15C – WAVE FLYING

INTRODUCTION

For BGA clubs situated in Scotland, Wales and Northern England useful wave is fairly common. However, for the other clubs it can be quite unusual. This makes picking up wave flying techniques difficult compared to the ongoing thermal practice that most students enjoy. Further, whilst we are blessed with a plethora of excellent text books that cover thermalling and cross country flying in all its aspects, information on wave flying is comparatively sparse, particularly when it comes to anything other than strong straight forward wave. Whilst many textbooks 'cover' wave, reference 1 being particularly good, few are of much help if previous experience is low. Hopefully this edition of the Instructors Manual will improve instruction and knowledge in this area.

The SFCL SPL Syllabus requires that the following are taught within this exercise:

Exercise 15C: Wave Flying.

(i)	Look-out procedures
(ii)	Considerations and techniques for wave access and exit.
(iii)	Speed limitations with increasing height.
(iv)	Considerations for use of oxygen.

THEORY BRIEFING

The range of knowledge of students to be briefed is likely to be very wide and heavily dependent on the frequency of wave flying at their club. This must be allowed for if they are to be appropriately briefed, not only to complete exercise 15C, but to subsequently wave fly effectively and above all safely. This subject can only be effectively dealt with in the classroom either with pre-prepared material or generous use of 'chalk & talk', particularly if the students' knowledge level is low.

- What conditions are required for wave to form?

In brief, wind over hills. However, that alone won't necessarily produce usable wave. Bigger hills and stronger wind usually produce better wave, but the most important factor is the state of the atmosphere. Orographic Lee Wave, to give it its full title, requires an unstable layer at low level, a stable layer above and an unstable layer above that. Also, a wind that tends to increase with height and changes little in direction.

Wave is frequent, but usually too weak or localised to be of any use. Sometimes it interferes with thermal conditions or makes ridges with a suitable wind on them unsoarable. Wave has its downside, literally.

Innumerable smaller factors, the shape of the triggering hill, the depth of the various layers, etc., affect the wave. It is a complex subject as yet to be fully documented. Figure 1 gives a 'General Arrangement' of wave, although the patterns can vary considerably:

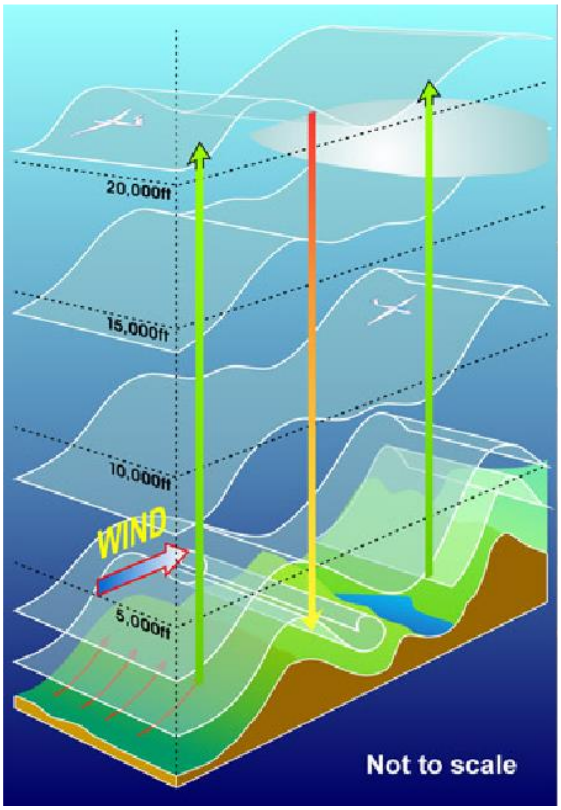

Figure 1. Wave – Typical Arrangement.

- How can we soar in wave?

Unlike the meteorology behind wave, the principle of soaring wave is straightforward. Find the line of rising air and fly along it. When conditions are good and the wave is marked by its characteristic lenticular cloud it really is that simple. However, it's not always like that. Wave, sometimes very good wave can occur in blue skies and, with no visual clues to its position, soaring it is more challenging. Also, disappointingly, most usable wave isn't suitable for high climbs or travelling great distance. However, it can provide much interesting soaring.

