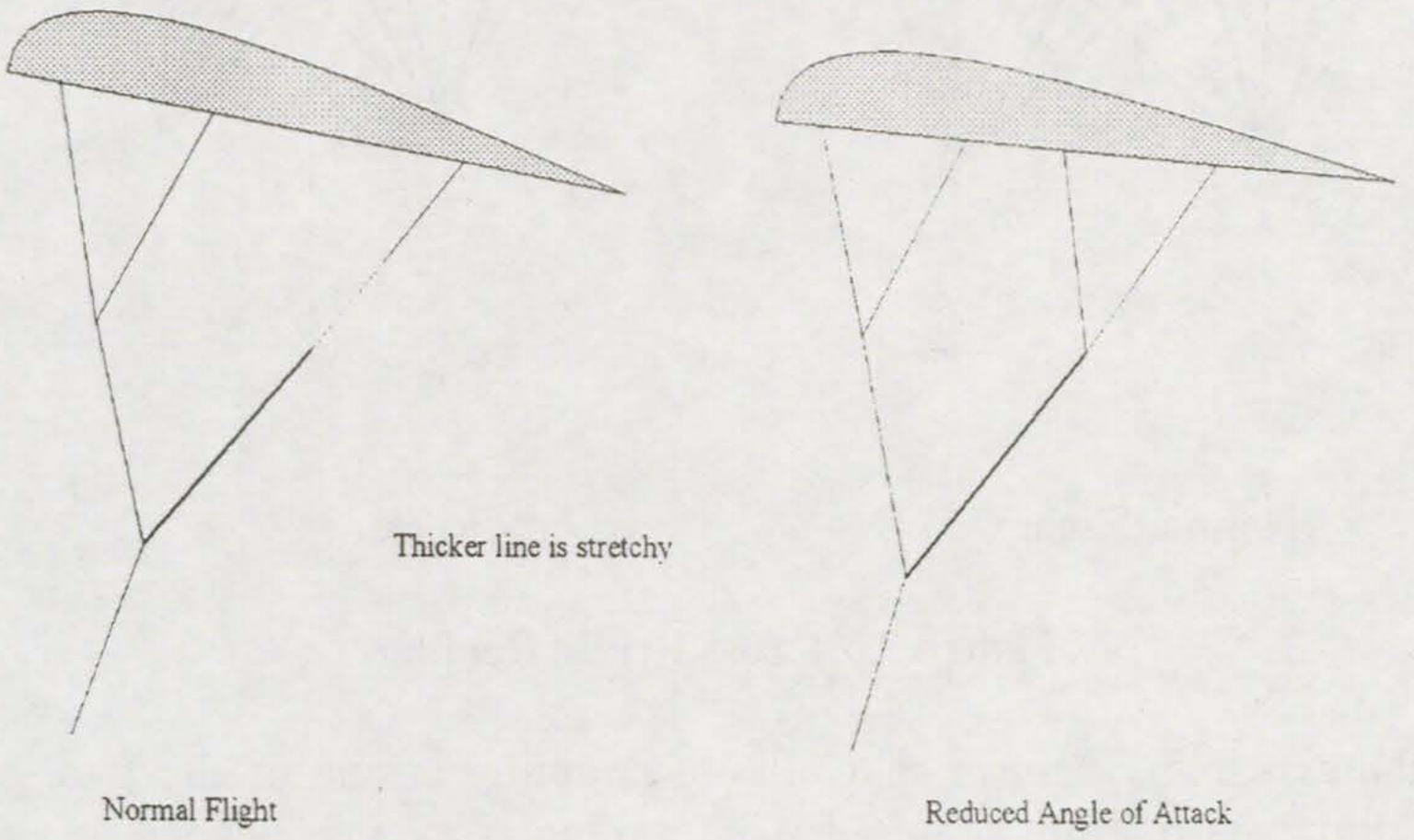


Figure 6. Angle of Attack Reduction

My diaries from 1988 onwards are peppered with unsuccessful attempts at Peel reefing. I developed what I thought was a clever, organised search system just for the purpose of finding a usable Peel reefing system but after four years of rigorous application I had exhausted all possibilities. The next night a solution just occurred to me in the middle of the night! It does cause a deterioration of LDR as reefing progresses but so does every available system on other kite styles (except, I suspect that wing tip twist off as used on delta style stunt kites probably helps to control tip vortex losses at the same time as reducing pull) and it works! Currently achieving about 25% pull reduction over non reefing layouts, it has the potential of achieving 50% reduction or more. It also appears to have the bonus of reducing the occurrence of AW luffing. I surmise that as the kite's momentum carries it into a lower apparent wind zone, the kite responds by

increasing its effective lift area, allowing the kite to climb out through the danger zone. Experience seems to be confirming the result at least if not the hypothesis.

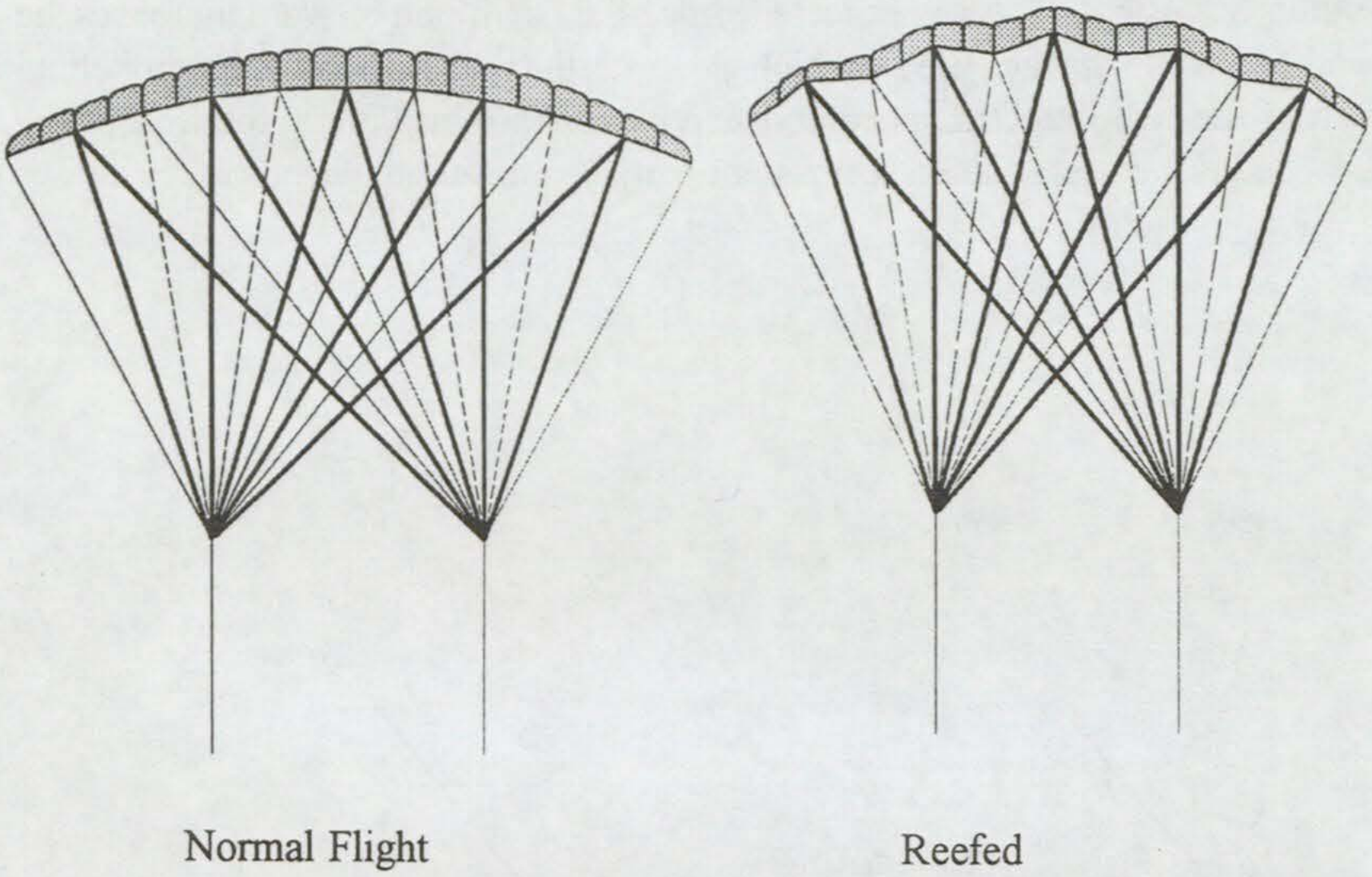


Figure 7. Cross Bridle Reefing

As things stand I believe that effective reefing is one of the two great breakthroughs that are required if kitesailing is ever to become a viable recreational activity. After 3 months use I believe this Peel reefing system is at least the beginnings of that breakthrough. (The other required innovation is an on-the-water launching and retrieval system which I believe is also close to being achieved.)

OTHER AVAILABLE TRACTION KITES

Flexifoils The original and most popular traction Kite. At present, users report that Flexifoil powered buggy/kitesailers do not have good upwind performance. I have tried buggying/kitesailing using Flexifoils. There is no theoretical reason why they shouldn't be excellent for the job, and they are, especially in stronger winds and when you have plenty of space to build up useful apparent wind. Even though the Flexifoil airfoil profile is not a conventional high LDR form its LDR is at least up with what is currently available from its rivals in the traction kite stakes. In terms of MMR it seems to me that by using

more flexible front spars there is available a simple mechanism to reduce their maximum pull without sacrificing pull at the edge. A third consideration, that larger Flexifoils require too much arm movement to effect adequate control, is easily resolved by using a pulley system or by using a stack of small Flexifoils.

Rigid Frame Stunt Kites Before developing the Peel range of soft stunters I used rigid frame delta style stunt kites extensively for kite traction. They have considerable natural advantages: control is good, kites can be made in almost any desirable size (I built a series of 5.5m wing span stunters) or smaller stunters can be stacked to get sufficient pull. They have a built in mechanism to improve MMR. By utilising spar flex and skin stretch, delta style stunters automatically 'twist off' at their wingtips as pull increases giving very good MMR. This desirable characteristic can be enhanced by building stunters with extra wingtip area, held out by battens, which only generates lift when the kite's apparent wind is low. Although the recent trend has been for delta form stunters to tend towards long tapered wingtips the reason for this has particularly to do with the rules and requirements for precision stunt kite competitions. Kites for traction don't need to follow this trend. One kite style that should have considerable potential as a traction kite, for the reasons outlined above, is the Volkensturmer 101 from Germany. Another design which should also have very good inherent MMR is the Speedwing from Vlieger Op in Holland. Lacking a spine, it contrives 'twist off' in the middle of the skin, again by spar flex and skin stretch.

