BGA Advanced Gliding Training Notes.

This guide forms the advanced syllabus for the BGA Advanced Gliding and covers those areas of gliding which are not covered by the BGA instructor guide of basic gliding. It is for students and instructors as a reference pre-flight briefing document and takes students from having gone solo into how to soar, fly cross country and even to do it a little faster.

The scope of this guide is essentially limited to thermal flying and techniques which are beneficial to speedy cross-country gliding and of course competitions. It does not include either ridge flying or wave. These types of useful lift are well documented elsewhere and they are relatively easy both to understand and use. On the other hand the bulk of cross country flying in the UK is done using thermals for which there is an inadequate level of understanding.

A number of analogies are used throughout but bear in mind that these are simply tools to enable you to try and get a picture of what is going on. Like women are from Venus! So get the picture without any emphasis on a direct comparison because the actual physics may not be the same. In other publications water is used to describe motion of air or example, but it is a liquid and its properties are quite different to that of the gaseous air.
The simple computer binary language of ones and noughts produces an extraordinary complex world in tech capability today yet a simple error generates an utterly failed program. In a similar way gliding is the simple shoving of the stick forwards and back or side to side in a timely manner which results in a successful and fast 500km task or in a series of circuits due to one misjudged error. The information contained here is a simple starter to help you know when and by how much and in what direction you should shove the stick, to increase your success! The full explanation of what happens in our thermic sky is actually considerably greater as outside of the low level boundary layer all turbulence is caused by the interference of rising and descending air. A number of links on the BGA 'Aim Higher' web page will offer greater study of the subject.
There are the laws of physics and then there is theory. Hence aircraft fly either to Newton's Laws or Bernoulli's theorem. You can now probably guess who I support. On the other hand there is rule of thumb which is loosely based on the laws of physics. Herewith then, the rule of thumb of thermals, lift and sink, based purely on physics!

So please clear your mind of the likely many ill conceived, confusing, and conflicting ideas which have been suggested to you in the past that do not work because they can't and start afresh.

Compiled by Kevin R Atkinson BGACCL

AN IMPORTANT NOTE FOR THE STUDENT – Pre brief Self Study!

To date the lessons that you have learnt are well documented by the BGA instructor manual and the essential aspects of the majority of lessons can be briefed in 10 minutes or so and similarly demoed, taught and practiced in the air in 3 short winch launched flights. It has meant that there has been no need to prepare yourself as all that is needed will be taught to you by the experienced instructor just before the chosen glider has been allocated to you. In other words the mechanics of flying gliders is quite easy. However the dynamic aspects of thermalling and going cross country require a considerable greater amount of knowledge which can not be simply achieved by applied numbers.

Consider the ‘simple’ exercise of learning to thermal. A winch launch into a 6 knot thermal climb to 3000’, descend and land after 30 minutes flying is actually only a lesson in thermalling of 3 minutes! I defy anybody to teach and for the student to learn the skills or identifying, entering, centreing and climbing effectively in a thermal in 3 minutes! For a start, have you been taught how to read the sky, how can you feel a thermal if you don’t know or understand what you are feeling for and what are the difficulties interpreting sink, brief string and instrumentation indications?

Perhaps by now you are approaching or have achieved that mile stone point in your gliding where the view of the local seniors is that you are fit safe solo and require no additional checks. Well done.

But to progress further, however, and cruise effortlessly around the beautiful English countryside you seriously need to think how you will gain the knowledge and the many complex skills and techniques to progress further! In other words how do you learn what you don’t know, flying solo? Well you can but it is painfully slow, frustrating and expensive learning from your continual mistakes. I know this because this is the way I and the vast majority of my generation learnt. Sadly many clubs still appear to stop teaching after safe solo has been achieved. If on the other hand you fly for an hour or so with an experienced instructor who will teach you some aspects of the syllabus included here, then your progress will be accelerated many times over and it will avoid those tedious and frustrating failures. A very useful comment made by one of my students was that the only similarity between the flying that he had been taught and the flying that I was teaching him was to fly safe, as every other aspect of flying water filled glass gliders cross country was completely different.

Whilst your eyes may well be focused on how to fly your first cross country there are a few other basics that you need to have in mind.

The Sporting Code.

The sporting code requires you to make a declaration (all done by you!) before any FAI attempted task and clearly explains all the requirements (declaration, rules of, and evidence required) that must be fulfilled to make a successful flight - a qualifying flight! You need to thoroughly read this document before finding an Official Observer at your club who will clarify any parts you don’t fully understand.

The FAI Sporting Code deals with rules concerning badge claims, records and international competitions.
The documents for section 3 (which deals with gliding) can be found at:

www.fai.org/igc-documents

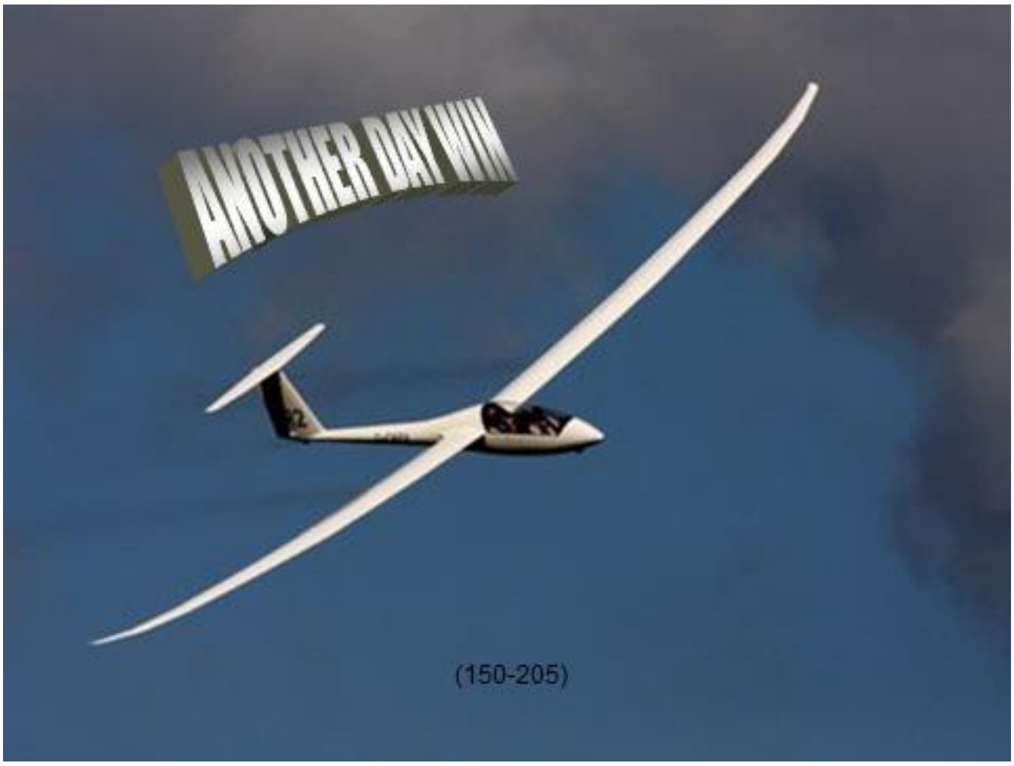
under “Sporting Code and Gliding Rules Section 3: Gliding”. In particular, the Official Observer and Pilot Guide (Annex C) can then be found under the "annexes” subsection.

Personal preparation

From the outset it is better that you plan where you are going to go, even for your first 50 km Silver distance, so that you can fully comprehend the planning requirements for any subsequent long distance cross country flight. Consideration includes the basics of Navigational features to look out for, airspace restrictions, topography, diversion airfields and the suitability of farmers fields enroute, any requirements regarding operations at the planned destination and of course the predicted weather. This prior planning allows more time available once airborne on concentrating on staying airborne!
How does the glider derig and secure safely in the trailer with all the tools and fittings?
Can you (or your crew) drive (and reverse) (are they insured) your car hitched to a glider trailer?
Whilst the crew will bring your empty trailer to your landing point, it is traditional that the pilot takes the responsibility of returning the glider and trailer home, usually via a restaurant!
Will your car pull the glider and trailer through a ploughed field?
Have you a tow rope?

Pages 3 – 12 General explanations and diagrams

Topics covered.



The Condensation on the Bathroom Ceiling Analogy.

Imagine a ceiling and condensation forming on it.
All drops which fall off are the ‘same’ size (surface tension v gravity). You don’t get a fine spray in one place and a bucket of water in another so I say again that we may effectively assume that all drops are the same size.
If the ceiling has a varied surface temperature then the cooler areas would produce more drops and the warmer areas less or none. (But the drops are still the same size as before) (Cold spots/hot spots).
If the surface is uneven then we can see that the drops would run and form where the ceiling surface hangs down.
If a breeze is introduced it forces the developing droplets along towards any barriers.
Equally important is to note that the droplets will form and fall from the same place each time.
This is just like bubbles in your beer or coke glass which form continuously from the same points, even when you swirl the glass around. (And by the way, the bubbles are essentially the same size as each other)
The whole process is governed by physics and in the same way thermals are governed by physics and are effectively the ‘same’ size, forming at the same locations on a blue day. (Buoyancy v gravity).

Whilst there are circumstances which will generate larger thermals, please though for now just remember that all thermals are also governed by physics and consider as a starting point that they are all about the same size - 200 metres across, regardless of how strong or how high they are. Equally though, in just the same way snow flakes are essentially the same, each one is slightly different so no thermal is the same but all have well defined similarities.

Finding Thermals.

Part of the issue is that many solo pilots only start to look at the sky after they have pulled off the launch mechanism. There are many opportunities to seriously study the sky. Our club require ground duties to be undertaken and this gives you the opportunity to study and see results. As a winch driver watch where the glider you have just launched has gone. Would you have gone that way and did they climb successfully or fail? Before even getting airborne on a club day, just after eventualities, you should start thinking and have a plan on where you are going to find your first thermal.
If you take an aero-tow count the number of thermals that you randomly pass through, mentally note their strengths and size (width) and relate them to areas on the ground plus the wind and the cloud.
To find a thermal you need to use the:
Ground.
Clouds.
Other gliders.
Birds.
Feel.
Smell.
Instruments.
MAP! Pre flight planning.
Common sense – not luck.

<u>THERMAL STRUCTURE</u>. – The Rule of Thumb - Theory!

Before we can possibly 'feel' the air we have to have a clear understanding of just what is happening.

There are Three Forces in a thermal.
1. Reduced Density - Buoyancy due to temperature relative to surrounding air.
2. Reduced Density - Buoyancy due to higher humidity relative to surrounding air.
3. Higher Pressure relative to surrounding air causing expansion.

There are Two Motions within a thermal.
1. 'Vortex' motion of a bubble.
2. Vertical motion of a column.

The air mass lifting a gaggle of 20 gliders in total weighing perhaps 10 tons is unhindered in rising by the weight of the gliders, because an average bubble thermal of 200 metres diameter and vertical displacement of 200 metres has a mass of 6300 metric tons and has both velocity and momentum. (20 gliders @ ½ton X 1 knot (ROD) = (10) tons/knot straight down. Verses (6300 tons X 4 knots) = (25,200) tons/knot straight up. This mass and momentum must not be taken out of context though, as the mass of the air it is rising against is greater. The effect is not Niagara, but more like rain hitting a pond.
As a side, 200 metres is a good guide as this is the width of a standard thermal, regardless of how strong it is, it is physics and you can't keep hot air down! This does not mean there are no bigger thermals. They do exist but they require additional analysis for which there is no

space here.   Bear in mind it takes just 6 seconds at 60 knots to transit the 200 metres across the middle from zero lift through the core and back out through zero lift again, so any slow reactions to the initial contact will jeopardize your ability to centre.
Air circulating in the form of a smoke ring (or doughnut shape) is easily induced and can be seen in many examples from the smoke of a cigarette to an atomic explosion. A smoker, however, has to do specific things to produce a smoke ring and whenever they exhale it is not hot air. Yet the structure of a thermal is often drawn as that of a bubble thermal rotating as a smoke ring vortex. Can it happen in a natural environment?   Well it can, but it is not the commonest structure so please discard it from your thoughts for now.