Sometimes a wave triggered by a lee of a slope will be cancelled out as a result of the topography downwind. Conversely, it may boost subsequent waves. Sometimes secondary or even tertiary waves prove better than the primary. Wave systems commonly interfere with each other. Constructive and destructive patterns form and these can be seen on satellite pictures.

Although often referred to as 'standing wave', the lift is rarely completely static. Usually, the position of the best lift moves a little over time and occasionally it can move quite quickly. Sometimes having climbed in good wave it weakens and dissipates leaving one to slowly sink back to low level.

- What can we do in wave?

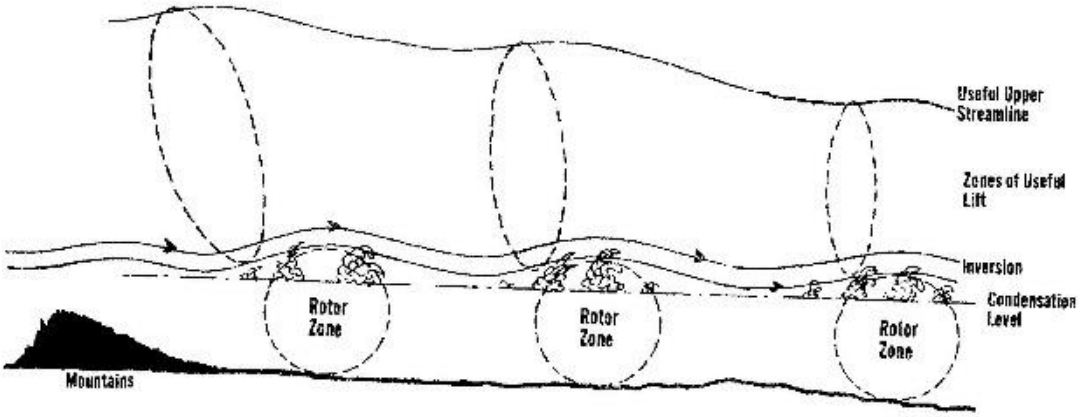

Figure 2. Wave Cross Section.

Above all, we can have some really interesting flying and most wave flying, particularly that at sites not commonly blessed with frequent wave, is interesting rather than spectacular. Most Gold & Diamond height climbs are achieved in wave and, as it isn't fussy about the season it occurs in, it can provide some good, albeit cold winter soaring. In fact, wave is often more frequent outside the summer season when reduced thermal depth can be more conducive to good wave. If the wave is long, it is possible to cover great distances, sometimes at considerable speed. Also, as waves usually re-occur a number of times downwind of their trigger, having gained height it is possible to travel up or downwind to the various areas of lift, by "jumping" from one area to another.

- How do we get into wave?

The simplest way to start a wave flight is to aerotow to the front of a lenticular cloud in an active wave system. Unfortunately, text books make little reference to getting in to wave at all, let alone by any other method and most of them seem to assume powerful well organised wave systems that are easily seen and understood. Unfortunately, most UK sites don't see too many of those and frequently we have to fight our way up through weak and often broken lift to get into the wave proper.

These notes attempt to cover the 'classic' case and the far more common situation where we usually struggle to get into wave. If it's too rough to aerotow, you are airborne when the wave starts, or just too mean to pay for an aerotow, then hard work, cunning and above all patience, can be employed instead. It's also more rewarding when you then succeed!

Occasionally you can transfer directly from ridge lift to wave, but more commonly from ridge lift, to thermal to wave. Ridges provide a useful 'Base of Operations' that you can keep returning to climb up and try again. Very useful, as most attempts to get into wave fail.

If your ridge is working better than it should be, then suspect wave, even if it doesn't look like it. Even if the ridge isn't unusually good, always keep wave in mind, particularly if the forecast suggest conditions are favourable.

Whilst airborne monitor the situation, what does the sky look like? If it is full of lenticulars, then great, where you need to be is clear. However, often there will be a poorly defined pattern and it may not be visible at all. Observation over a period of time may reveal a stationary sunny or perhaps just bright patch on the ground and frequently that will be in the lee of high ground.