Four Line Kites Four line kites have almost total control of MMR and would, theoretically, seem to have all the advantages for kite traction use. Indeed Revolution and Quadraflex kites are commonly used for buggying. That four line kites have not yet demonstrated competitiveness in buggy racing and do not yet appear to have made any significant impact on kitesailing could be for a number of reasons. Maybe I have not yet met adequate four line buggiers! Maybe current four line kites are not big enough or, no matter that a kite has good MMR it still must have good LDR to be suitable for kite traction. Another possible reason is that the ability to 'sweep lots of sky', a supreme characteristic of two line kites, is an overwhelming racing advantage even though this technique can only be used on non-upwind legs of racing courses. But, why cannot four line kites also be used to 'sweep the sky'? It's just a matter of having greater flier skills.

During 1990 I built and raced with four line versions of the Peel (set up for angle of attack control rather than full reversing ability). At that time these kites were definitely not as fast around the buggy course as standard Peels. Why was this?

I note, analogously, that in International 'A' class catamaran racing, sails which are constructed with good built-in gust responsiveness are consistent winners against probably superior sails that require continual operator adjustment for optimum performance. A year ago I said I would still not be totally surprised if four line kites eventually prove superior for kite traction. Now I will be surprised if they don't eventually become the traction kites to beat. Thinking this through, to balance against the advantages of self launching capability (even off water to some extent) and superior control, the only necessary disadvantage of 4 lines is the extra drag of two more lines. However, I'm not sure that any of the current crop of 4 line kites have the necessary characteristics. Perhaps the new Legaignoux kites will have, but it seems to me that an essential characteristic is high lift/drag ratio (LDR) for which a higher aspect ratio is required than either of these kites or the Quadrafoil have. The Peel does have adequate aspect ratio and can be easily rigged for 4 line flying. For the purposes of kite traction 4 line kites need to be divided into two types. The first type, like the Quadrafoil and Peels rigged as per the method described later, use the 3rd and 4th lines to operate trailing edge brakes which provide for very rapid turns, stalling (great to prevent luffing including AW luffing) and even upside down relaunching. The second type, like the Revolution, give full control of angle of attack and can therefore be used also for de-powering the kite. This is a major advantage.

PEEL DATA

From June 1992 four models of Peels are available 3.6m (2.5sq.m.), 5.1m (5sq.m.), 5.1m (5sq.m.) reefing and 6.4m (7.5sq.m) reefing. The reefing models can be flown with the reefing system engaged or (by attaching the flying lines differently) as non reefing kites. The reefing system (filed for patent June 1992) works by causing the Peel canopy to assume a corrugated form as pull increases thereby reducing effective span. Working to reduce maximum pull by about 25% (currently), this system allows the use of a bigger kite with its greater pull at the edge. All models of Peels can be retrofitted with the reefing system.

Peels can be tuned for different performance characteristics. We use a table of differences to set up our Peels for racing. Differences are listed for the four bridles on each cell as first minus second, third minus second and fourth minus third. Generally, first-second is the critical dimension. If this is too low the kite will exhibit worse luffing characteristics. Because the second bridle takes the greatest load, after extensive strong wind flying this bridle will stretch more than the others, causing a gradual deterioration of flying characteristics. 'Blue Printing' the bridles back to the table of differences will restore the lost performance.

Also, because of unavoidable small differences in knot tying when the Peels are first bridled, even 'Blue Printing' a new Peel may improve its performance, but do some flying first to 'settle the bridles in'. Increasing third minus second and fourth minus third will assist high wind buggying/kitesailing but light wind buggying/kitesailing performance will suffer. This may seem to be the reverse of how it should be but it is all to do with the previously mentioned fact that it is no use having a kite that will go along way around the edge if it hasn't enough pull left to get you moving when it gets there!

Moving the bridle point back increases the apparent wind speed at which the onset of stall will occur. It also makes the kite much less pleasant to fly. Winning is what matters though and back bridling definitely improves light wind buggying performance. This situation poses a problem for buggy racing rule writing as the better answer to improved light wind performance is to use a bigger kite but there is a strong temptation to set kite area limits on buggy racing classes.

The technique we usually use to fix a cut bridle is to first match up the cut ends and mark back 75mm each way, tie in a 100mm length of similar diameter line and adjust the knots until the two marks are 150mm apart.

Launching Basic launching techniques are assumed to be understood but we have developed a (relatively) safe strong wind launching system. Launch the kite at the edge of the wind facing outwards not upwards. Although this requires some experience from the launcher it does get the kite up safely without that arm wrenching rush as the kite heads for the top from a downwind launch. For launching by yourself from sand or grass surfaces, attach a short (say 100mm) peg permanently to each main line attachment point. Fix rubber bands to these pegs so that they are normally held up parallel to the main line loops. For launching in all except very strong winds just stand the kite on its trailing edge restrained against the wind by these two pegs stuck into the ground. Pulling on the line handles will now release the pegs from the ground, launching the kite. This system was developed by Phillip McConnachie, Ashburton New Zealand.

Bridle Untangling It's a matter of experience and is surprisingly easy. I'm very sloppy about packing so generally have to untangle every time I bring a kite out. Lay the Peel out on the ground, hold one line tie loop in each hand and just do what looks logical. It always works. When packing away I don't braid the bridles, but some do, doesn't matter either way but the key is to avoid letting either line tie loop pass through any bridle lines - fold the kite up towards the face but separate the loops and settle them on the back (top skin of the kite).

Peel Fabric All European manufactured 3.6m Peels use Carringtons. New Zealand manufactured Peels, up until about mid 1992, used Bainbridge, subsequent kites were made in Dimension (ex U.S.) with some Polyant (German). For 1993 all standard and reefing Peels are in Carringtons. Racing specials will probably be in Dimension (not quite as strong but lighter).

Porousity Peels are not very sensitive to fabric porosity. I fly one 5m Peel which I can comfortably breathe through! Its performance is not noticeably different to impermeable kites. Paradoxically, as the skins become softer and perhaps more porous with use the fabric also becomes stronger.

Repairs Peels can be split in heavy nose-first landings, especially if onto water because this closes the gauze leaving the internal pressure nowhere to go except out by bursting rib seams on the top skin. It's not easy to do, I've only split 3 kites in 3 years, always in wild, high wind, out of control water crashes. Don't despair, permanent and effective repair is easy, at home, by most kite retailers or, in the limit, at one of our factories. The steps are; unpick the trailing edge seam where necessary for access and also unpick the split seams, repair splits in ribs and skin using ripstop tape (white tape applied on the inside shows least on all colours), sew the ribs back to the skin, and finally, close the trailing edge. After incidents like this it pays to re 'blue-print' the bridles.

Peel Reefing To add the reefing system to existing Peels, the cross bridles must be separated into two groups on each side, one set from each alternate primary bridle starting from the wing tip set, the others for the remainder. This will require some cutting and re-tying. A loop is made at the confluence of the wing tip set of cross bridles on each side and to this a 1.5m line is attached, to the other end of which the flying lines are attached and from which point 1.25m of 'stretchy' returns through the loop to the remaining cross bridle set on that side. Confused? I am; then have a look at an existing reefing Peel.

Four Line Peels Any Peel can be rigged for 4 line flying. There are many different ways. I usually attach (sew) four loops of light braided line, to each side of the kite, the eight attachment points being evenly spaced along the trailing edge. The extra flying lines on each side are attached to these loops by other loops. All knots are left to float so that the control line pulls evenly on the kite's trailing edge. At Fano in 1992 someone from Switzerland who's name I should remember showed me his Peel rigged for 4 line flying in a manner similar to this, but without floating knots, this had required the addition of a restraining line between the attachment points of the 3rd and 4th lines to improve control.

Rather than attaching the extra lines via loops to the trailing edge the loops can just be tied onto the rearmost primary bridles on each side. This is O.K. for flying but not so effective for reverse re-launching.

For larger kites, 4 line control of this type runs up against the limits of wrist-twist movement. At a certain scale there is just not sufficient movement available to effect satisfactory control. The 5m and 6.4m Peels are large enough to have this problem to a minor extent, but it can be alleviated by adding a 'displacement doubler' at the handles or at the kite in a manner akin to that used for the new 2 line quick turning system as described later.

Peel Safety Peels are large strong pulling kites quite capable of injuring the flier or bystanders if used injudiciously. If you are not experienced in the flying of this type of kite you MUST take special care.

* Choose light or moderate winds.

* Fly in large unobstructed areas clear of people, cars and power lines.

* Ensure a clear recovery area downwind of where you are flying in case you need to release the kite.

* Don't go further into the air than you are happy to fall - kite jumping, except perhaps over water, is not a safe activity. Broken ankles and worse are not uncommon.

* Don't fix yourself to the kites without a 'deadman' release system.

* Tethered Flying.

Flying kites while suspended off the ground between kite and anchor is not safe and has resulted in fatalities. Kites are absolutely not safe when used in this way.

DON'T DO IT!

PEELS: THE FUTURE

The potential is huge. Firstly, I have no doubt that current primary bridles, cross bridles, rib profiles and rib spacings are not optimum. A simple and informative experiment with Peel development was to construct some prototypes with twice as many ribs and bridles as the standard. The results were as expected:

1. Higher L.D.R. (goes further around the edge, and over head, has less pull at its equilibrium over head position than standard models)
2. Faster
3. Smoother skin less wrinkles, especially along trailing edge.
4. Marginally more liable to collapse - thinner, has less compressive strength from internal air pressure.
5. Less liable to 'clap hands' - thinner mid section has relatively less drag, wing tip drag doesn't change as much.
6. For buggying, generally slower around the course. Top speed, especially on reaching legs, is higher.
7. A problem is that the weight of ribs approximates to the weight of the lower (or upper) skin.

I have thought that this significant overall weight increase would have dramatic and damaging effect on light wind performance and on that very critical situation in stronger turbulent winds when the kite flies into a 'hole'. From experience flying wet kites, (rigid frame single skin, soft or semi soft) kite handling characteristics deteriorate alarmingly. More recent tests seem to be showing that flying characteristics are more dependent on how weight is distributed than the total weight, and that wet kites lose performance more because the fabric becomes soft and sticky than because of increased weight.

One obvious improvement for Peels is to use Spectra, Kevlar or Technora bridles. Of course there is a cost penalty but drag is significantly decreased and, because bridle drag is below the kite, it usually exacerbates luffing problems. Work that Nop Velthuizen has done on high speed Flexifoils has shown that top speed is incredibly sensitive to line diameter. Experience here supports this. Thin spectra bridles on Peels improve speed significantly and seem to improve control as well. Thinner bridles are always advantageous and have no performance disadvantages.