Before considering any movement of the air in and around a thermal you must simply remember two facts (laws).
Rising air primarily only has a vertical force acting on it, buoyancy, in other words straight up.
If strong enough, it also exhibits an 'explosive' high pressure force of expansion around the core where the horizontal temperature gradient is at its' highest value.
Just to be clear, however, hot air does not go down or sideways without some external force being applied to it.
Sinking air has only one force acting on it, weight, so straight down!
Again then cold air does not go up or sideways without some external force being applied to it.
The warmth of air can only be transmitted by convection (conduction or radiation is minimal in this situation) and therefore it has to physically move to make somewhere else either hotter or colder. (Hence why fans are used to blow hot or cold air around) The air under a lit match for example does not get hot. Any air warmer than its surrounds will not go down! Similarly air above a cold lake cannot go up and generate sink!
On the boundary of the strong updraft to the down draft is an outwards flow, other wise known as the gust and then cobbles stones where it interacts with the descending air (turbulence or boundary layer).
It is these three forces within the thermal that we must try to feel and look for.

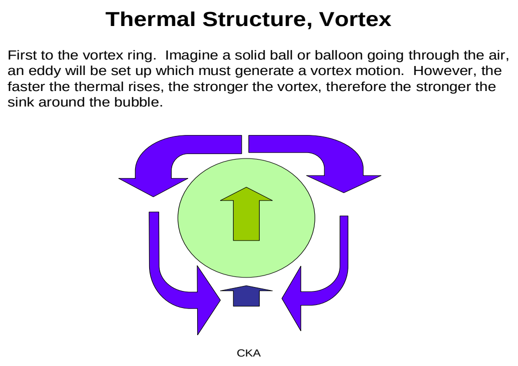
There is one other thing to grasp. Everything which travels through the air is restricted by drag. In terms of an aircraft for simplicity the drag is divided into to 2 distinct parts.

1. Lift dependant drag; is that drag generated as a result of producing lift,
2. Zero lift drag.

Zero lift drag is made up of three forces.

1. Profile drag – the frontal surface area view in the direction of travel.
2. Interference drag i.e. turbulence between the deflected airflows interacting around the object.
3. Surface friction drag. - The area also effectively known as the boundary layer.

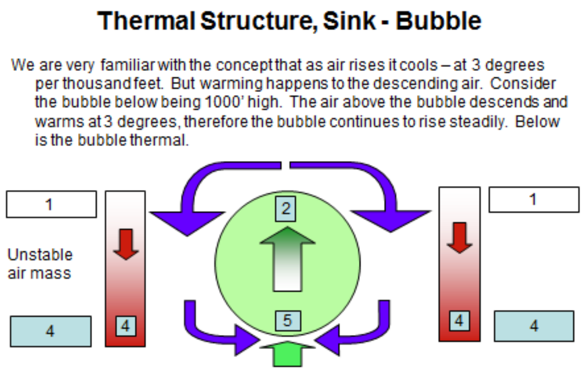
Tests in wind tunnels will indicate the total drag caused by any shape at any speed.
Hot air moving through cool air is subject to the zero lift drag aerodynamics just as any object but air has 2 additional properties. Unlike solid objects, the shape of the warm air can freely change and second, it can mix with the surrounding air. It is easier initially though, to simply consider the warm rising air as a single entity, like a hot air balloon. Whilst these additional properties are significant, the effects generate complications which do not need to be considered yet but they are covered later.

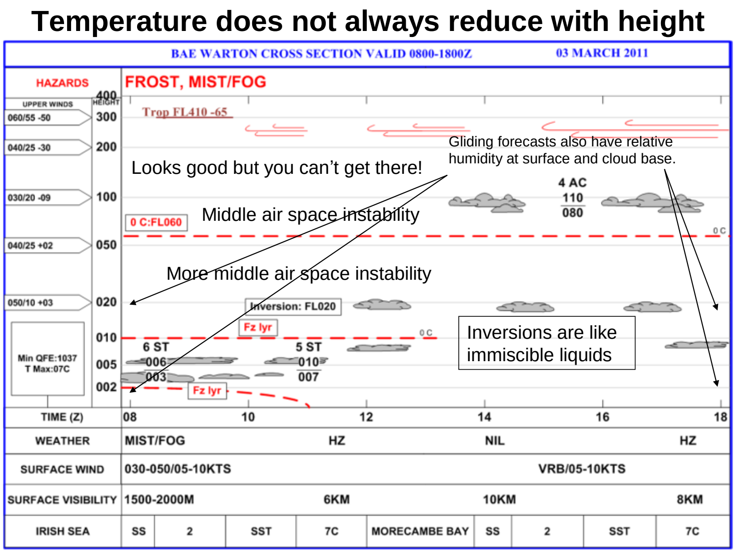


The sinking air is not air that has risen, it is air which has moved out of the way and rushed around the rising air. Whilst we often talk about climbing in strong or weak thermals, little is discussed about the structure of sink except that we had a bad bit somewhere, the distribution of which for several reasons can vary considerably over the sky at any one time. For our rising thermal, the sink therefore always matches the rate of climb of the bit we call a thermal.

Most important is that it is the sinking air which determines the structure of the soaring sky and this is one of the most fundamental points to remember in any subsequent analysis!

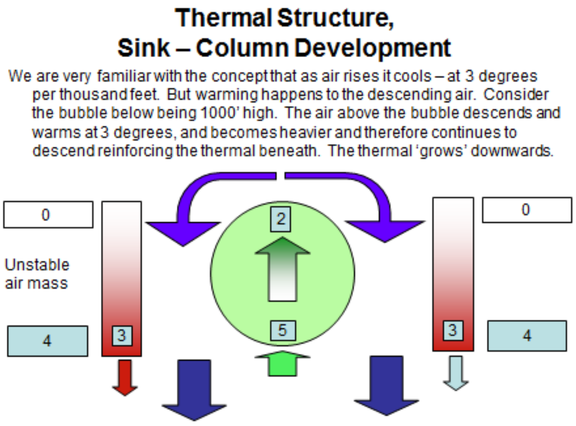
Rising through a band of limited instability the bubble climbs in isolation and its buoyancy (ROC) remains steady.

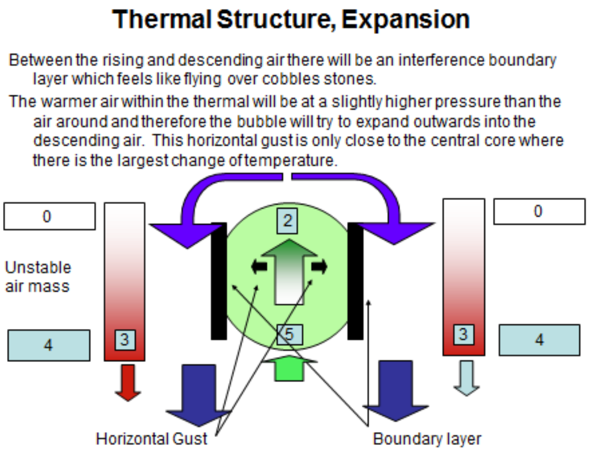




This real cross section for Warton on 3 March 2011 shows 3 freezing levels.
You will notice that early in the day with the sea temperatures over the Irish Sea and Morecombe bay at 7C and an air temperature at 200 feet of zero, fog has formed.
Meanwhile the temperature (In the left upper wind column after the wind values) is +3C at 2000 and +2C at 5000 feet giving a strong inversion somewhere in that band but with instability in the lower levels.
There is another unstable layer indicated around 8000-11000 feet – hence the term - middle airspace instability.

As the bubble climbs through an unstable layer the temperature difference increases, accelerating the thermal upwards but also generating an accelerating downward flow. The descending air subsequently enables the thermal to grow downwards. Just bear in mind that the stronger thermal is narrower.





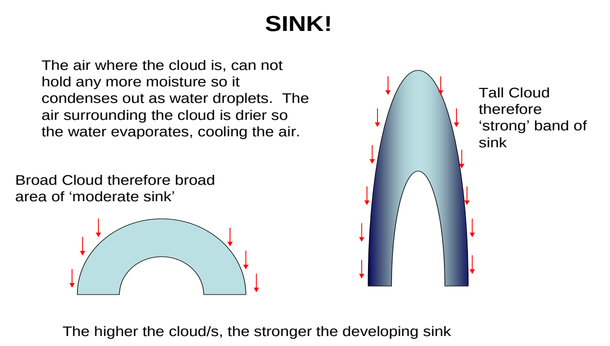
The following 2 pictures clearly show (via the smoke) the development of the castellation and the formation of column thermals, in an unstable layer from a constant heat source. Notice how the volume of the thermal is increases vertically by extending down, not horizontally.

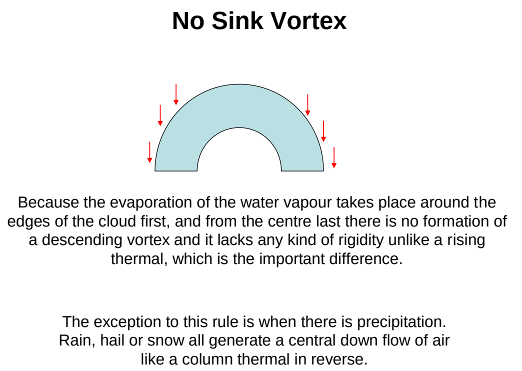
Consider the cloud at the top of a thermal.

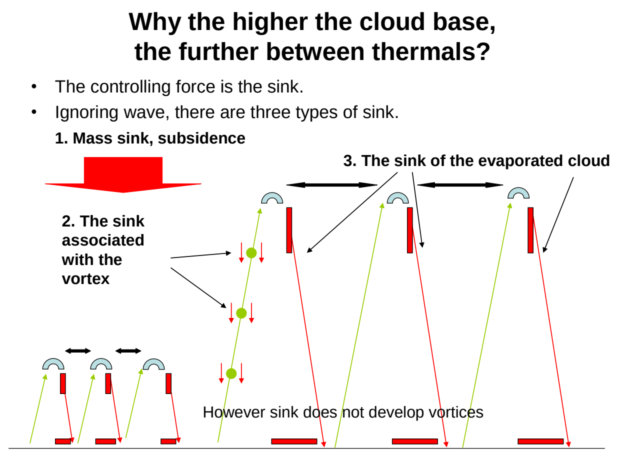
As it pushes up into the drier air the cloud droplets will start to evaporate into the dry air next to it which has already starting to descend, as explained above.

It takes 130 times as much energy (heat) to change a water droplet into a gas as heating the same water up by ONE degrees C, in other words a lot. This energy is taken from the dry air (which rapidly reduces in temperature) so the air next to a cloud increases in humidity, but

becomes rapidly cold, therefore denser and heavier than the air around it so descends, hence sink! The higher the cloud top and the drier the upper air, the stronger the sink will be.
Of course whilst cruising in your glider at lower altitudes the cloud may well have fully evaporated and hence the occasional scenario 'where did that sink come from'?
Just like thermals, sink slugs can vary and even slightly accelerate downwards.