Whilst assessing the situation you should also be trying to gain the maximum height. Height is everything when wave hunting, the higher you are the further you can search and normally the higher you meet wave the easier it is to climb further. Much of the time when useful wave is present, it is above the height that we can climb to using ridge and thermal. However, the height that usable wave comes down to fluctuates and possible entry points move around and come and go.

It can be an extremely difficult and frustrating process to get started, particularly if inexperienced. Often just a few pilots get into wave and frequently their entries are closely spaced in both time and position and then no one gets in for ages, if at all. Encouragingly however, some pilots succeed more frequently than others, so evidently it is not entirely down to chance. With practice, persistence and above all patience we can get better at getting into wave.

As wave requires an unstable layer at the surface there will usually be thermals and even if you have a ridge to keep you airborne, it will often be necessary to use them to get as high as possible. If you are getting a good height then you can try a straight glide to any likely looking gap in the clouds, or in the absence of clouds into wind, but on most attempts you will be disappointed.

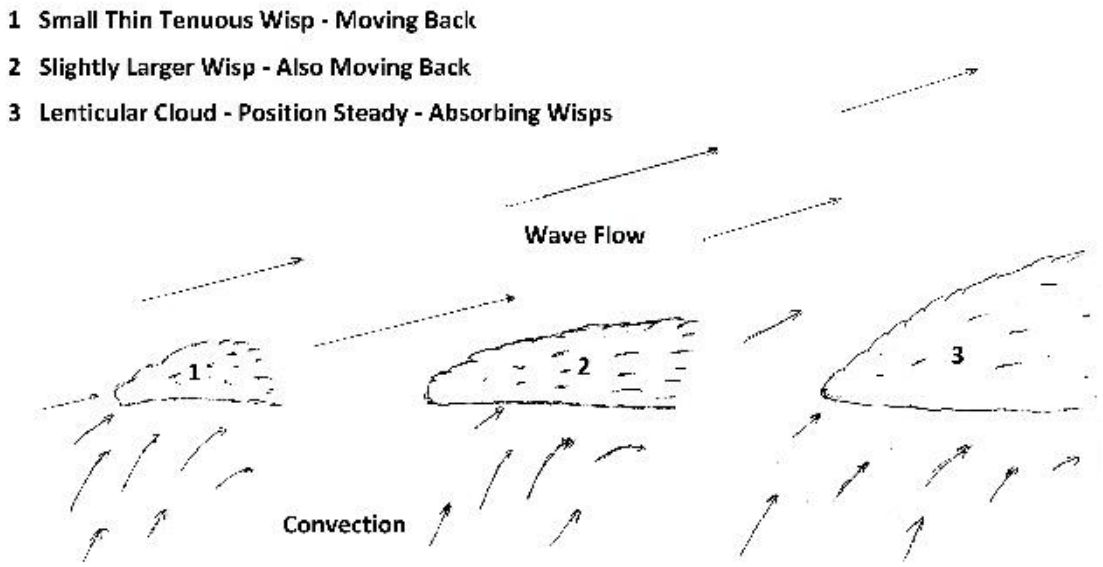

Figure 3. Wave Wisps in Section.

Successful attempts are often preceded by a thermal significantly better than the rest. These are commonly found just behind the up going wave, where the unstable thermic air and wave flow meet at the inversion. As well as being stronger, these thermals are frequently small and rough, increasingly so with height. If you find a stronger than usual, tighter than usual thermal then make every effort to gain the best height you can in it. If you find you need to keep centring up wind then that is a good sign and if you get to cloud base then you are now in with a real chance. Glide to the gap or brighter patch pulling up in lift if clear of cloud or accelerating in lift if at cloud base. With luck you may fly into the beginnings of wave lift at the edge of the cloud. However, you may do this many times or even all day and still fail to get into the wave.