Scale effects penalise most bigger kites but Peels are relatively exempt from this. Using Bainbridge 3/4 oz ripstop, the 5m Peel is about maximum size for the available fabric strength. Fabric stress for soft kites is approximately proportional

to cell size not to kite size. Using 42gm Polyant or Teijin, larger size kites are okay (up to double!). Hence a larger kite (up to the fabric stress limit, when fabric weight must be increased) will not suffer light wind performance deterioration.

I believe that, in spite of the extra weight, Peels with more ribs will be the trend because they offer higher top speed and higher LDR. Answers must, can, and are being found to CP Luffing, AW luffing and weight problems.

Reefing is an absolute must, preferably with constant LDR. and hopefully to below 50% of initial area.

During 1992 there have been some exciting developments in Peels which could totally revolutionise traction kiting. Of course, 'there's many a slip twixt cup and lip' and I'm not anything like 100% confident that all the new systems will work together in the way I hope. There are also the problems of what to do about gaining protection by patenting etc and then how to go about orderly development of the new markets that should become available.

The first new development is a retrofittable quick steering system. Using the (I think new) principle that additional 'information' can be passed to a two line kite by using a pulley system on the kite which only comes into operation when the kite is 'oversteered'. For example, this can be used to operate trailing edge flaps when more than, say, 400mm difference is detected in the main lines. The effect is dramatic and can be used with almost any two line kite, although it doesn't improve kites that already have rapid turning.

More profoundly, new traction Peels are being developed that use only a single line and are controlled by radio. Control can be applied to steering as for current two line kites, additionally, to control angle of attack (now available only with 4 lines) but there can also be servo control of reefing and the line winch. Although not tried yet I anticipate that the winch control will be on the basis of setting limits. When the line pull drops below a settable figure, the winch will automatically pull in - this should effectively eliminate apparent wind luffing. Above an, also settable, pull the winch will automatically let out. With up to say 1000m of line available this should significantly reduce the problems of gusts and those terrifying surges of line pull that occur during changes of direction. At one end of the scale a hand held system should be possible for buggies - one hand, finger tip controls, self launching and retrieving, with a belt pack battery - expensive, say more than Dm 1000 retail for the hand control but it will sell. At the top end of the scale ocean going kite sailing should become truly practicable. What is there to prevent the building of a 50sq m kite system for 12m purpose

built yachts? In the middle scale, small recreational kite sailing (in the windsurfer size range) should become really practicable.

This system has further potential in that with the addition of available gyroscope inertial control systems (ex model radio controlled helicopters), it will become a superior lifting kite for cameras and scientific equipment - 8 km/hr to 100 km/hr, and 5000m altitude, 100 kgms payload if necessary and controllable from the ground as to lateral position within a wide arc.

KITE TRACTION, THE FUTURE

My purpose in publishing this account is threefold.

* To give the field of kitesailing (land and water) the beginnings of a theoretical framework as an assistance and focus for other designers.

* To encourage new designers to take up the excitement and challenge of kitesailing research by depicting some of the evolutionary processes through which some current designs have come.

* To give current and future kite buggy and kitesailer users some basic equipment and technique data.

The future for kite traction, buggies and boats is now more secure. The great problems of inadequate kite performance, inadvertent kite crashes and (boats only) lack of an on-the-water kite launching system look like being solved before the world gets bored and finds some new more exciting recreation.

Buggying has a secure future. I can already detect that, as a sport, it is developing a life of its own. A worldwide organisation will be necessary but will no doubt get itself formed at the right and proper time.

Kitesailing is less secure. At present it can be a fairly difficult and unsatisfactory activity - kite launching and getting started problems, kites falling out of the sky with no way to relaunch except by paddling back to land, inadequate speed (relative to potential). Still, developments already in the pipeline from myself and others look like making these problems of the past. We have, at least, a good starting point and if progress continues as rapidly for the next few years as it has for the last few, kitesailing will become the new water/wind recreation.

DEFINITIONS AND ABBREVIATIONS

Angle of Attack. Angle of the apparent wind relative to the (nominal) lower surface of the kite. This angle is positive when the apparent wind strikes upwards onto the kite's lower surface.

AR, Aspect Ratio. Roughly, the ratio of wing span to chord (wing width) but more precisely span^2/area.

At the Edge. A semi circular arc in the vertical plane, centred downwind from the flier which represents the furthest upwind positions that a kite can maintain in steady state flight for given wind velocity.

AW, Apparent Wind. This is the air velocity and direction as it appears to the operator and is the vector sum of true wind (speed and direction) and the buggy/ kite boat speed and direction. For the kite the apparent wind is the vector sum of the true wind (speed and direction) and the kite's speed and direction.

AW Luffing. Apparent Wind Luffing. This occurs when the kite suddenly flies into a zone where the apparent wind direction is such as to create negative angle of attack, causing the lines to go slack and the kite canopy to collapse.

CP Luffing, Centre of Pressure Migration Luffing. This occurs when the point at which the lift forces act migrates sufficiently to the trailing edge to tilt the kite down (negative angle of attack) into the wind causing the leading edge to fold under, collapsing the kite.

LDR, Lift to Drag Ratio. The ratio of lift force generated by the kite to the aerodynamic drag forces operating on the kite and line. (The downwind component of all the aerodynamic forces acting on the kite/line system.) A quick method of measuring kite LDR is, for the situation of apparent wind equal to true wind, to park the kite overhead in steady state and determine the tangent of the angle between the flying line and the horizontal plane. This is exact.

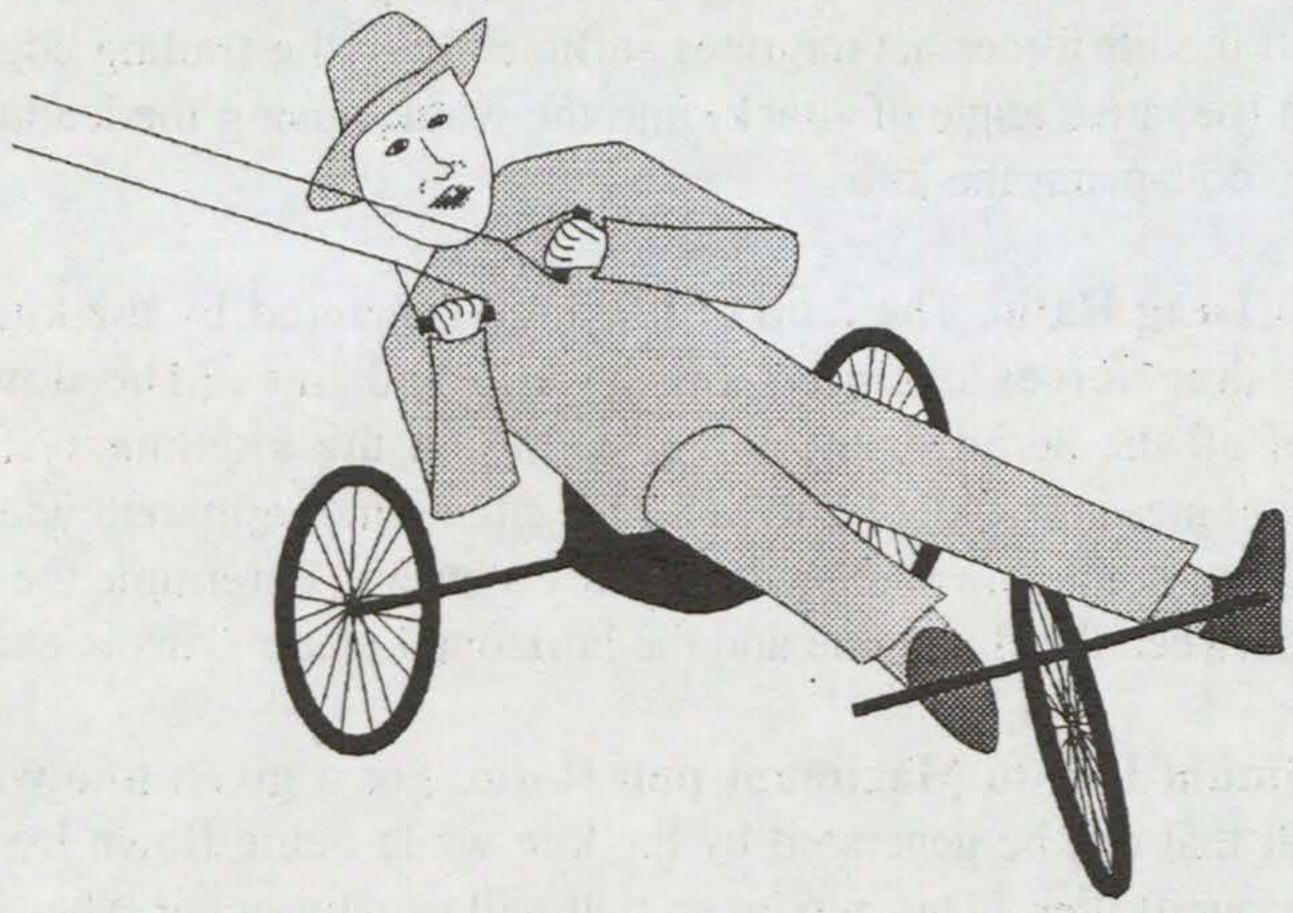
MMR, Minimum Pull to Maximum pull Ratio. For a given true wind, the maximum pull that can be generated by the kite while being flown by a static (feet on the ground) flier, (This maximum pull will usually occur when the kite is climbing at maximum velocity and is directly downwind from the flier) is divided by the pull generated by the same kite in the same true wind when the kite is parked up at the top or at the edge.

Reaching. Sailing on a course approximately at right angles to the true wind direction - usually the fastest point of sailing.

Stall/fly. A kite characteristic in which the kite stalls, often hovering or even falling backwards, needing to be 'pumped' to get it started again. Usually caused by having the bridle too far back. Kite stall/fly is usually an undesirable characteristic, interfering with smooth flying, but for kitesailing and buggying it can be advantageous as it can allow the kite to be de-powered even while in the centre of its power band providing the true wind speed is under say 25 km/ hr and can in some other cases improve light wind upwind performance.

TW, True Wind. the actual wind speed and direction

VMG, Velocity Made Good. Not your actual speed but the effective speed at which you are proceeding in the desired direction. For example; using sail or kite traction it is not possible to hold a course directly into the eye of the wind. A best course of about 45 degrees from true wind is usually all that is attainable. If your speed, when holding a course 45 degrees to the true wind direction, is 30 km/hr then VMG to windward is (30 km/hr x sin 45 degrees) or 21.2 km/hr.



Traction Kites

Commercial and Home Made

by Chris Sands

Having been involved in flying kites for several years, we began 'Buggying' in late 1993. We have sailed for many years and we liked the fun of flying kites, combined with the thrills and spills of physical challange in buggying. Our buggy is a home-made version of what is available commercially; three wheeled, low slung, single front wheel steering. I think that the Lynn buggy is still the best commercial one yet.