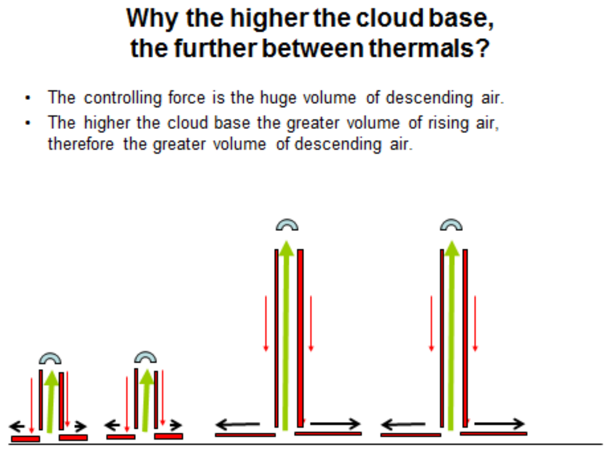


The examples above are necessarily simplistic.

Just before we go on to thermal triggers there are some very important basics to understand. We have a pretty good idea that thermals are 200 metres across but to know the volume we have to know the height of the column. Can we work it out?
Accepting for the moment that all thermals are essentially formed by bubbles of air leaving the ground and rising, then we have to investigate bubble thermals and their volume.
If we watch a cloud for a few minutes we will see that after the initial wisp, a cumulus cloud will develop and then dissipate. The whole process may take 5 minutes with the cumulus cloud being in a state of development for only 3 minutes. So a 2 knot thermal (200/min) means that the column was only 6oo feet tall. Even if the development was 5 minutes then it was only 1000 feet tall. As the cloud develops the tail of the thermal is climbing up, disconnected from the thermal source and ground, leaving perhaps only a little turbulence behind, but no thermal! If the thermal was a little stronger though, assuming the same cross sectional area, then the column will be taller. 3 knots for 3 minutes makes the column 900 feet tall. This tells us 2 things. Why on some days despite seemingly flying under every cloud we can reach, we don't find a climb and second, on some days it clearly pays to stay high up near the clouds.
So from this simple picture we can calculate the volume of air in a standard thermal and transfer this volume to cover the ground i.e. the thermal source.
If we keep the maths really simple and consider a thermal to be a cuboid then 200 x 200 wide x 300 metres high = 12,000,000, cubic metres.
If we use Google maps we can find many fields in the UK country side 500 metres square. So 12,000,000 divided by the fields' surface area of 500 x 500 = 250,000 square metres gives a depth of 48 metres! (about 150 feet).
When we compare this deduction with what in practise we feel on the ground and experience flying at low level this all makes sense. How often do you find that at about low key to final there is often a broad 'thermal' just too late (low) to use but you subsequently end up relatively high turning final. Another question though is more telling. How often are you in a flat glide below 500 feet? Probably this is likely to be, (so far) only during the late part of a circuit. As you do more cross countries or more importantly, final glides back to base for a straight in approach, you will often get significant benefit from flying over what would appear to be good thermal production areas with gentle climbs and no significant sink. Having height in hand speed is increased and you safely cruise at lower heights during the last few kms because of the surplus speed. As a result during the late stages of the glide you continue to gain energy and you go even faster. This is usually mistaken as an error of setting off too late 30 kms back for the final glide and if only I had known that it was going to be so good! Wrong! Do not assume that it will always work. When you really need it, it won't.
The effect then of anything, which shields an area from the wind to encourage the build up of hot air and therefore allows for the generation of the appropriate volume of hot air to produce our thermals is worthy of notice. These shields would legitimately be trees, buildings, small ridges and the like and lee wind shielding generating a weak rotor.

What goes up must come down.
For thermals this means that there must be an equal volume of descending air to replace the volume of rising air. The huge thermal volume of column thermals will only be generated and get taller (increase mass) by effectively growing downwards as they climb into an increasingly unstable layer, as explained previously. But then once fully developed they also generate an equal volume of cold descending air which cascades down and floods the ground over a considerable area. It is quite reasonable then to assume the greater the volume of active cloud, there will be a greater amount of sink, no matter how it is generated. This

descending air is therefore a major contributor to the thermals developing further apart as the cloud base steadily moves up. In light winds fixed column thermals develop and the thermal width will broaden (volume of rising air increases) and the huge volume of sinking air will kill off the weaker areas for miles around.



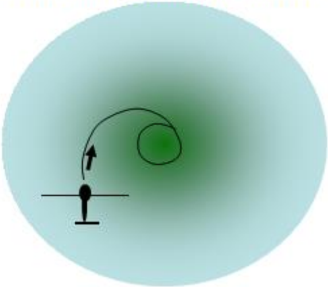
<u>(Atkinson's) String Theory.</u>

Ignoring mechanical turbulence, all conflicts between rising and descending air generate a horizontal gust and this is always from the lift to the sink. (This is equally significant during any glide).

Approaching a thermal you will experience in order the downdraft, cobble stone turbulence, speed gust increase, then the lift. The speed increase will also be detected on the variometer in the total energy system as a climb, do not be fooled! (You are unlikely to be climbing yet). It is important to acknowledge that if you are in rising air without a gust you are not near enough to the centre of the thermal. Transiting deeper into the air you will normally find yourself rewarded with a stronger climb.

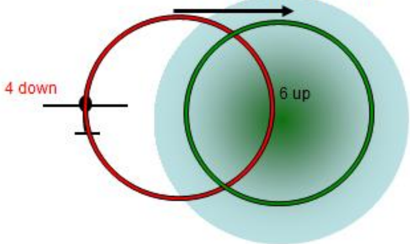
If you don't hit the thermal head on then you will feel the wing lift and/or better, see the string indicating a brief side slip (Atkinson's string theory) i.e. at the moment the string is blown away from the thermal centre due to the horizontal gust, it is time to roll with full aileron and rudder! The bigger the gust the stronger and tighter will be the thermal core. Remember that the force required moving the string is tiny, at any speed, compared to the force required to lift the wing. Indeed the outward gust may be detected outside the area where the wing would give you such a useful indication.

Conventional Centreing
Weak Thermal and Vario Peak



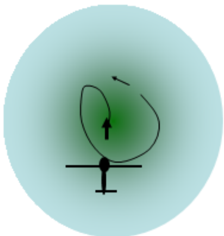
Right Wing Lifts therefore turn right with increasing bank (keep tightening the turn) until a maximum turn is achieved.

Conventional Centreing
Vario Minimum



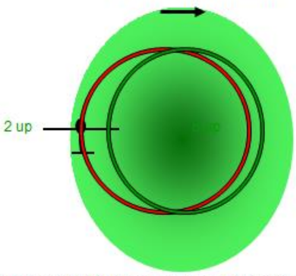
The one thing you can say about the vario is that it will tell you that you are in sink! Therefore 90 degrees after the highest sink value, roll out and after a pause, roll back in.

Conventional Centreing
Approaching the Vario Peak
No wing lift and no string

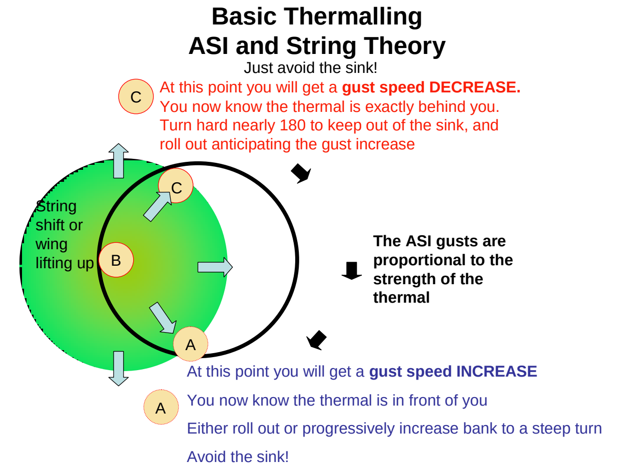


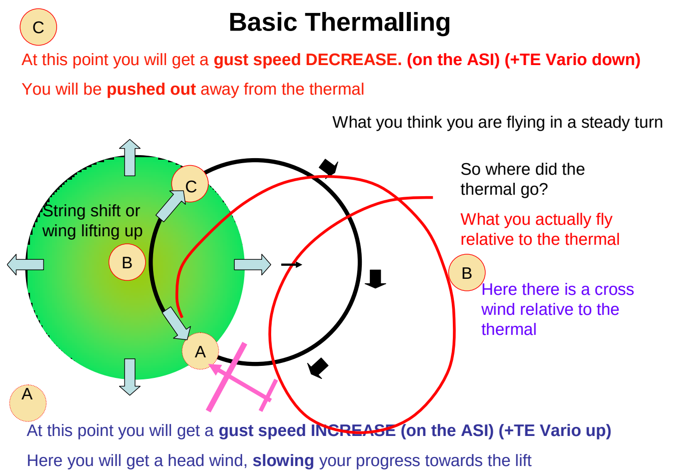
When the vario has been giving an increasing climb for 3 seconds turn using full aileron and rudder – it does not matter which way you turn – so long as you turn! You anchor the wing tip at that point.

Conventional Centreing
Vario Minimum



The same technique can be used in the established turn using the weakest part of the climbing turn as a reference.





So this is what we are feeling if we fly through a thermal!

1. Feel, and Hear on the audio the sink.
2. Feel cobble stones.
3. Hear and See the speed increase.
4. Hear the audio vario up.
5. See the string deflection and wing lift.
6. Hear and See the speed decrease.
7. Feel the sink.

And this is what we are feeling for whilst turning within the thermal!

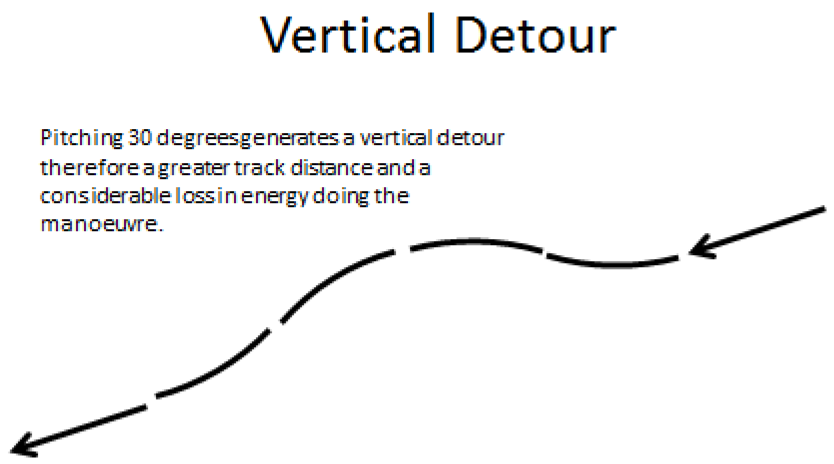
1. Feel, and Hear on the audio the lift.
2. Hear and See the speed increase.
3. See the string deflection and wing lift.
4. Hear the change in audio vario up.
5. Feel the tail go up (or nose yawing down).
6. Hear and See the speed decrease.
7. Audio indicates lift values reducing.
8. Feel the sink.

If the thermal is stronger it will be narrower, therefore, the stronger the thermal, the tighter you must turn. The turn radius is the important factor and this is achieved either at higher angles of bank or reducing your speed with the same bank angle.