If you get into the bottom of a wave system then the first bit of the climb is critical, one mistake or a moments' inattention and down you go. Initial climb rates are often poor and contrary to what the textbooks say the lift is not necessarily smooth. This is an area where the thermals and wave are mixed. Stick with it, even if only climbing very slowly. If good lift is above, it should improve and smooth out as you climb.

Having taken a thermal at the windward edge of cloud you will have drifted back under it because it is held in place by the wave system. That is a good sign and you can move forward again and hopefully find another strong wave induced/boosted thermal. Use it, if possible, if not just pull up in it and then continue forward to the edge of the cloud. Keep a good lookout for all the others gliders playing the same game! Beware of staying with a thermal that drifts quickly to under the down-going part of the wave and disintegrates; keep pushing forwards into wind.

If you push out into the clear and find lift, fine, but if you don't find it in the first few hundred metres then you probably aren't going to. But you can look back at the front edge of the cloud and return to the waviest looking bit; that may or may not prove to be useful.

It is vital at all times in wave to be certain of the wind direction. If as is usual the wind gets stronger with height, then even a modest error regarding its direction can result in significant cross wind movement or even drifting downwind rather than progressing into wind.

Thermalling into wave near cloud base frequently has one thing in common with getting in from ridge lift and that is cloud wisps. In otherwise clear air or a confused (ie. normal) situation even the tiniest, transparent and most transient cloud wisp is valuable information. Cloud wisps are there because lift has put them there and if it is wave lift or wave assisted thermal then it's best, if you are already at or above the wisps, to skirt around the windward side of them. As you do this you can sometimes see a pattern forming as the wisps line up.

The sharp leading edge of lenticular cloud observed from the ground is not usually like that when you are there. Often the edge of the main cloud is rather ragged, being fed by growing wisps that form in front of the main cloud and as with wisps lower down its best to keep moving around the windward side of them. Normally, as you do this another will form into wind from you, and another, and so on. It's easy to linger too long, particularly when the wind is brisk and end up engulfed in cloud. Apart from the obvious collision risk you are much less likely, if you get disorientated, to get promptly to the next lift and wet or icy wings won't help. If not experienced at cloud flying and with the right instruments up and running then drifting backwards into the cloud is very dangerous. There is a high risk of losing control and unless you can fly **directly** into the wind, clearing the cloud will be prolonged as you will drift sideways.

If you are lucky, persistent and above all patient, sometimes you will get into the wave proper and things normally become easier as you climb. Usually, once you are above cloud the wave pattern can be seen much more clearly.

When it is blue, with no cloud to guide you, GPS provides your reference in space which is very useful as wave lift, in the short term, is fixed in space. As the areas of lift low down are often small and difficult to stay in, it's very useful to be able to fly back to them accurately and it also helps to be able to turn reliably back along a track when establishing a beat. As you discover better lift you can modify where you go back to.

All of this can be attempted with a simple GPS just by noting range & bearing from a point. However, it is much easier and more accurately achieved with a moving map that leaves a 'snail trail'. Also, Moving Map displays usually provide a good measure of wind strength and direction, enabling progress back into wind to be made efficiently. They are also essential if there is any airspace nearby, as it is impossible to judge your position accurately from ground features when very high.

- What safety issues are associated with wave flying?

There are several safety issues involved with wave flying that we do not normally encounter with other forms of soaring.

Oxygen: For UK pilots' wave is the usual way to get really high and if we get high, we must use oxygen. EU regulation states that, oxygen must be used above 10kft unless the PIC is certain all occupants are not suffering impairment or harm. Traditionally the BGA recommended that oxygen should be carried above 10 kft and used above 12 kft. The French say it should be used above 12.5 kft.

If you plan to use it then make sure you are familiar with the equipment. Also, pilots should familiarise themselves with the symptoms of hypoxia. However, hypoxia is usually subtle and the sufferer may well be unaware of it, making it uniquely dangerous.

Cold: Even in summer it can be cold at height and particularly so under cloud. In winter it can be very cold from the ground up! At higher altitudes very, very cold indeed. Parts of you exposed to the sun may feel OK, but your feet will certainly be cold. It is important to dress appropriately. Sufficient layers, multiple warm socks and boots, and warm gloves. Extreme cold impairs concentration and shivering increases the need for oxygen.