We started with two line kites. The Flexifoil has been used for several years as a traction kite system (even on boats, Jacob's Ladder etc). It can be stacked, ie used in multiples to build up the power required, and is available in 6', 8' and 10' versions. It is a good kite but costs £60 - £120 per unit. Also we are not very keen on being hit by the 8mm carbon rod in the leading edge.

Flexifoils can also be home made, see the Speedfoil in 'Stunt Kites to Make and Fly' for a version of this kite.

We went the way of the fully soft, two line kite first. Again see the Sputnik I and II in 'Stunt Kites to Make and Fly'. We made several versions of these kites. Double and treble size work really well. We regard it as a poor man's Peel (the Peter Lynn kite). We feel that it performs similarly to a Peel but does not look quite so pretty.

We then started looking for more control and the ability to fly on shorter lines.

To achieve predictable results we first copied the American 'Quadrafoil', which is a very good kite but with some limitations. It is very powerful, but not too controllable in high power conditions.

Quadrafoils are approximately twice as wide as they are deep, with fairly simple bridling and end keels. We produced a kite 2.5 times as wide as it was deep; this seemed better. More knowledge was needed.

We went kite buggy racing in Wales, the home of Mick Parsons, the developer of the 'Spider Modulus' kite. This is probably the best yet, commercially available, traction kite. By using a zip together, modular, system, it can be made into many

sizes, from approximately 1sqm to 5.5sqm, but it costs £675.00.

From seeing this kite perform and chatting to others at the leading edge of traction kite design our latest thoughts are as follows.

1. Make the aspect ratio of the kite about 3.5:1
2. Follow the Sputnik type rib profile
3. Keep the cell width between 160-190mm.

We have made our first prototype a 3.0sqm which we have been able to compare with our 3.0sqm Quadrafoil.

We are happy with our new four liner so far

1. It is much more controllable.
2. It has more power on the edge, ie close to the wind.
3. It will fly closer to the wind.
4. It has more power all around

There are many possible variables

a. Inclination of the profile to the wind (angle of attack)
b. Size of mouth opening
c. Cell size and number
d. Bridling
e. Keel size, shape and number.

I think that we shall have plenty to try out over the next few years.

Peels, Flexifoils, Spider Modulus, Quadrafoils are all good kites and very good value for money when you consider the labour, materials and development costs.

We have little money to spare and so we need to develop our own kites. I do not like to copy other designs; I prefer to learn from them and produce our own, hopefully superior, designs.

Our kite enables our buggy, in the hands of my 14 year old son Andrew, to be sailed just like a dinghy. One can beat to windward and tack through 90 degrees or less and sail at all other points at 35 mph and more. We sail on sand beaches because it is much softer when you leave the buggy and slide along the ground.

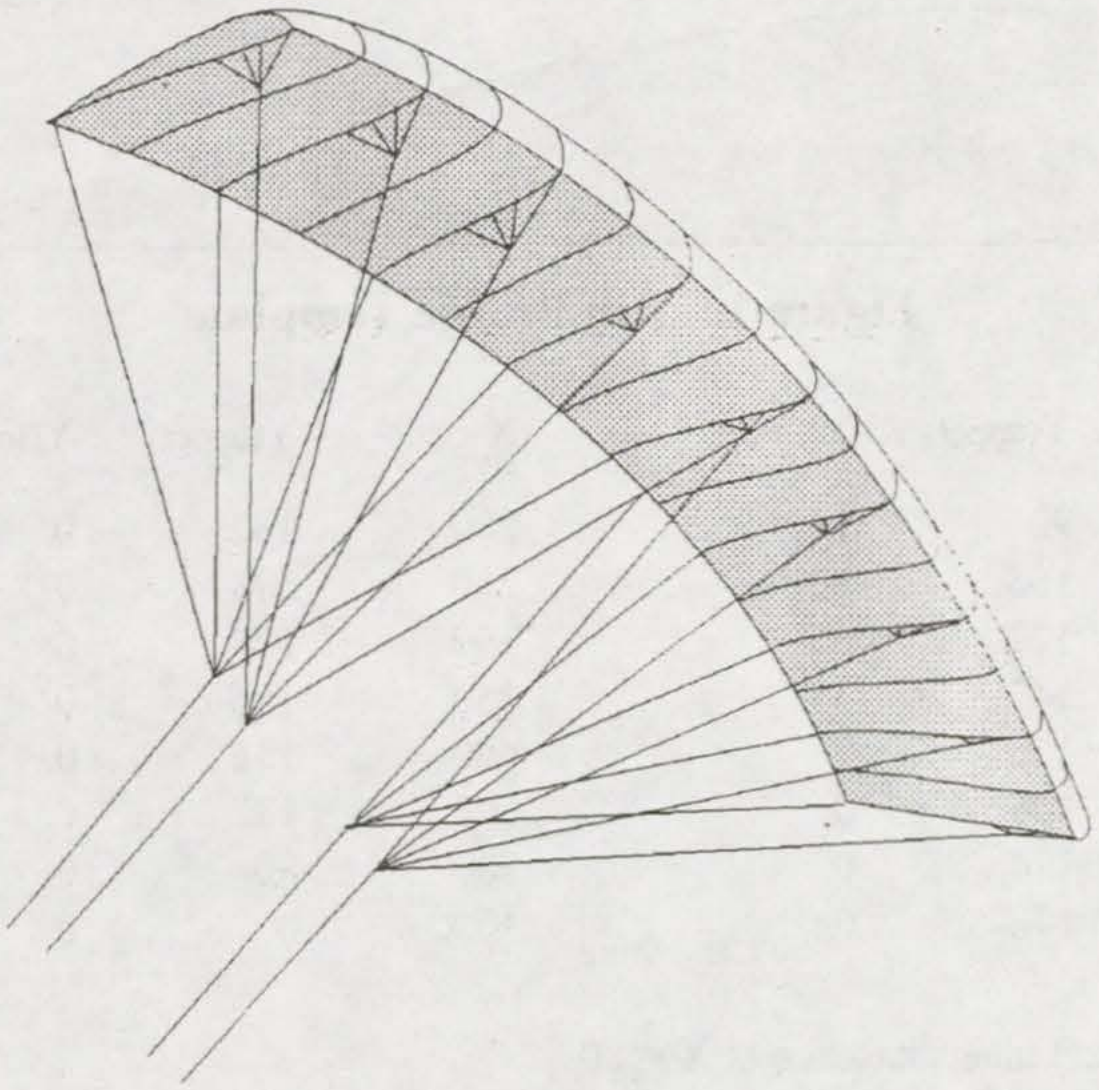
Because of the speeds that we want to attain we are using very powerful kites. These are kites that should not be taken lightly. They need many hours of practice in light winds before you start trying to use them for traction purposes.

If the kite and wind are right, my son expects to be pulled at least 10 m along the beach as he launches the kite and before he puts it overhead, in a non-power mode. He can then ski down the beach, for as long as the beach lasts, at approximately 5-8mph on his feet. If you get it wrong you are pulled down the beach on your face, just as quickly.

Power kites must only be used with consideration for others. When things go wrong, they go wrong in a big way. Any kite that can pull my 16 stone down the beach on my face is powerful. Insurance is very difficult!

See the plan details of the Sands Three Square Metre Quad for the best current design so far. I am sure that it will improve, but it is a good place to start.

The kites are flown on special handles using 300lb Dyneema for the top lines and 150lb Dyneema for the bottom line. Dyneema is HiTec, low stretch kite line, but beware: it is easily cut by conventional polyester or nylon line.



Sands '4-Liner'

Design for a |4-line Traction Kite

by Chris Sands

These plans were produced by Chris Sands and assume that you have some experience of making kites. I have added some information to augment the original notes that Chris prepared, but there may be some details that are still difficult to understand. The best solution is to obtain a copy of 'Kites: A Practical Handbook' or 'Stunt Kites to Make and Fly'. I think that you should be able to get the kite out of 8 metres of 150 cm wide Ripstop.

Step 1.

Make a rib profile template from 3mm MDF or hardboard. Mark out the profile using the values from the profile coordinates table. Join the dots using a springy batten for the curves. Cut out this pattern and sand to a smooth curve, you will be using it to mark out 18 fabric ribs.

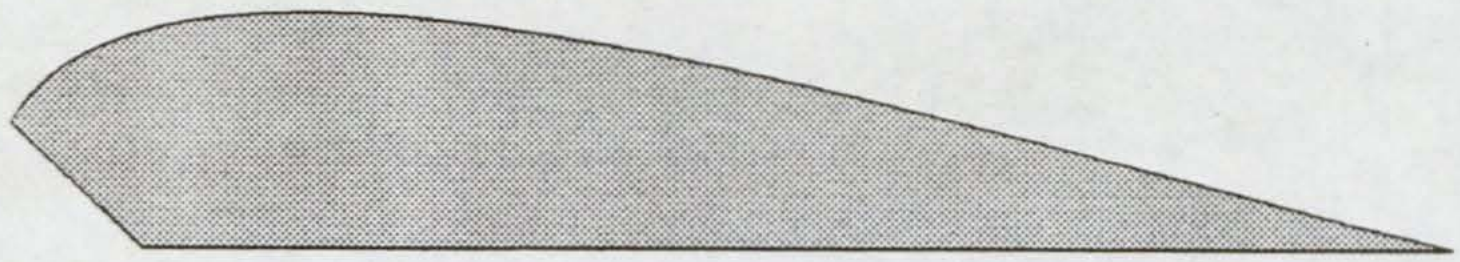


Figure 1. Rib Profile Template

X	Y(upper)	Y(lower)	X	Y(upper)	Y(lower)
0	92	92	200	182	0
12.5	108	80	250	178	0
25	122	65	300	174	0
50	142	35	350.	166	0
75	156	7	400	156	0
100	166	0	500	132	0
125	174	0	700	80	0
150	178	0	1000	0	0

NB Y(lower) meets baseline at X = 80

Table 1. Rib Profile Coordinates - in millimetres.

Step 2.

Cut 18 rib profiles. These will be the shape of your template, plus 7mm all round for hemming. Chris suggests a cunning method for doing this. I have not tried it, but it looks like a good method. You will need a modest sized soldering iron with the tip sharpened to a cutting edge, plus a washer with 7mm difference between inner and outer radius. The iron is guided inside the washer whilst the washer is run around the outside of the template. Remember also to mark the stitching line on each rib using a soft leaded pencil. Your marks will be easier to see if you have chosen a light coloured material.