Detour

Before we consider determining what speed we should fly we have to look at the way we are going to fly it.
Wood is good and the speed range between climb and cruising is relatively small, the gliders relatively light with large wing areas and low wing loadings. In this case dolphin as you wish.
There are 4 types of detour.

1. Vertical Detour.

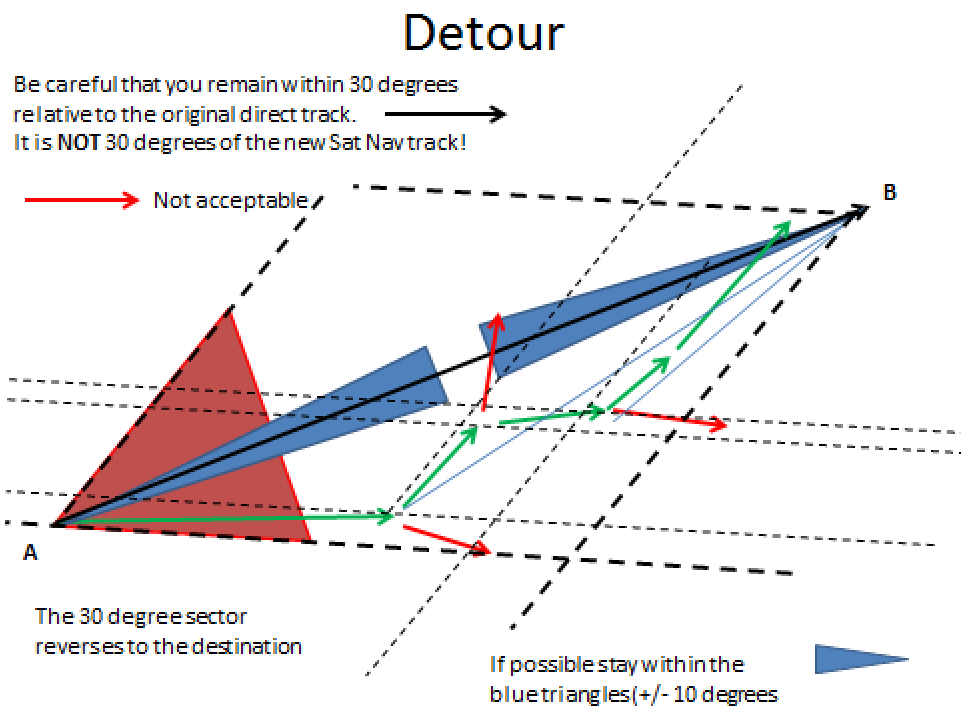


The moment you start flying glass, however, there are a considerable number of critical inputs to be assured of any benefit. The key here in simplistic terms is to fly a 'block speed' until the next thermal that you are actually going to climb in. There is no abrupt dolphin in the cruise.
This is due to 2 main contributors; Vertical detour and drag during manoeuvre; more distance and large drag values. In the first consider the extra track distance flown pitching 30 degrees up, easing over to ensure an acceleration before reaching the sink and then pitching up again to return to block speed. Finally just consider the time lost slowing down from 80 knots to 40 and then accelerating away again. Try it in the car on the motorway!

2. Horizontal Detour – chasing the better weather but remaining close to track!

Consider the following.

If you were to fly a task from Strathaven to Swindon the direct track distance is 481 kms. The route essentially follows the motorway structure. If you, however, put the route on to route master, the distance covered by gently swathing through the country down the motorways is 560kms, yet the route would not appear to have any significant detour! An extra 80kms 16% distance to be flown and requiring an additional 6000 or 7000 feet to be climbed!



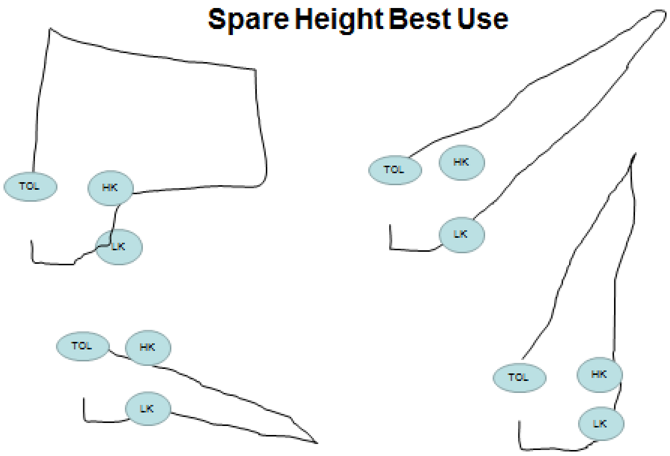
3. Necessary detour – nothing enroute but inevitable land out therefore reroute just to stay airborne.

4. Useless detour – Chasing the 'better' weather way off track when there are options on track.

Hopefully you will find the above extracts useful both for clarity as to what happens in the thermic sky and that as a result your soaring flights will be more successful.

Kevin

1. Making the best use of spare height after a winch launch



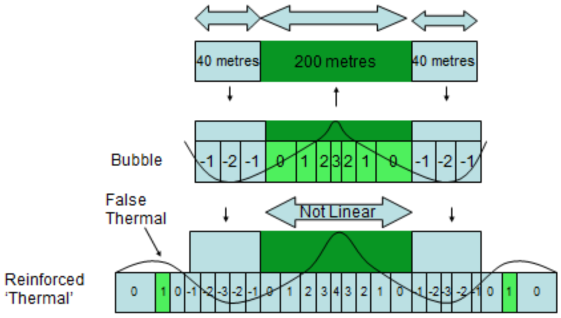
2. Judging distances

An aspect which is important is the skill of judging distances. This is not just whether you can make a landable airfield but also having identified a cloud ahead, or a series of clouds which you think are going to be good, it is clear that you need to know that you can make it and how much height you will have left when you get there. We know that our launch run is about 1 km and we also know that on most days we can achieve 1 km for each 100 feet of height. In the case of chasing clouds the wind is irrelevant. As the performance of the glider goes up this 1/100 remains the same but we just get there at a higher speed! On the other hand with gliders fitted with satellite navigation aids we can use these to help confirm distances (for example put a TP within 10 kms of base) and now knowing that distance you can add or subtract an amount to give you the distance to the cloud shadow, even if it is well to one side of the selected TP, and subsequently build up a level of judgement in just the same way as with practise we developed the broad skill of recognising that we can glide home safely whilst local soaring. The next development then having estimated the distance is to estimate how far other cloud shadows are away from you, and then work out how much height you are going to lose to get there and how many other cloud options are in range. Ideally three should be available within a single glide before you are likely committed to a field.

3. Description of a thermal cross section

Thermal Cross Section

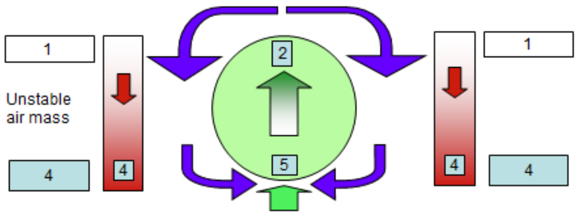
Consider what the cross section of a thermal is likely to be rather than just up and down. If we consider for simplicity that a 1 degree temperature difference equates to 1 knot of lift or sink.



4. Bubble thermals

Thermal Structure, Sink - Bubble

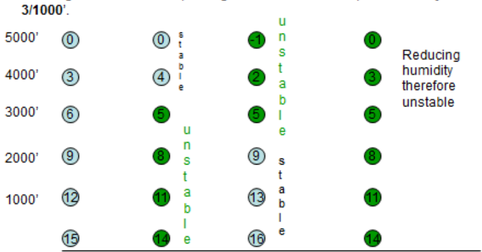
We are very familiar with the concept that as air rises it cools – at 3 degrees per thousand feet. But warming happens to the descending air. Consider the bubble below being 1000' high. The air above the bubble descends and warms at 3 degrees, therefore the bubble continues to rise steadily. Below is the bubble thermal.

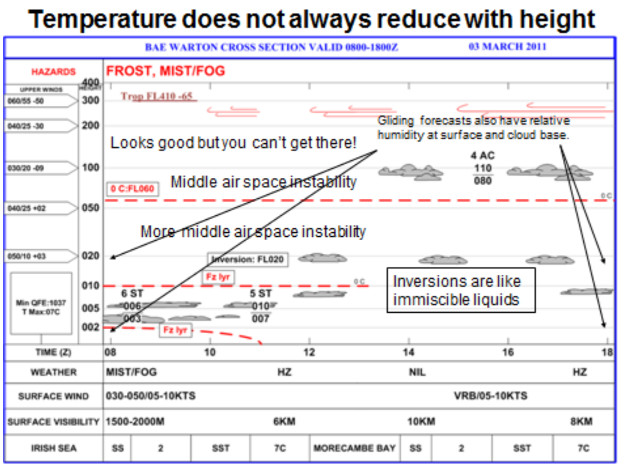


5. Lapse rates

Instability

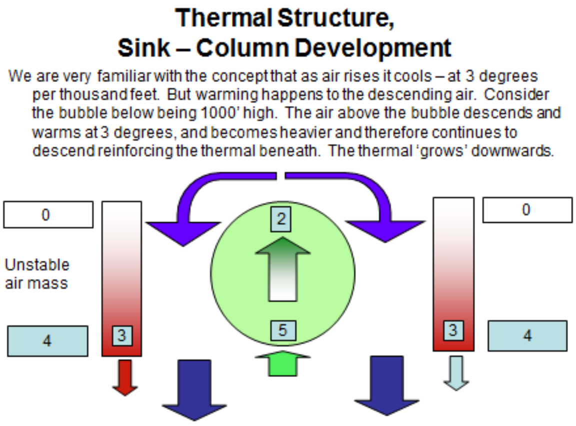
Assuming that any bubble of 'warm' air will cool at 3 degrees per 1000' as it climbs then its relative buoyancy will depend purely on the surrounding air at that height. The actual temp change of the natural atmosphere is **rarely 3/1000'**.



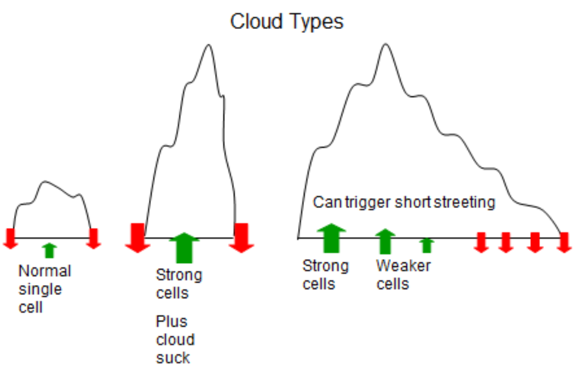


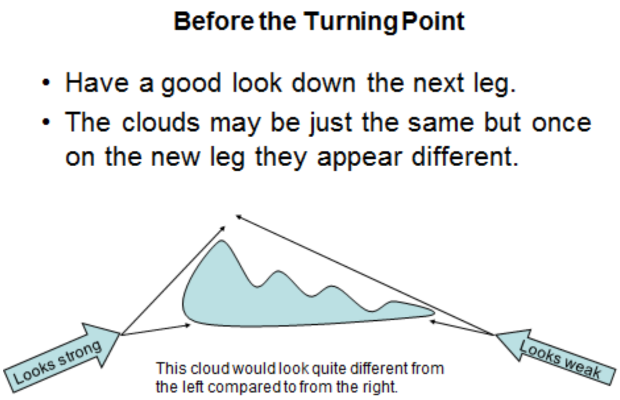
6. Column thermals and stronger thermals

Clearly once a lump of warm air has started to rise, its energy is effectively fixed. If, however, it is rising into an unstable layer it can then accelerate, generating a stronger thermal, as below. The thermal then grows downwards forming a column thermal which means that you can connect underneath a cloud even on a windy day despite being well below cloud base and there being no obvious thermal source.