Turbulence: Wave lift is noted for its smoothness, but wave systems sometimes feature a turbulent 'rotor' structure under its crests. In a system associated with moderate hills and wind strength, they may not exist or at worst just contain some choppy air. However, if the hills are mountains and the wind is strong, then significant, sometimes severe turbulence can occur which may or may not be marked by cloud. Aerotowing through it may be very challenging and encountering it at more than manoeuvring speed is inadvisable. Sometimes there can be severe turbulence at the top of the wave too, if a drop in wind speed towards the crest produces a breaking wave. If flying fast along a wave bar, slow down if you encounter this. Also, if the wave system positions itself inconveniently, rotor may establish itself over your airfield with very significant turbulence and an entirely different wind direction to greet you on your return.

True Air Speed: TAS is important at high altitude. To avoid the possibility of flutter gliders have a reduced VNE with altitude. This is detailed in the Flight Manual and should be placarded in the aircraft.

Being blown downwind: The practicalities of getting on and off the ground normally limit the wind strength we fly in. However, usually the wind increases significantly with height in wave and we may find ourselves flying in windspeeds at height way above that we are accustomed to. 40 kts is common, 60 kts plus can be encountered. Given that your true airspeed at 15 kft is more than 25% higher than indicated, caution is required moving downwind. You may have taken hours travelling 20 miles into wind, repeatedly climbing as you go, but getting back may take just 10 minutes. Be cautious not to overdo a downwind run, many sites in the UK are only minutes flying time from the sea!

Unlandable territory: When we initially climb in wave there will normally be hilly or mountainous terrain upwind. Having gained significant height an obvious next step, if you aren't already in the primary wave, is to jump forward and climb again. However, there is a risk that on occasions you may push forward, fail to climb and find yourself low over hostile terrain. If you climbed into rather than aerotowed into the wave, then you will have some idea how low the wave can be climbed in. However, going this low deliberately is risky and if you are pushing forward through sink, you will be going fast both horizontally and vertically and things can go wrong quickly. It is important to think ahead and make sure that if you fall down you will have sensible landing options. Remember, you will have a far greater range to find a field if you turn downwind. Also, when jumping forward to the next upwind wave bar, it makes sense to find a weak part of the wave, where the sink will also be weaker.

Look out: Above cloud some of the joys of wave are unlimited visibility and brilliant sunshine. Despite that, effective look out is an issue. Smooth lift, bright sunshine and the steady tone of the audio vario' can be quite soporific, lowering ones' guard. It can also be quite difficult to spot gliders approaching as white gliders don't stand out well against gleaming white cloud. Given that the best lift tends to be confined to a fairly narrow band it's not surprising that we encounter other gliders despite the huge operating space. If two cross country pilots are flying fast towards each other on the same wave bar, their closing speed may be in the order of 200 kts!

FLARM can be very useful given the limitations of our lookout, but it too has limitations. FLARM indicates the direction of the threat relative to the gliders track, not its heading. In the absence of wind that's the same thing, but with a strong wind there can be a big difference. See Figure 4 and the example below. We must be alert to this

issue which is also applicable to ridge soaring. We need to be consciously looking relative to our track, which means we need to know our track.

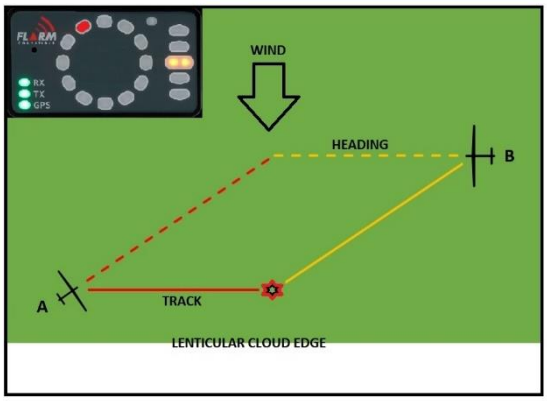

Figure 4 FLARM and Crosswinds.