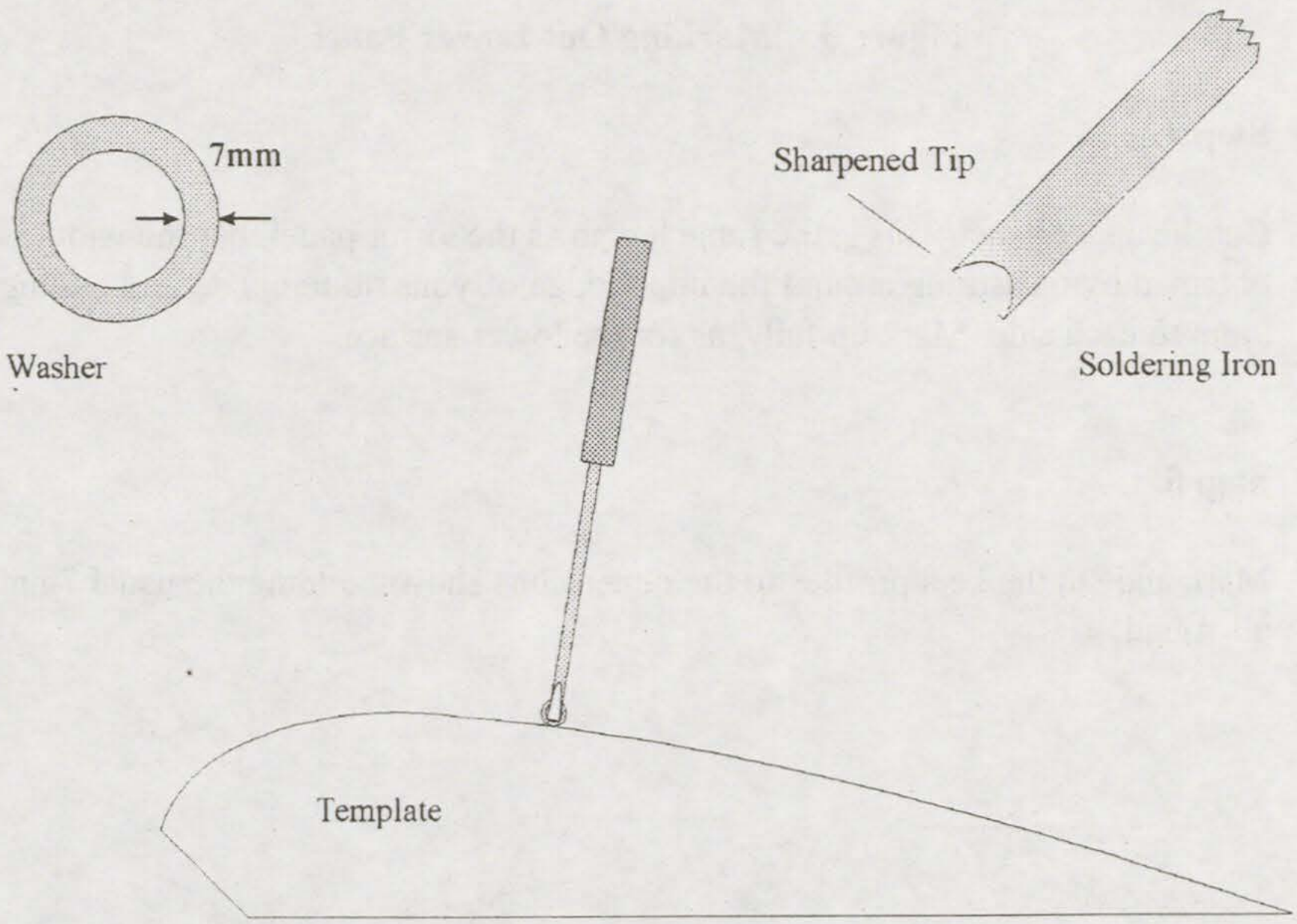


Figure 2. Method for Cutting Out Rib Profiles

Step 3.

Mark out the lower panel. Complete all the lines in the diagram, the outer cutting line, the hemming line and the rib position lines. Cut out this panel.

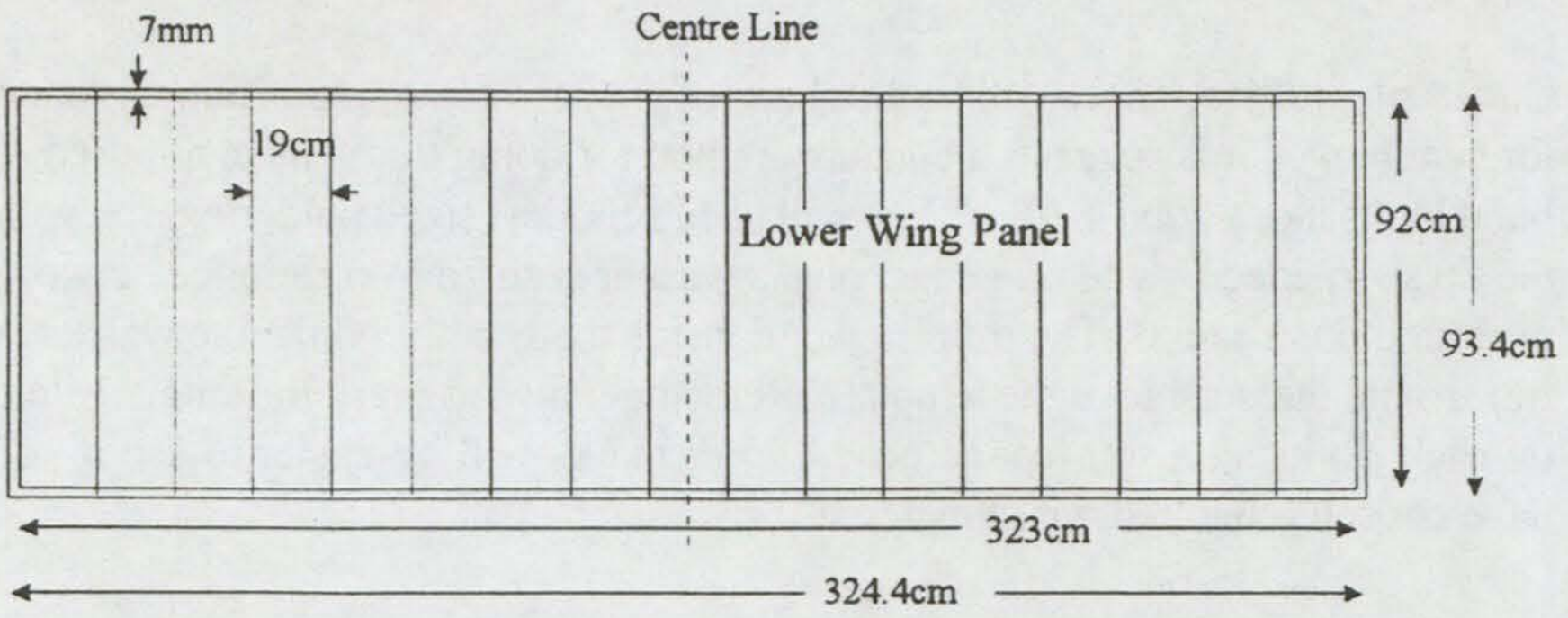


Figure 3. Marking Out Lower Panel

Step 4.

Cut the upper panel. This is the same length as the lower panel, but the width is obtained by measuring around the upper edge of your rib template and adding 7mm to each side. Mark up fully, as for the lower surface.

Step 5.

Mark and cut the keel profiles to the dimensions shown, adding the usual 7mm all round.

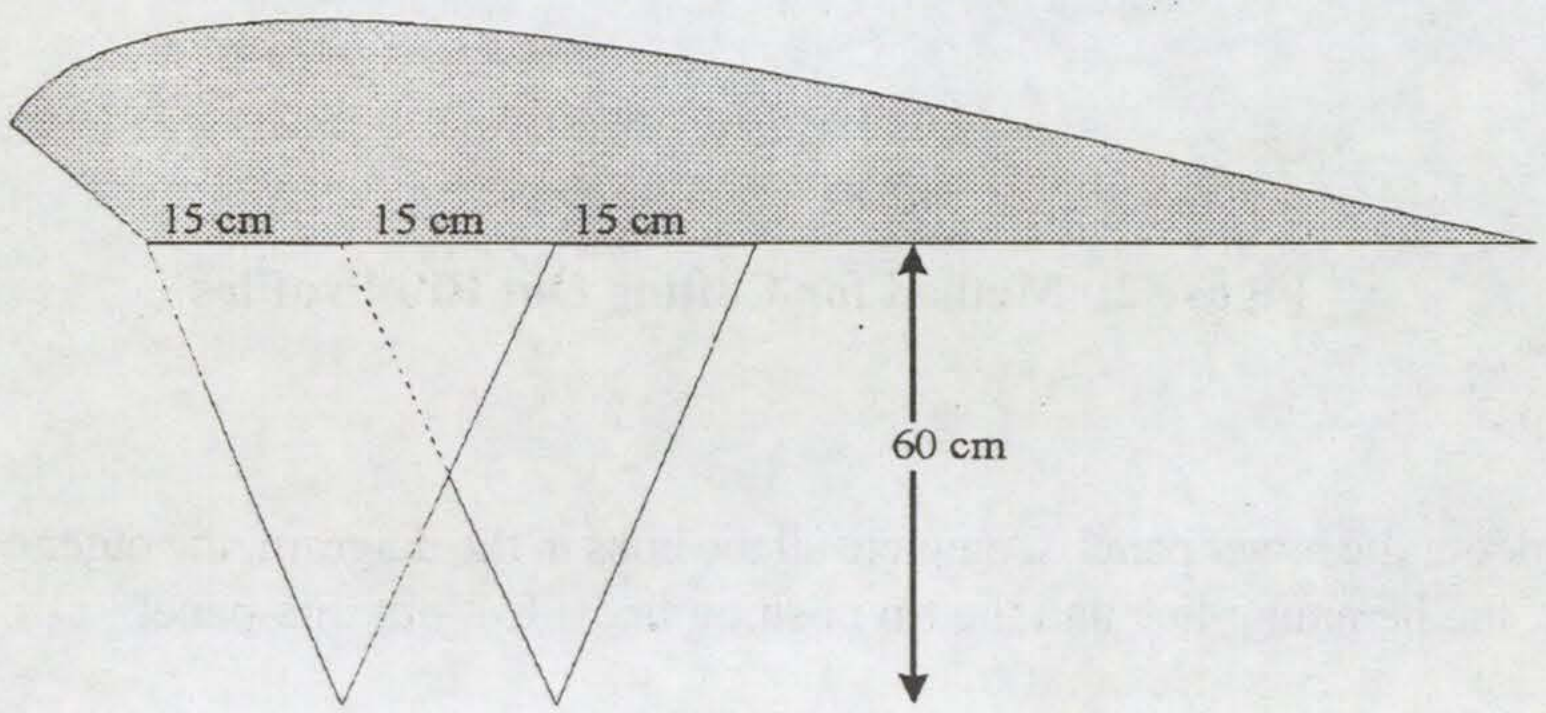


Figure 4. Keels

Step 6.