7. Cloud appreciation





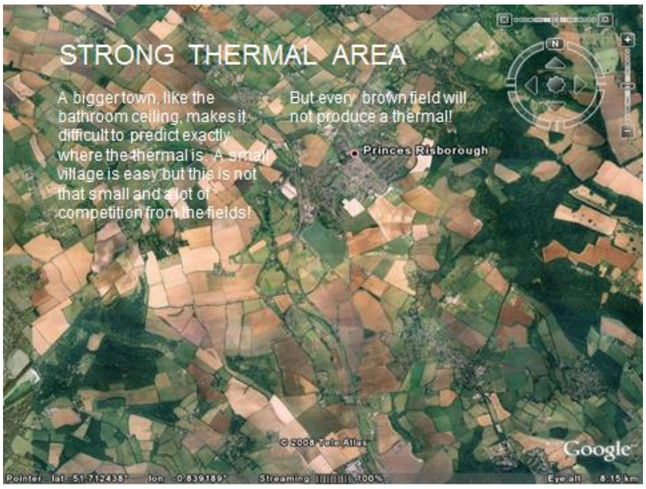
8. Blue days

The bits which get hot on the ground should be fairly obvious. Identify them because they are the only bits which are going to produce thermals. The strong sources often produce weak streeting but if ever you lose a thermal, then go immediately up wind for the next bubble.

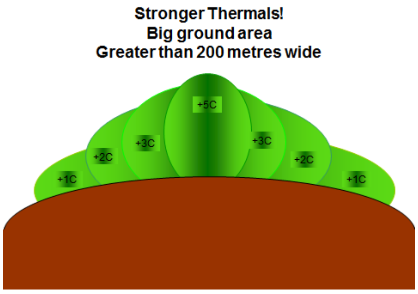
9. Inversions

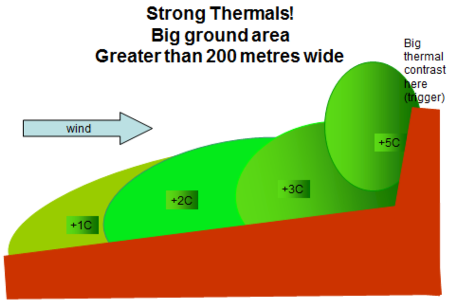
Inversions are like immiscible liquids. Whilst it is common for the air to be cooler as we climb this is not always the case and we can get warmer air sitting on cooler air. (First thing in the morning this is always the case). As the thermal rises it is no longer warmer than the surrounding air and stops climbing. We see a clear haze horizon and you will not get any higher.

10. Hot spots

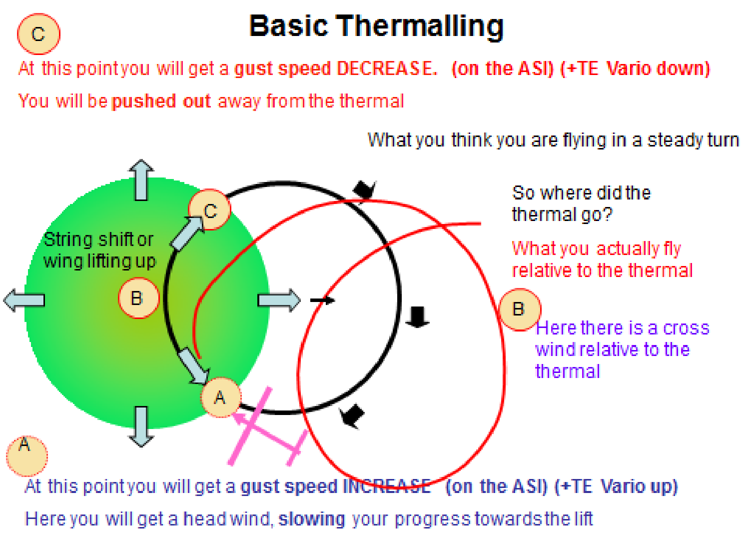


11. Thermal triggers

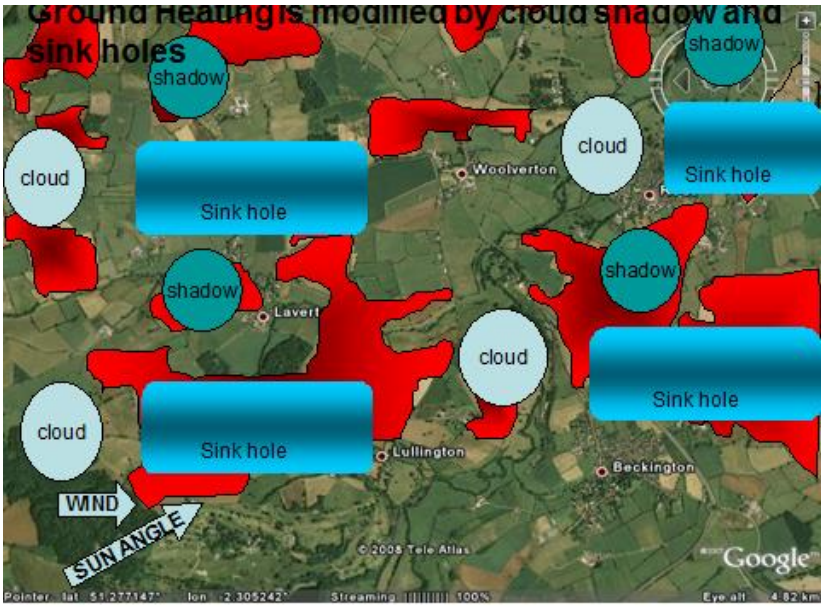




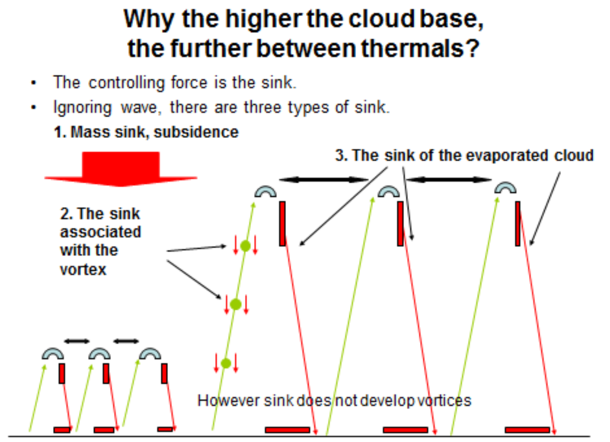
12. Centreing



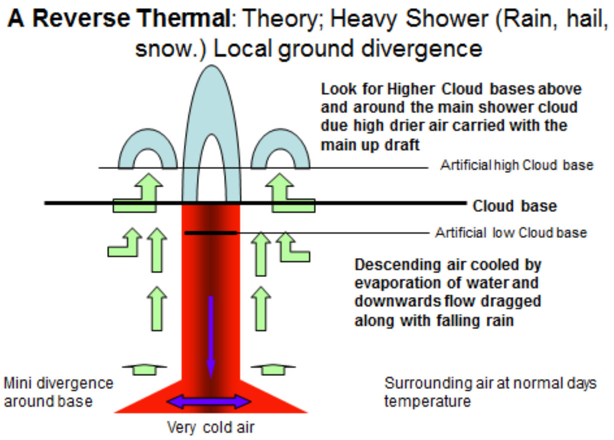
13. Cloud shadow effects



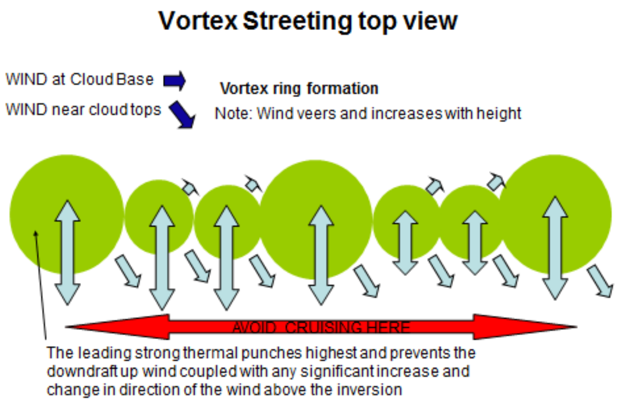
14. Types of sink



15. Rain/storms and reverse thermals



16. Streeting



17. Turning tightly

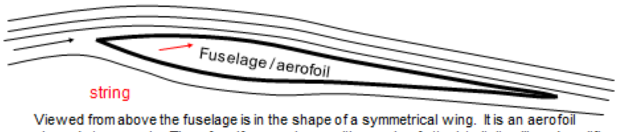
Speed Verses Angle of Bank
Turn Radius Achieved in Metres
BANK = SPEED Elevator often fully up!

	40 kts	45 kts	50 kts	55kts	60 kts	65 kts
35	61.7	78.1	96.4	116.6	138.8	162.9
40	51.5	65.2	80.4	97.3	115.8	136.0
45	43.2	54.7	67.5	81.7	97.2	114.1
50	36.3	45.9	56.6	68.5	81.6	95.7
55	30.2	38.3	47.3	57.2	68.1	79.9
60	24.9	31.6	39.0	47.2	56.1	65.9

18. Atkinson's string Theory

There are 2 aspects to this. The first is in identifying the thermal core to one side of the glider by noticing the string deflect in the horizontal gust. This has been covered in centreing.
The second aspect is used to obtain the maximum rate of climb from our glider flying a steep turn within a strong thermal.

Wasted Opportunity Climbing
In a left hand turn viewed from above

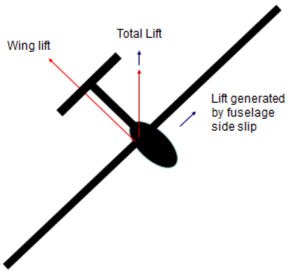


Viewed from above the fuselage is in the shape of a symmetrical wing. It is an aerofoil viewed at any angle. Therefore if we apply a positive angle of attack to it, it will produce lift off the fuselage, which actually has about two thirds the surface area of a wing (but sadly not that efficient!)

So the question is how much side slip should we use? This depends on a few things but a simple rule of thumb is the tighter you turn (the fuselage is more on its side) and the stronger the thermal, the more sideslip, but not beyond the limit of efficiency. The actual optimum is 15 degrees but the string will exaggerate this.

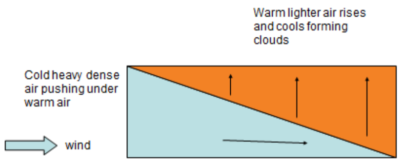
To find out just how far we can go on a smooth flat day simply fly straight and monitor the increase rate of descent on the vario as you fly more and more out of balance. The 'limit' will be obvious and the same right or left. Now practice turning with the string held just short of the limit towards the top wing.

Wasted Opportunity Climbing
In a left hand turn viewed from behind



19. <u>Sea breeze</u>

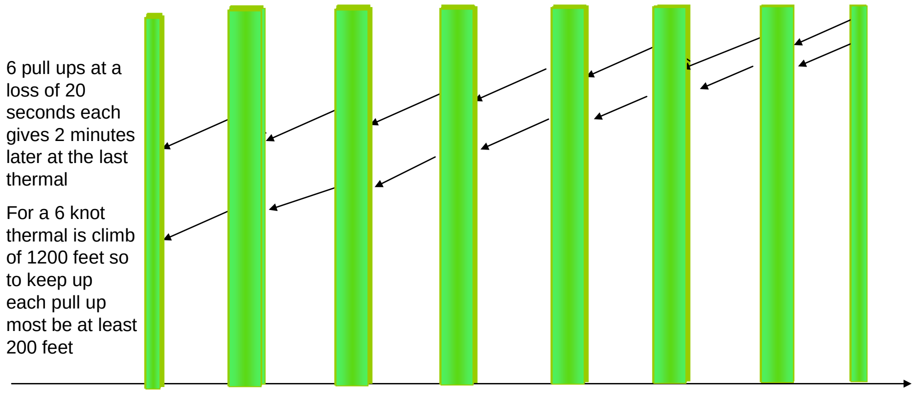
Classic Convergence
Sea Breeze



20. <u>Dolphin</u>

Dolphin

- **Another misnomer**
- **Following the MacCready religiously, it is efficient but slow. Like driving a formula one car for best fuel efficiently does not win races. All these little climbs are at nearly half the cruise speed and if any accelerations are late then it is a case of accelerating in sink – huge mistake. Simply use the lift as a gymnast uses a spring board. A gentle short pull up and bounce to maintain never less than 20 knots slower than cruise. More commonly only about 10 knots.**

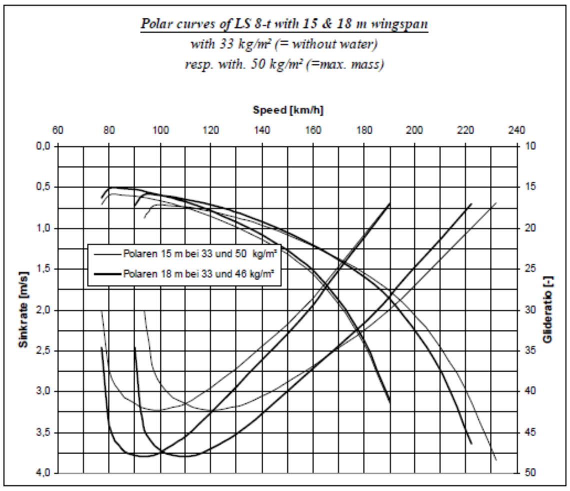


If you want to think about how much time is lost, try driving down the motorway and slowing down from 80 to 40 every couple of minutes! Hopeless!

You will recall, however, that there is a fine balance between climbing and cruising when the thermals are weak. We tend to spend the same amount of time climbing regardless of thermal strength but less time cruising if the thermal strength is weak and the thermals are closer together. This is important as the cruise speed is significantly less and the sink associated with thermals less. This means that benefits of Dolphin techniques are more pronounced.

21. Mass or Span

5.3.2 FLIGHT POLAR



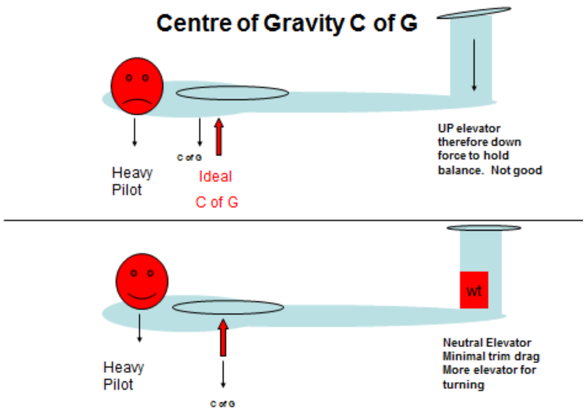
Conversion table for Airspeed and Sink Rate:

kmh	60	80	100	120	140	160	180	200	220	240
mph	37	50	62	75	87	99	112	124	137	149
kts	32	43	54	65	76	86	97	108	119	129
m/s	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0		
kts	1	2	3	4	5	6	7	8		
Ft/min	98	197	295	394	492	591	689	787		

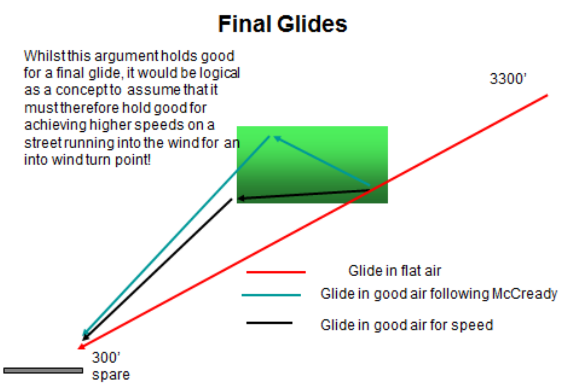
Polar Curve from the LS8 Manual

The most striking thing to you should be that on closer inspection at 65 knots the 15m curve intercepts the 18m line. Above this speed the 15m easily outruns the 18m. So any racing day when you think that you are going to maintain a high cruise speed you obviously need 15m. So what about ETA, EB28, Nimbus ¾ and Ash 25/30? It is the same deal. At higher speeds all the gliders effectively achieve a very similar glide angle simply because the lift dependant drag is minimal and the real deal is in the zero lift drag of surface friction, interference and profile drag. From the front all gliders have the same profile and present around the same area. The wings can't be made any thinner, the fuselage can't be any smaller to fit normal people but if you increase the wing span you increase the zero lift drag components. In simple terms you are dragging more (largely useless) wing through the air so it produces more drag. This is why the current design trend is towards finding an optimum span which is about 23 metres. Of course light wing loadings to allow slow speed and low sink rates during thermalling are equally desirable and require larger wing surface areas so as you lose the span, chord lengths increase and the aspect ratio goes down giving greater vortex drag for the same surface friction areas again. However just before you start to believe big wings are not good, you can achieve some outstanding cross countries in big wings with patience in weak conditions, and any race day which has a weak leg offers the opportunity to seemingly thrash the opposition. If you consider the chart 5.3.2 Flight Polar,
An Ash 25 will fall at around 0.4 minimum sink rate where as the 15m LS8 is falling at 0.7. If the thermal air is 1 knot the rate of climb of the Ash is twice as fast. So it is only on weak days that the big wings enjoy a greater margin in performance, cruising little above 50 kts.

22. C of G



23. Final Glides



Final Glide

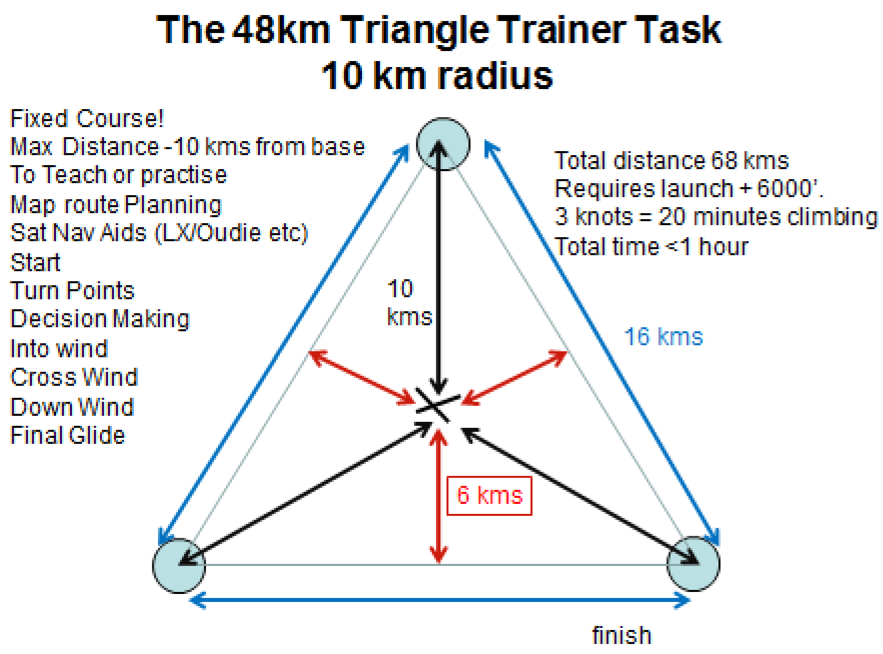
- One such danger is the reality and what the LX is actually telling you.
- The LX is simply a computer and you must understand the short falls.
- It assumes that you have entered the current QNH, correct weight, that the air ahead is standard, that the glider is really polished and it tries to give you a realistic compensation for the wind on the final glide, but it is only a simple calculator and does not (it can not) give you the full picture in terms of height needed to get in. Look out of the canopy and Bring back the John Willy!
- How accurate is the altimeter at height and how much lag do you get on the run in. A slight tap 'by' the altimeter can make an okay looking final glide into a loss of most of your safety height in a blur!
- The LX does not know the sea breeze is now blowing in your face.
- To simply set a lower MacCready so the numbers appear to work and slow down so that it infers that you can make it is simply not good enough.
- So a confident start to the final glide is a must and not become oops!

24. <u>Electronic Navigation Aid Training</u>

Navigation Aids Training.

Stable air. Even if there is no thermal activity we have the easy chance to practise and develop our confidence in both the machine and the electronics. Setting a task starting in the airfield overhead and a single turn point just 5/6 kms away and return allows us to start, achieve a TP and final glide. So a task requiring 1100 feet and a launch of 1500 feet gives 400 feet to play with. This allows us on subsequent flights therefore to fly at different McCready and improve our visual judgement. If flown in different winds the same applies. Bear in mind that there will be no prompting down wind leg so remember the gear!

For a club only operating at weekends 70% of good days in the year are lost. The remaining period, weekends, still means that often the UK weather prevents us wandering too far from home so any opportunity to teach, learn or practise and improve must be made. A simple triangular course with 3 TPs just 10 kms away from home offers a good chance to keep up to speed. Further adjustments to the task due to local restrictions can easily be made whilst satisfying the aims, whilst short out and returns do not. Orientation for the weather remains flexible whilst never being more than 10 kms away means that field landings can be avoided. (10 kms needs about1000').



25. <u>Speed to fly head/tail winds</u>

The following table shows the actual glide angle if a Duo flying at different speeds in differing head winds. The benefit of additional ballast is obvious. Flying at the speeds depicted in green shows a significant improvement in ground speed for a relatively small loss in performance. Note that this has nothing to do with thermal strength but if the thermal strengths suggest these speeds then so much the better. As such then they represent the minimum block speeds to be flown.