Reinforce the front of the upper and lower panels and the rib profiles. First turn and stitch a 7mm hem. Then cover edge with 50mm wide tape (or strip cut from Ripstop material).

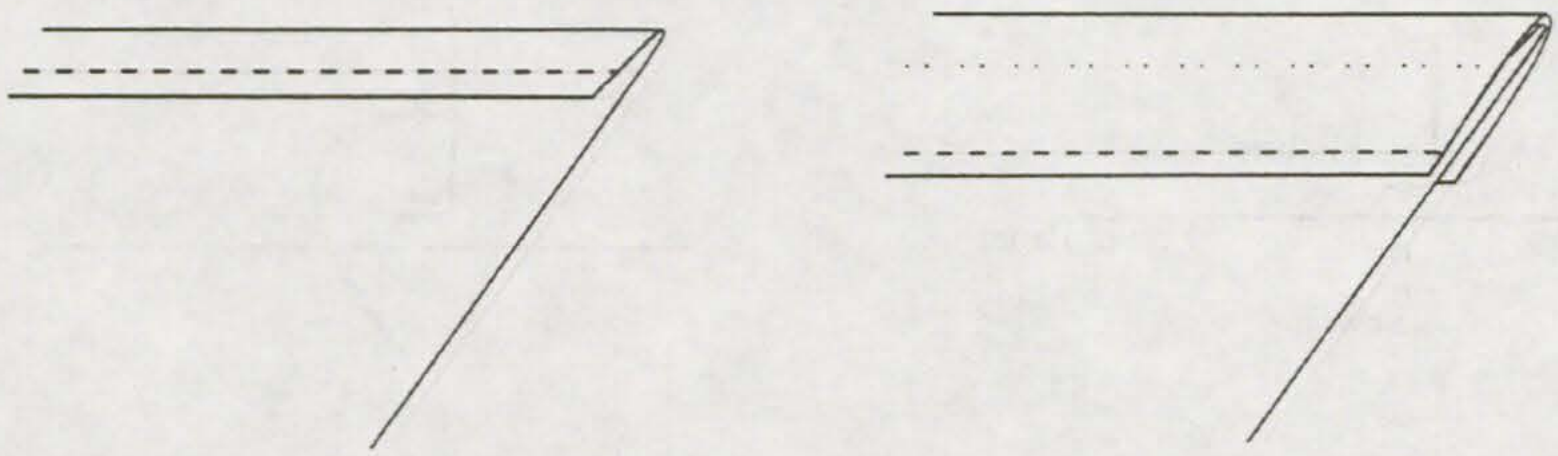


Figure 5. Sewing Hem and Reinforcing Tape

Step 7.

Sew the rib profiles to the lower panel, not forgetting to include the keels at each wingtip. Before you do this you must decide whether the kite will have tabs (sewn on loops of tape) for the bridle attachment or have a 'tabless' bridle attachment.

Tabless is theoretically better, since there is less to cause drag, but Chris and some other constructors now favour tabs as being less trouble and not producing any noticeable difference in performance. Make your own choice.

For tab bridling you must sew in the tabs and the inner reinforcing piece (5cm x 5cm) whilst you are joining the ribs to the lower panel. The bridling positions are shown in the diagram.

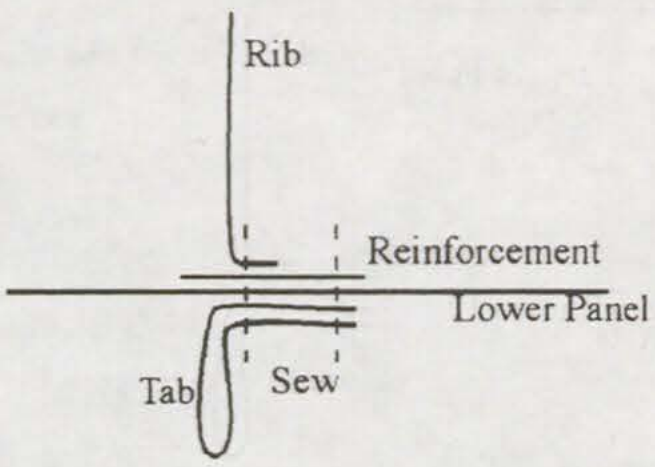


Figure 6. Tab Bridling

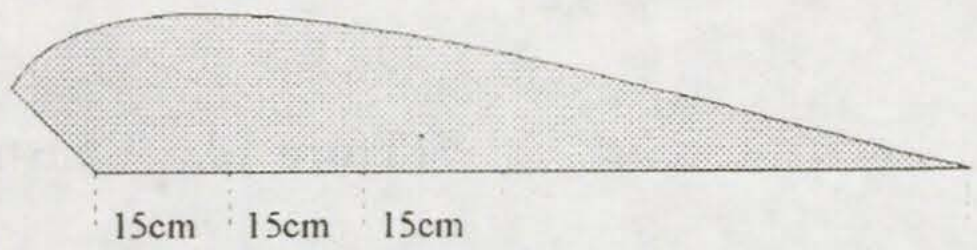
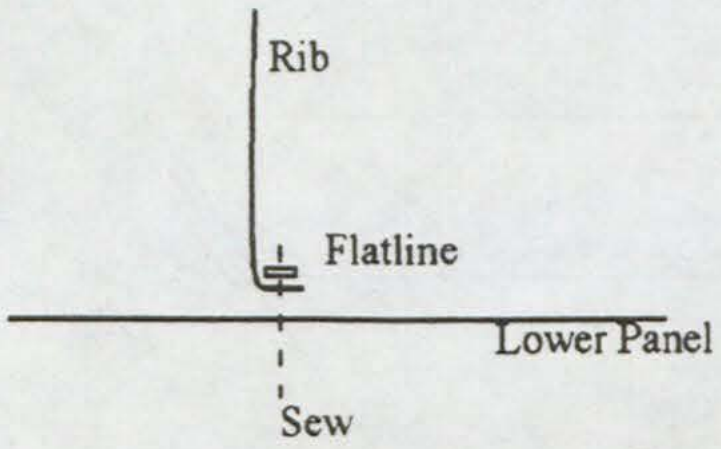


Figure 7. Bridle Spacing

For tabless bridling you must sew in some flat line. This will later take the strain of the bridle loop. These loops should be fitted before you attach the ribs to the upper panel.



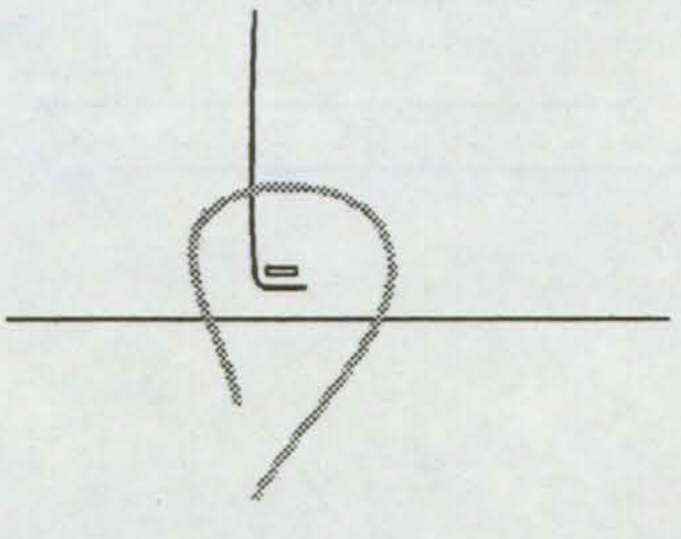


Figure 8. Tabless Bridling **Figure 9. Bridle Loop**

Step 8.

Sew the rib profiles to the upper panel. This is very exciting on your first home made soft kite! I spent hours trying to work out the best way to do it. If you are careful you can avoid having to pass too much material under the arch of the sewing machine by choosing the right order in which to procede. However you cannot avoid the fact that on completing the final cell, the entire kite must pass through that cell to get the seams back on the inside.

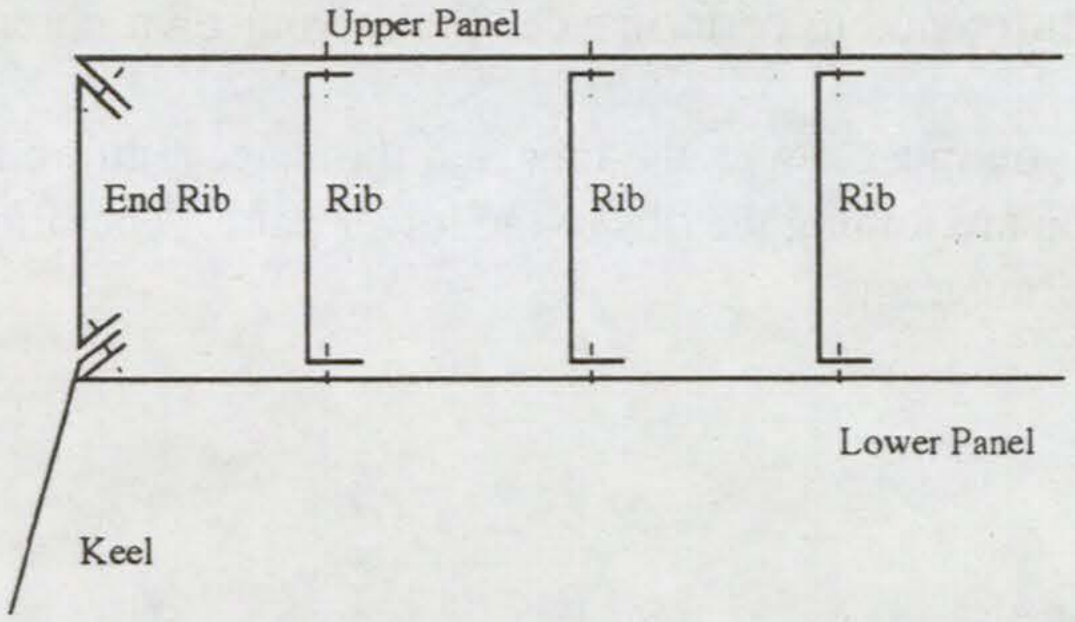


Figure 10. Construction

Step 9.

Close the trailing edge seam. I usually just trim the edge to a straight line using the soldering iron to cut both upper and lower panel together. (Cutting them together tends to form a 'welded' edge) Then sew with two lines of stitching.

Step 10.

Attach the bridle lines as shown in the bridling diagrams. Chris does not specify line for bridling, I suggest 150 lb polyester.