Speed to Fly and Final Glide

Head Wind - Zero on the MacCready

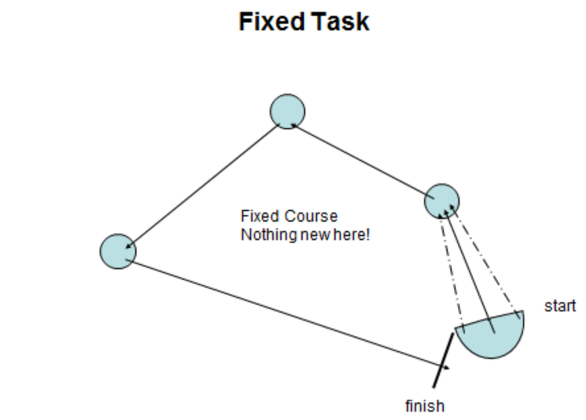
DRY

IAS	ROD	L/D	WIND 10	WIND 15	WIND 20	WIND 25
50	1.2	41.6	33.3	29.1	25	20.8
53	1.3	40.7	33	29.2	25.4	21.5
55	1.4	39.3	32	28.6	25	21.4
60	1.7	35.3	29.4	26.5	23.5	20.6
65	2.0	32.5	27.5	25	22.5	20
70	2.25	31.0	26.6	24.4	22.2	20
75	2.78	27	23.4	21.6	19.8	18
80	3.25	24.6	21.5	20	18.5	16.9
85	4.25	20.0	17.6	16.5	15.3	
90	5.2	17.0	15.4	14.4	13.5	

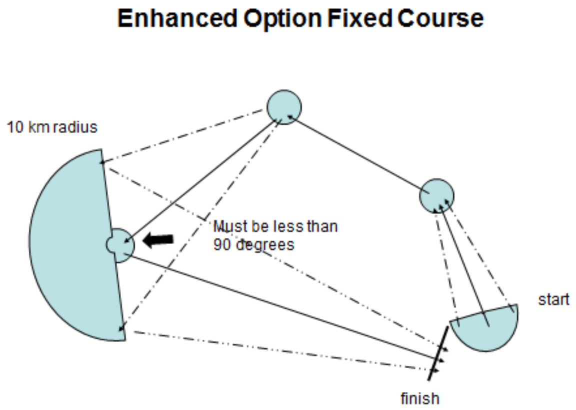
WET

IAS	ROD	L/D	WIND 10	WIND 15	WIND 20	WIND 25
50	1.25	40	32	28	24	20
55	1.3	42.3	34.6	30.7	26.9	23
60	1.5	40	33.3	30	26.6	23.3
65	1.7	38.2	32.3	29.4	26.4	23.5
70	1.9	36.8	31.6	28.9	26.3	23.7
75	2.2	34	29.5	27.3	25	22.7
80	2.5	32	28	26	24	22
85	2.85	29.8	26.3	24.6	22.8	21.1
90	3.3	27.2	24.2	22.7	21	19.7
95	4	23.75	21.25	20	18.7	17.5

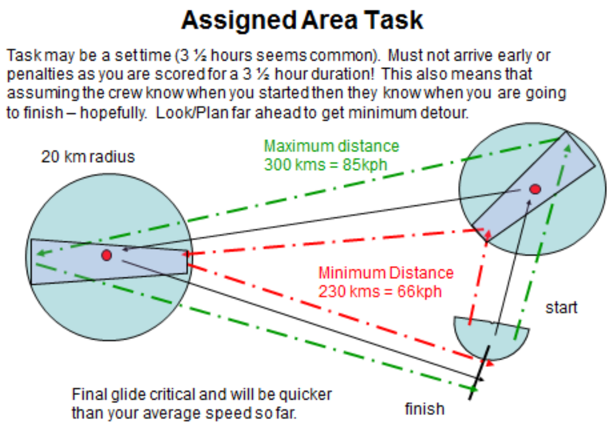
26. Fixed Turn point tasks



27. Enhanced turning point tasks



28. Assigned Area tasks



Decide what you want to try and learn.
Check the weather for good areas and how far from home you wish or need to go.
Check the airspace and NOTAMS. Draw up the route with options to extend/contract..
Establish earliest and latest times to achieve task.
Declare it to someone (For possible overdue action). Fly it.

29. Self Task Setting

Task setting has to start with the aim – invariably to learn, develop new or practice better techniques and to do this so that the exercise is accomplished with little anxiety or distraction. Most lessons in cross country are learnt solo (and there is a lot to learn), so it is important to set off on any task with a specific aspect to learn and afterwards measure the level of success. With this in mind then the chance of a field land out and a subsequent expensive and time consuming long road retrieve is best avoided. After all, on a good day the weather is generally the same over a large area so there is no point is tasking over difficult terrain 100 miles away when this offers only greater risk, greater caution yet with no real benefit. It therefore makes sense to plan any task such that for at least for some of the time (if not all of the time), known safe landable air strips are in easy gliding range and some thought should be made as to just how far from home you need to go.

With smaller weather windows or smaller good weather areas and airspace restrictions (SPINE is a very useful aid), planning a length and shape to optimise the need on a given day requires a sensible flexible approach, particularly when the forecast may be unreliable. Romping around a 50 km triangle six times still achieves the aim of trying to do 300kms. It just does not qualify for an FAI badge. However, the navigation is made easy, any land out is close to home and the pilots mind can concentrate on the job in hand – invariably in the early days of cross country, reading the sky and staying airborne – on track or later achieving faster lap times. You have a good idea of your current ability and gliders performance so each task should just stretch or reinforce your progress to date. At the beginning of the season give yourself a number of goals to achieve. The club ladder is a good way of scoring your overall improved cross country achievements of further and faster, even if you only do the scoring for your own benefit.

A good task should be completed with the minimum of luck and programs such as RASP give you an excellent set of tools to identify whether a task is doable assuming the forecast weather is correct, with the earliest and latest start times offering a sensible window to go off on task with. Also such internet tools allow you to practice setting a task if the only good weather happens to fall midweek whilst you are otherwise stuck at work. Consistently 'under' setting your tasks fails to take advantage of the few better days. Consistently oversetting, however, results in slow learning and unnecessary frustrating land outs.

The key to setting a good task is to establish what the meteorology information suggests is the 'rough area' where the task should be best set and what the 'length' of the soaring day is. Again programs like RASP offer a good indication of this. Remember that the met is always correct, it is just the timing and location that is incorrect and so 2 or 3 days in advance you can start to look at possible tasks which you might want to complete, if the weather window remains on time. For the most part fixed course tasks are normal but there is no reason why you can't set yourself an AAT, particularly if the weather might be slightly better or difficult in one particular area, as this offers considerable flexibility in either extending or contracting your task. In the same vein, there is no reason why you don't make the TPs enhanced option, even when there is no chance of showers.

Enhanced Option Fixed Course Task Option The "enhanced option" fixed turn point design has the normal 90 degree 20km sector behind the 0.5km radius extended to 180 degrees but reduced in radius to 10km. This effectively creates a huge opportunity to gain control at a TP and gives a viable alternative to entering the 500m radius of the conventional

TP in showery conditions. Please note that the 500m radius still exists in this format and in competitions flying to these will always represent the shortest task length.
The task when using this type of TP is still a fixed course task and no benefit is accrued for any extra distance flown as it would be in an AAT.

30. Pairs flying

Mutual, Pairs and Team flying.

What are the advantages and what are the disadvantages?
Two is company, 3 is a crowd is a good starter!

Cranwell club is fortunate in that we have a high performance 2 seater and some experienced racers who are prepared to teach in it. Even then, however, with the 20 week season and generally small weather day window that we have in the UK, assets are understandably scarce. There is though a lot of middle and high end performance single seaters, most of which are privately owned, so it does make sense that there may be opportunities to learn new techniques and skills by following a similar glider flown by a more experienced pilot. Firstly just bear in mind that by far the best lead and follow is done with the follower sat in the back of a good 2 seater!
The first consideration is why you are flying intentionally close to another glider having spent most of your gliding life looking for and flying well clear from other gliders. The military do formation as a matter of every day flying but just be aware that each pilot has been thoroughly trained in the art, remains in current practice and every mission incorporating formation flying have several key aspects specifically briefed.
Any intentional lead and follow/mutual/team/pairs flight therefore requires critical aspects to be covered. These will include;

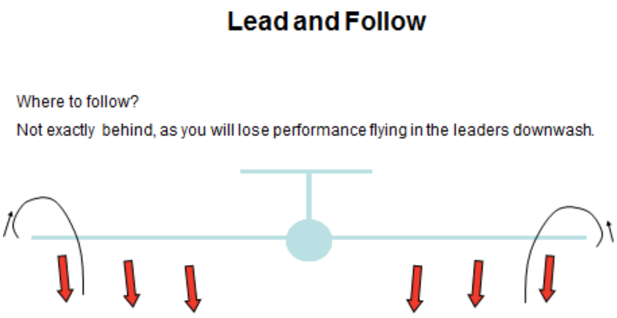
1. Who is the leader? (Not quite so obvious – see later).
2. The No 2 will always make every effort to avoid the leader.
3. The aim/point of flying together.
4. Radio calls (code or abbreviations) and the meaning. Such items would be Climb/Cruise, Left/ right routes, run home, lost you, help! etc. in other words very simple clear unambiguous communication.

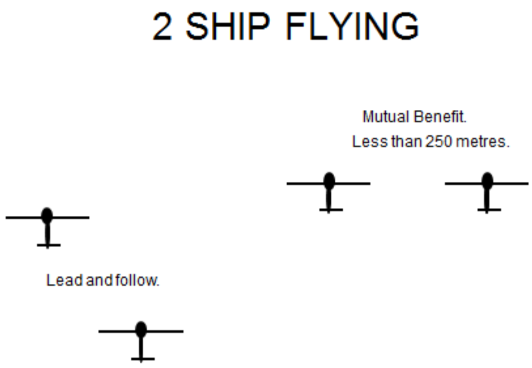
Following another glider can be quite fun and it can show you the many variations in the vertical motions of the sky whilst on a flat glide, but sadly as gliders are generally difficult to see from the immediate rear, even from just a couple of hundred metres, looking and tracking the leader often tends to absorb 80% of the followers attention. For anybody embarking on this kind of training just remember:
The first rule is - do not hit the leader!
The gliders really need to have similar performances but if the less experienced pilot flies the higher performing machine then they should have less difficulty in keeping up. Bearing in mind that as a teacher you are trying to demonstrate some particular aspect for the student to learn (with almost no airborne conversation), the student will likely have quite limited capacity. It is also easy for the leader to press on before the follower has actually absorbed or fully understood what you have just done and what and why you are going to do the next! The student has to have the opportunity to catch up mentally. As an instructor it sometimes feels painful to do an extra turn or 2 at the top but there are ways in which to make this all so much easier. If you do insist on teaching and leading from the front then the first thing your

student has to learn in any lead and follow is how to follow, prior to any other task you are trying to demonstrate/teach. Learning to follow might be practised during a totally separate local soaring flight. (In weak conditions which are not good enough to go cross country or whilst you are waiting for the cloud base to go up). If your student is overloaded absorbing the rationale behind going down any particular route, then his basics like navigation tend to get brushed aside. Despite what you think you have taught, it is what was learnt that matters and this situation the learning value – can be very little. Flarm will help but not everybody has it. A lead and follow would appear to be simple enough, but those who try it in dissimilar performing gliders will quickly recognize theory and practice are polls apart. The leader must be in a lesser performing glider for the inexperienced follower to keep up and not feel permanently demoralized and quite literally always behind the drag curve! Where the mentor is in a better glider, (perhaps a Duo with a student whilst leading a Discus) as the climbing pair approach the top then he should brake down below his student and practice his own techniques for catching up whilst his students settle and suggest the next decision. In this way the solo student is only ever going at his own pace. Whilst this can be at times frustrating for the instructor, perhaps you would rather go back and do some basic instructional in the club brick! Always remember that one day this man might be able to show you where a thermal is if you are flying for mutual benefit. In competitions team flying is very much in the rules and in fashion these days and you often find that most day winners in nationals and beyond are not running around on their own! As it implies, ideally the follower must follow using the same thermals, leaving on the same turn, cruising at the same speeds, on the same tracks. In a thermal the follower is directly opposite his leader matching speed and angle of bank and will need to adjust his turn to maintain this spacing whenever the mentor recentres. The leader will often use his follower to recentre. The follower must allow the leader absolute freedom to turn in either direction or to pull up/push down on the cruise whenever he desires. The number 2 always misses the leader- did I mention that earlier? If the mentor insists on leading he would prefer never to have to stop and look for you or wait because you have elected to do something different. So in this scenario - Keep up! On each glide/cruise, work out the leaders reason behind each decision. As the experience and capacity of the follower improves they may then adopt a stick, search and subsequently report (like gliders turning ahead) suggested courses of action which are then confirmed by the leader.
If ever you are to fly as a pair then, the first item to sort out is exactly what leading and following is to be done and what is the lesson/s to be learnt. The second is what radio calls you are going to use and the third is when and how the No2 should call for help.
There are several benefits for a lead and follow, but learning how to stay in a thermal is not one of them, whereas how to climb faster might be.