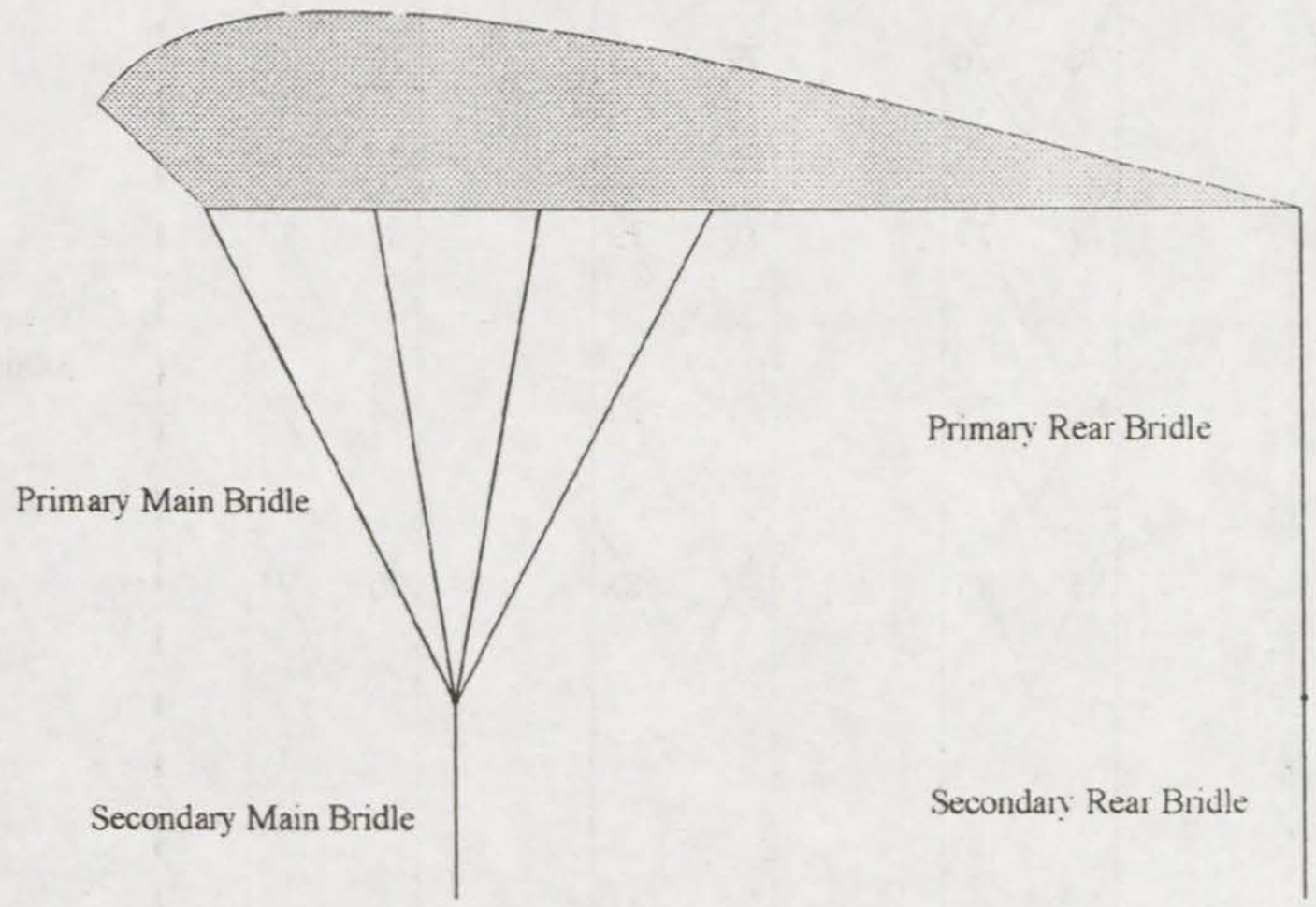


Figure 11. Bridling Arrangement

Step 11.

Buy or make some handles and buy some flying lines. The main handle should be long enough for you to hold comfortably. It is nice to cover this part with some of the hard sponge rubber sold for covering bicycle handlebars. The lower part should be around 20 cm long and at about 30 degrees to the handle.

Dyneema or Spectra line is best, because it is strong, thin, and low stretch. Chris specifies 300lb Dyneema for front (main) lines and 150 lb Dyneema for the rear lines.

Step 12.

Fly your kite.

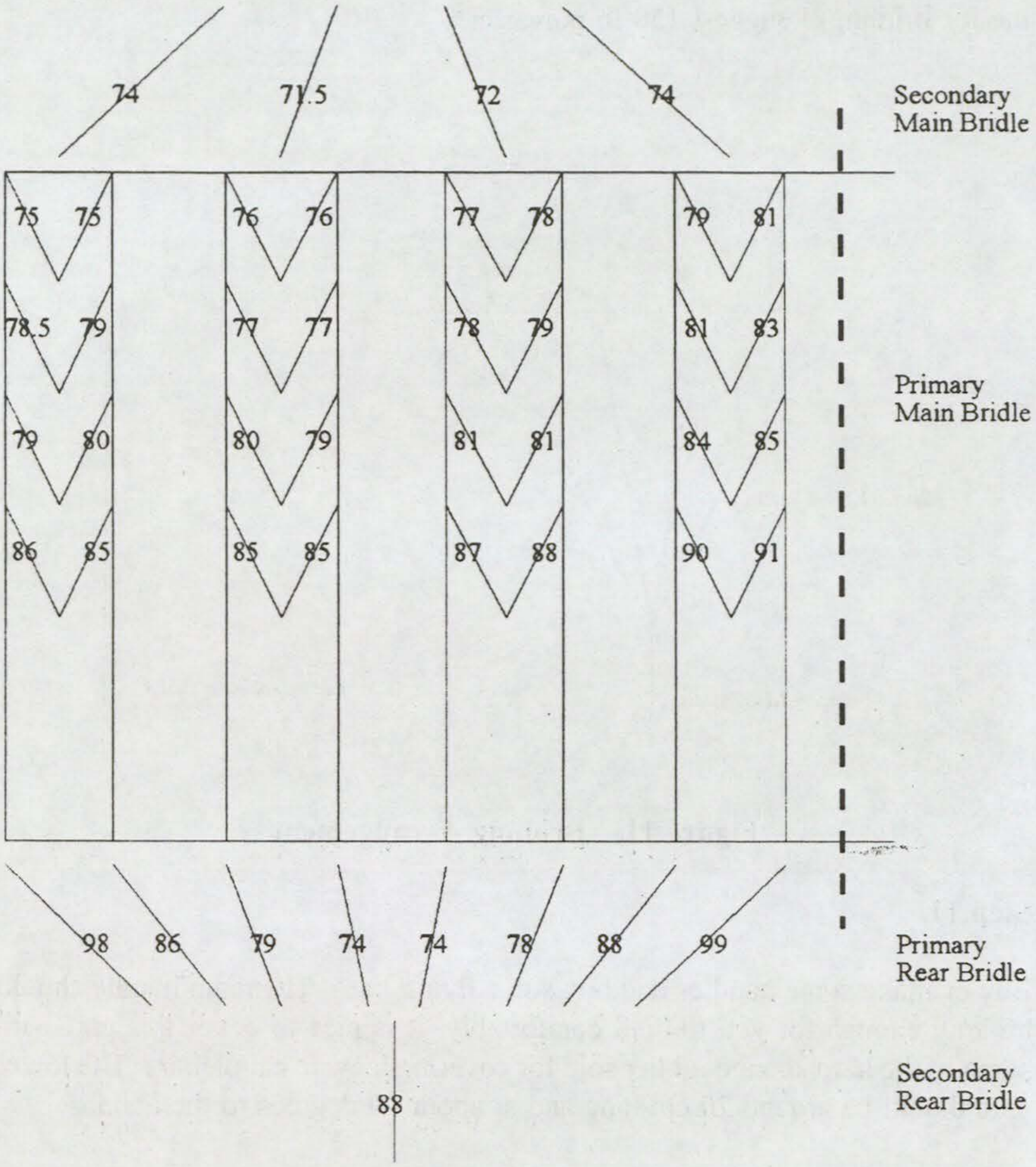


Figure 12. Bridle Component Lengths - in Centimetres

Sources

Information

Books

"Kites: A Practical Handbook for the Modern Kite Flyer"
Moulton, Ron and Lloyd, Pat
Argus Books, Hemel Hempstead, England, 1992
ISBN 1-85486-050-X

This is a really good place to start if you plan to make your own kite. There are chapters on history, materials, methods and designs. One-, two- and four line kites are covered, and many plans are included.

If you tire of kitesailing you may even wish to follow up the chapters on how to lift a camera aloft (safely) or how to drop parachuting teddy bears (more adventurously).

"Stunt Kites to Make and Fly"
van der Horst, Servaas and Velthuizen, Nop
Thoth Publishers, Amsterdam, 1992
ISBN 90-6868-052-8

Another useful starting point. This time only two- and four-line kites are covered. After the usual history of kites and description of modern stunt kites, the authors give a useful guide to materials and construction techniques and present eleven of their own designs including two soft kites (Sputnik 1 and 2) and a variation on the Flexifoil. Their advice on construction will be useful to anyone building the Sands 4-Liner.

"The Penguin Book of Kites"
The Penguin Book of Kites
Pelham, David
Penguin Books, Harmondsworth, England, 1976
ISBN 0-14004-117-6

This older book has mainly single line designs. There is some interesting information on the early development of parafoils and the Rogallo kites (the inspiration behind hangglider design).

"The Science and Wonder of Kites"
Ito, Dr Toshio and Komara, Hirotsugu
Japan Publications, Tokyo, 1983
ISBN 8-87040-526-8

This appears to be 'the' book to read. I have found it very difficult to obtain any 'scientific' information on how kites fly and why one model performs differently from another. Most of the designers appear to work by intuition and kite design appears to still be at the 'artist / craftsman' stage.

I have not yet managed to obtain a copy of this book, as it is now out of print. It is the one that all the kitefliers and makers quote when I ask them for a source of information on the science of kite design.

"The Aeropleustic Art, or Navigation in the Air by the Use of Kites, or Buoyant Sails"
Pocock, George
Edward L Sterne, San Francisco, 1969

This is a facsimile publication of the original 1827 edition.

Magazines

"The Kiteflyer"
Published quarterly by the Kite Society of Great Britain (address below)

"American Kite"
Published quarterly by the American Kite Company, 480 Clementina St, San Francisco, CA, USA

"Kitelines"
Published quarterly by Aeolus Press Inc, PO Box 466, Randallstown, MD 21133-0466, USA

"Drachen Magazin"
Published quarterly by Axel Voss, Drachen Verlag, Brahmsallee 8, D-2000, Hamburg 13, Germany

Published in German with English summaries

Kite Festivals

These are the very best sources of information. Visit your local festival and meet the people who are active in traction kiting, they will give you all the information you need. The Kiteflyer magazine lists all of the UK festivals, or ask at your nearest kite shop.

Clubs and Societies

The Kite Society of Great Britain,
P.O. BOX 2274,
Gt Horkesley,
Colchester,
Essex, CO6 4AY
England

STACK: (Sport Team And Competitive Kiting)
Patrick Bonneau (Membership Secretary)
1 Terrace Road
Sittingbourne
Kent, ME10 4SF
England

American Kiteflyers Association
1559 Rockeville Pike
Rockeville, MD 20852
USA

Materials

The Kite Store, Neal Street, Covent Garden, London WC2H 9PA.
My 'local' shop. Good for all kites, materials, publications and helpful advice.

Cannock Kites, 6-6a Church St, Cannock, WS11 3BD
Stocks all the usual kites and materials and runs a mail order service. I have found them particularly useful for supplies of 'seconds' of RipStop Nylon and balloon material, either of which provides low cost material suitable for 'soft' kites and useful for experiments.

Spider Kites, Pembrey Farm house, Pembrey, Burry Port, Dyfed SA16 0YT.
Manufacturers of the Modulus, variable size, zip-up, modular kite system.

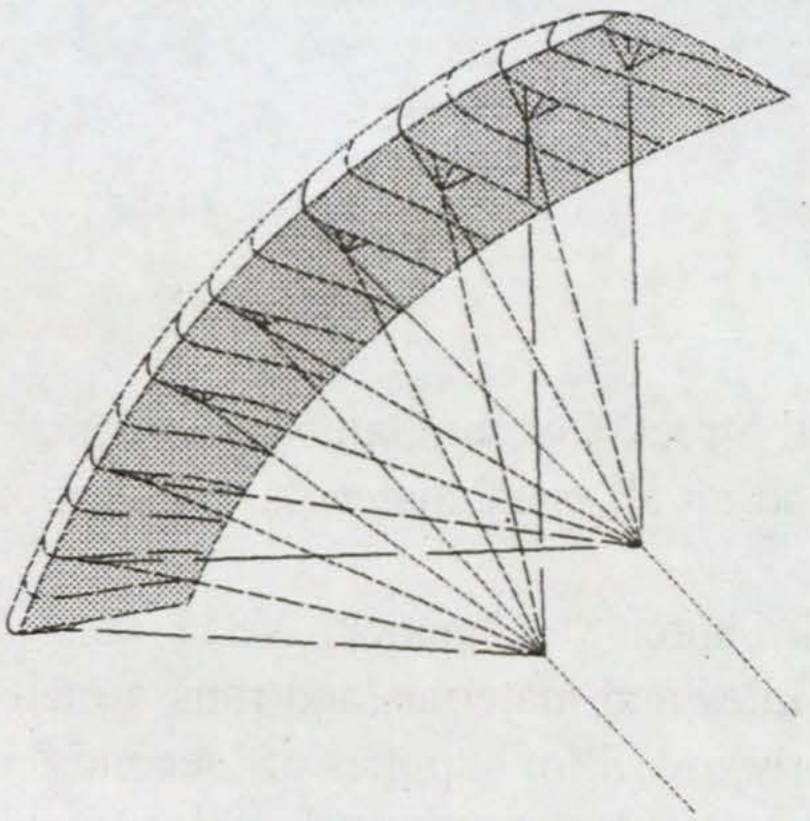
Peter Lynn Kites, 105 Alford Forest Road, Ashburton, New Zealand
If you do not know what Peter sells, go back to the start and read it all again.

High As A Kite, 153 Stoke Newington Church St, London, N16 0UH.
Jeremy Boyce is a member of the Aircraft stunt team which gave a talk to the AYRS London Meeting.

Tradewind Kites, 6 Harris Arcade, Reading, Berkshire RG1 1DN.
Stockists of Peter Lynn products, buggies, peels, quick release (dead-man) handles etc.

Editor's Note

These 'sources' are simply those that I have found useful in my own, very limited, foray into the world of kites (plus a few suggested by Roger Glencross).. This is not an exhaustive list, and is limited mainly to the United Kingdom. I should be grateful if readers would send me any useful information on additional 'sources' for future publications.



Editor's Health Warning

In their articles, both Peter Lynn and Chris Sands warn of the power of traction kites and the respect that they require. I make no apologies for repeating these warnings here. These are seriously powerful beasts, it takes great skill to control them, and even the experts get it wrong sometimes. Beginners get it wrong more often. I am still a beginner and I know!

I first tried to fly a Parafoil in 1992, a 25sqm Stratostar loaned by Roger Glencross. As soon as there was sufficient wind to keep it in the air, there was too much power for a team of us to hold it. After watching Didier Costes flying it at Weymouth I realised that there was a delicate skill to be acquired not just strength. I decided that I would learn by building a small parafoil. In 1993 I built a Sputnik 2. This is a 1sqm parafoil design from 'Stunt Kites to Make and Fly'.

After gaining some experience with the Sputnik, I visited the Blackheath Kite Festival where I met Chris Sands. His 14 year old son, Andrew, demonstrated their 2sqm four line kite, pulling the 'Sands' buggy across Blackheath. Chris offered me a chance to fly their kite. It was blowing hard, but young Andrew had controlled it and I had all the experience of flying my 1sqm, so I had a go. The next thing I remember is opening my eyes, looking up at some concerned faces and feeling very dazed.

A few days later I had a chance to try Andrew Beattie's 10sqm Peel. This time there was virtually no wind, only the occasional light gust, no problem. Even then I was taken off guard and a gust pulled me off my feet. It may only have been a light gust but it was hitting 10sqm, that is still serious power. The following weekend I was watching Andrew flying the 10sqm towing his Lynn trimaran across Weymouth bay in a moderate wind. It flew perfectly, I do not know for how long he flew it, but in the hour or so that I watched he did not 'ditch' it once. Experience.

It should not take too much imagination to realise the power that is being produced, just look at the mast and rigging needed to support the power of a 10sqm sail. Even the sailboarders have their mast attached to the board, and they rarely use 10sqm. You are holding that power in two hands. It cannot be done by strength alone, it requires considerable skill. Learn it on land, preferably soft land, with a smaller kite in light weather, progress to larger kites in higher winds. When you can do that, try to buggy. When you can do that, try your boat. When you can do that, talk to Didier Costes or Paul Ashford about a hapa.

Editor's Wealth Warning

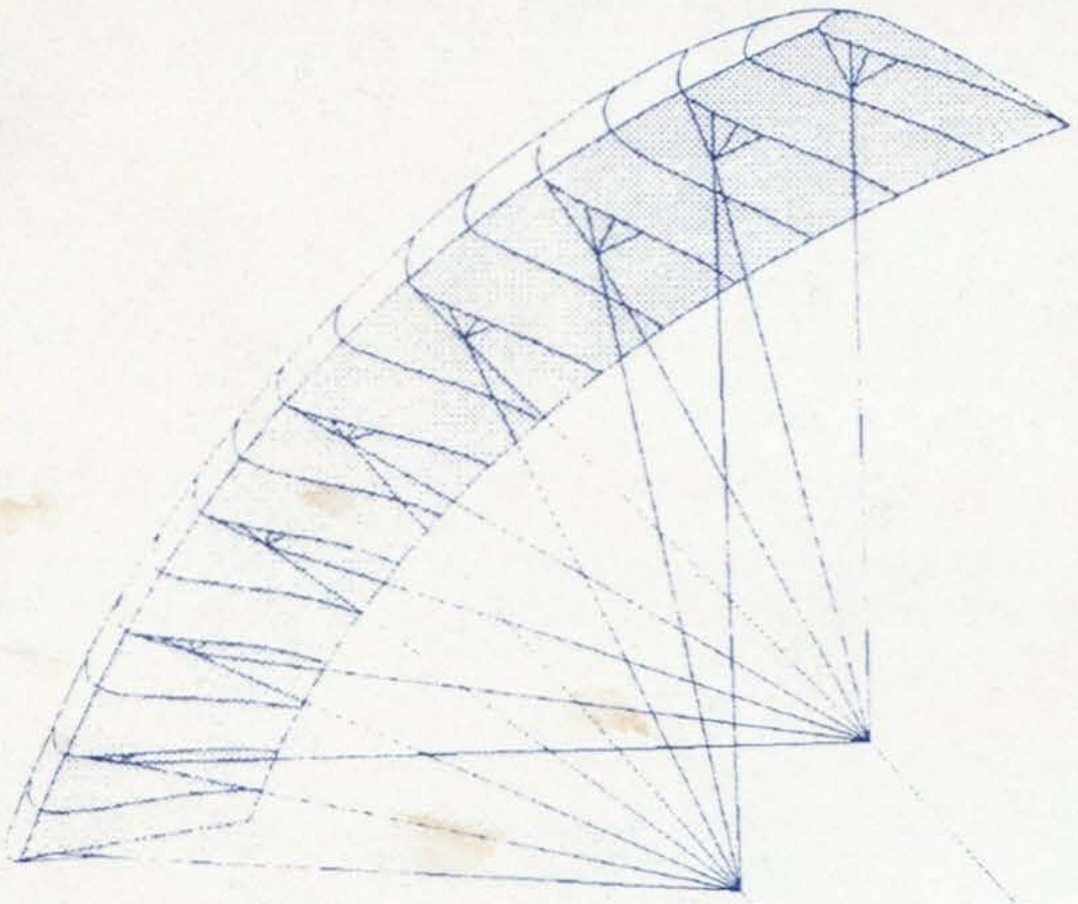
Kite flying is becoming very popular and, as it does so, the production of kites is becoming a viable business. One result of this is that kite designers are investing their time and money in research and are, quite naturally, taking steps to protect the results of this research. Innovations are being patented, see Peter Lynn's article.

The design that we publish is by Chris Sands and this is published with full permission from Chris. He is an amateur and keen to see ideas tried and progress made. However, as Chris explains, his thinking has been influenced by observation of a number of the commercially available kites in use today. It is therefore possible that this design contains aspects which, unknown to us, have been patented. Therefore, if you wish to avoid the possibility of legal action, the kite should only be built for your own use.

Conclusion

This second publication on kite traction has dealt mainly with the 'dry end of the string'. I hope that it has given you some clues as to how to retain the dryness whilst still making progress. AYRS 114 dealt with the other, the intentionally wet, end. In a future publication we shall try to put both ends back together with some examples of practical achievements and of speculative thoughts regarding kite traction and 'Ultimate Sailing'.

The reports by Theo Schmidt and Didier Costes and the paper by Burgess, held over from AYRS 114, have again suffered from lack of space. They will be included in a future publication in this series.



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