1. Confidence building.
2. Faster climb rates.
3. Perfect cruise performance.
4. Route and Cloud selection demonstration – decision making.
5. Street flying centre line.
6. Street flying – with the aim to keep flying it faster (Dolphin and anti-Dolphin).
7. Mutual pairs flying.
8. Final Glides.
9. Lead and Push – confidence and decision making.

For me I find Item **9** the most beneficial in trying to teach any individual most aspects of cross country gliding. Leading from the rear! The student (or mentee) acts as leader whilst the instructor (coach/mentor) is the No2. The mentor should have no difficulty following (or avoiding) and will ensure that his mentee has freedom to manoeuvre. Similarly the mentor should be able to absorb any required spacial awareness of airspace, airfield options, lift sources etc.) The student must be encouraged to make timely sensible decisions. The mentee decides (including when) the route to be taken (Left, middle, right) and the experienced guider will agree or suggest a simple alternative but likely only if the selected option is likely to be disastrous or the other option is clearly better! Hopefully the student is not continuously criticised for his decisions, the mere response of making a timely decision and committing to it is a good start for some! The chances are that most early cross country pilots will dally in their decisions, (under confident) cruise too slowly (no one has taught then to fly at 80knots) and stop in every thermal they hit, especially as they were advised to do this for their silver C - get high and stay high. The mentor can correct anything as appropriate including the cruise speeds and techniques in between. Hence the term ‘Lead and Push’.

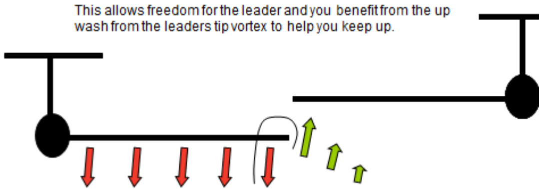




Lead and Follow

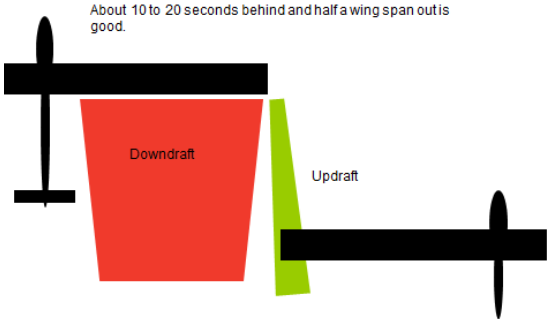
About 10 to 20 seconds behind and half a wing span out is good.

This allows freedom for the leader and you benefit from the up wash from the leaders tip vortex to help you keep up.



Lead and Follow

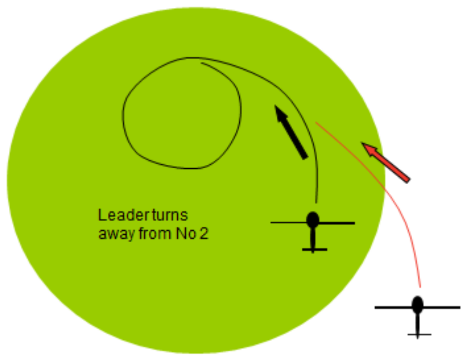
About 10 to 20 seconds behind and half a wing span out is good.



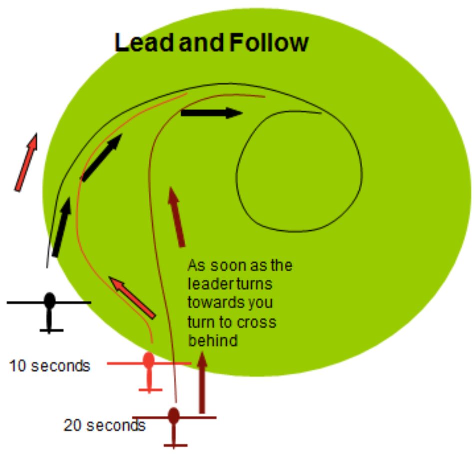
Spacing

- The reason for 10-20 seconds is simple. Firstly it hopefully means that you won't lose sight of him.
- It takes about 25 seconds to do a 360 once established in a thermal so cutting the corner slightly when turning in behind the leader means that you end up directly opposite so each are both in sight.
- It also becomes clear whether you are going to climb or 'S' turn.

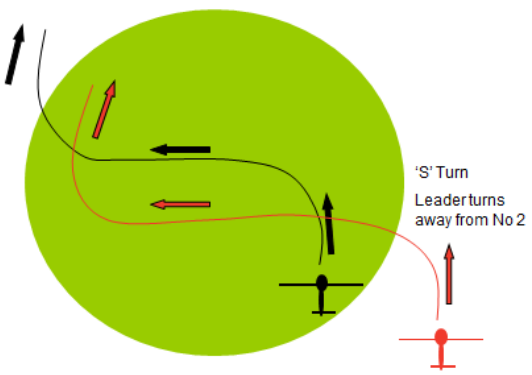
Lead and Follow

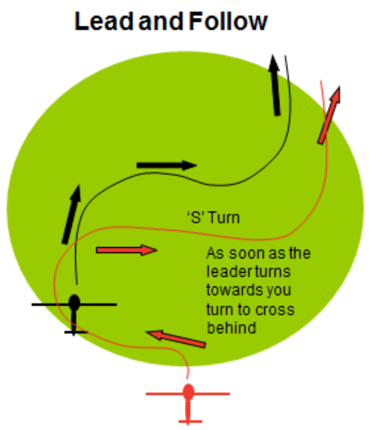


Lead and Follow



Lead and Follow





'S' Turns

The purpose of S turns is to confirm the real strength of the thermal you are brushing against. Hitting rising air coupled with a lifting wing is generally not enough information.
Turning hard against the rising wing will give a true indication of the thermal power and a decision is made after 90 degrees of turn whether to continue the turn and climb or reverse and run on.
The penalty on a loss of ground speed is significant. It is normally used as an addition to energy when cruising down wind.
Flying in to a head wind the height gained on a rejected thermal is often completely lost accelerating back up to cruise.

In club flying it is rare to find pairs flying routinely so it is important to recognize that when you encounter this situation you maintain a good lookout and expect the other glider to do something unexpected and never presume that the other glider knows what you are expecting.
In any competition the chances of finding yourself flying along side or just generally with another glider for some of the task, even though you have had no previous conversation with them, is high. It is more important to work with this person and as such you have inadvertently become a pair flying for mutual benefit trying to perform better than those in another thermal or on a different line/time frame. In other words you are not racing the man in your thermal. Of course searching on difficult days of spread out, blue, or low, as a pair covering twice as much area offers obvious benefits to both concerned. In these cases it is important to help each other and therefore beat those who are not with you.
The techniques described above about lead and follow, are exactly the type of flying the leeches do. Part of the sad fact is that in a gliding competition roaring ahead is rarely any advantage as you struggle to find that strong thermal which is surrounded by heavy sink, which is sometimes the only bit you seem to be able to find for a couple of turns, after which the followers come in over your head!
Planned mutual flying is not without its difficulties. The previous guide on lead and follow is still used but who ever is the leader leads and this can swop over several times during a long cross country until one gets left behind. However there is a risk that you can spend so much time looking at each other that there is no benefit because neither pilot is looking ahead. Also

there is a question of communication. For example who is making the decision about the routing and which thermals you are going to climb in? These decisions are normally taken after a considerable amount of information has been considered and depends on each person's brain power, experience and confidence. I would strongly recommend that you take an opportunity to fly in a 2 seater together a few times to see just how each of you fly and the considerations you take by chatting away without cluttering up the one air/air frequency we have.
Whilst flying dual there is an easy conversation between the pilots within the cockpit with a thorough discussion of ideas. Once in your solo machines the ability to chat is not available so some thought is needed to understand each others suggestions as to what to do and do it for mutual benefit.

Advanced instructional management.

There is currently no official policy or recommendation to have non instructor qualified coaches, particularly flying in 2 seaters (ignoring the insurance aspects for a moment). Clubs are controlled by a committee and I am asking for them to start thinking in a different way in what I believe is a worthwhile change. To me it is a necessary change. The difficulty with coaching is that clubs are not formally structured with advanced instructors. The operational side is based on CFI, DCFI and then the various instructors full filling the basic instruction. The majority of high performance machine are single seaters or privately owned 2 seaters, few clubs have high performance training 2 seater but assets are not the only problem.

As Tony Cronshaw says:

"The issues, in my view, are symptomatic of problems in society more generally. We can't fix these problems. We have to accept that society has changed from what existed 30 years ago. We have to live with it.
Phrases like "time poor", "quality time", multi-tasking, "short attention span", "instant gratification", etc. have entered the vocabulary because people are juggling so many things today, including family, work, social, social media, and an endless quest to satisfy high expectations of a consumer society. And finally, somewhere in the mix are sports/hobbies.
The impact on any sport, gliding included, is that it is harder and harder to get people to engage with an activity that is time consuming, difficult to master, only delivering small benefits at the start, and piling on a fair amount of frustration.
Coaching is the answer! Coaching means that people see what is possible, and learn quickly. Coaching means that the enthusiasm of the coach generates a positive attitude throughout a club in every respect. Coaching means people do not drop out but become good glider pilots.
The bottom line is: We need more coaches, not only at competition level, but for all up-and-coming pilots".

The requirement of knowledge and individual new skills to be imparted is relatively large and can be particularly time consuming for the less well read. It requires a far greater commitment of time of the instructor/coach together to complete any task. Whilst a mass brief would be efficient, it is unlikely that all advanced members progress is in phase with others and the knowledge given needs to be used practically before the sense of trying a particular technique or even understanding it is lost (use it or lose it). Motivation, time and leadership is required by someone who is able to guide further progress in fellow members wishing to achieve more, with what is sometimes seen as a less obvious rate of progress. Despite the limitations of weather, gliders and their different performance, availability of mentor/coach/instructor/s and mentee/student, each club has a varied daily routine. Some hold a full pre op brief which could offer the opportunity for a 15 minute hot tip lecture each day. Others just meet up, open the hangar doors and get on with the flying operation and sort individual briefs as appropriate. Full briefings therefore on non flying days would work well but temporal continuity is lost and often these days are used for members to catch up with personal activities at home.

The advent of email does at least offer the ability to communicate planned briefings to ensure the right people attend or offer the advance warning of good X/C weather which will motivate the team to start earlier and be prepared. Meanwhile the references of worthwhile trusted articles can be mentioned so that the student can do some self briefing/learning, in preparation for a particular skill to be tried.

For those members who are already flying cross country their progress at doing better can be made objectively qualified by scoring flights via the club ladder. Before this level is reached, however, there are a number of personal achievements (personal bests) made solo which are important to the individual; first thermalling flight, longest flight, highest flight, conversion to a new type etc. To the individual these are all important achievements not reflected by the glider licence. Some clubs tally all the small steps up so that a clubs progress can be measured for all to see, generating an inspiring feeling for all to achieve more. Hopefully the enclosed syllabus and notes will help in this task.