Example: You are in glider A in Figure 4 soaring along a lenticular cloud in a brisk wind and therefore crabbing into wind. On collision course is glider B. This is further out from the cloud edge, but tracking back towards it by heading parallel to it. Seen from your cockpit the glider you will hit is right of your heading. However, if the collision is allowed to occur it will occur from the left of your track and your FLARM will appear as illustrated. Unfortunately, if you only look to the left of your heading, you will not see the impending collision. You must look left of your track. Whenever the wind is significant these effects can be very large.

Airspace: In the UK we are limited to FL100 without a transponder. However, there are large scale exemptions over Wales and the West Midlands, much of Northern England and all of Scotland. In these areas we can go to FL195, permitting Diamond height claims. There are also higher wave boxes gut these have different rules. Make sure you understand what you can do and where before you take off. Whilst these exemptions are very useful, Class A airspace exists within them making reliable and accurate navigation vital. In practice moving maps are the only way to navigate accurately at height.

Daylight: Know the time of sunset. At height, it can still be bright after the sun has set on the ground. However, even with a 10 kt descent rate, it takes 20 minutes to lose 20,000 feet so ensure you start descending in good time.

Operation above cloud: It is perfectly possible to operate above 8/8ths cloud with moving map equipment. However, it is highly imprudent. Gliders do not have the multiplicity of power supplies or duplication of equipment found in commercial aircraft to trust one's life to. Operating above partial cloud cover is fine, but it is essential that a clear way down to a safe landing area is always available. In wave the reducing size of a gap below may well be because you are getting higher above it. Or it may be that the airmass is getting damper and the gap is closing! If forced to descend through cloud you will need the right instruments and be in practice using them. If conditions deteriorate the wave may collapse and the cloudbase may be much lower than it was when you entered the wave. Factor in hilly terrain and the dangers are obvious.

AIR EXERCISE & BY GLIDER BRIEFINGS

Aerotowing into Wave: At most UK clubs, where wave is unusual, it may be difficult to conduct the exercise of aerotowing into wave. However, when possible, take the student through your thinking on where and how high to go and involve them in the tug pilot briefing. This briefing should be two-way, as, assuming the tug pilot has already flown that day, they will hopefully know where and how strong the wave is.

As it is likely to be a windy day caution the student regarding the implications of aerotowing in these conditions, particularly if you might encounter rotor turbulence. Draw their attention to the variometer as a method of spotting suitable release conditions.

Guide them as required to get established in the climb. If brought up in a thermalling environment they will probably fail to appreciate the significance of turning into wind whenever lift is encountered, or the importance of staying on the windward side of forming cloud. Also, ensure that you guide their lookout to be both sufficiently frequent and appropriate in terms of direction.

Soaring into wave: This is likely to be even harder exercise to plan than aerotowing into wave. Whilst it can occasionally be a straight forward task, sometimes when it appears likely to be possible, it may prove impossible. There are several variations, climbing straight off a ridge, thermalling into wave or thermalling off a ridge into wave. They share a common requirement, getting as high as possible to maximise the probability of contacting the wave.

If planning to soar directly off a ridge into wave check the student understands how to best use the usual ridge soaring techniques to get as high as possible. Ensure they are noting where the ridge lift is best and that if there are clouds, they are paying attention to what they tell us. They are likely to need help with this latter point. With luck a seamless transition from ridge lift into the wave will occur.

If you don't have a ridge, but it's possible to stay aloft in thermal, then thermalling into wave, the most difficult method of entry, can be attempted. If the student is to do the flying in this exercise, they will have to be competent at thermalling. Frequently thermals are 'boosted' under the upgoing wave and get stronger but smaller as they go up. This is no place for lackadaisical vague thermalling!

They also need to be able to accurately hold a steady heading and manoeuvre the glider smoothly and accurately at minimum sinking speed (or appropriately higher if the thermals are turbulent). If they prove incapable of this then demonstration of the techniques involved is appropriate. Once as high as practical, ensure the student pushes straight into wind, hopefully into wave, but failing that into the next thermal. If any cloud is involved at the bottom of the wave ensure the student understands the significance of it and where to place the

glider relative to it. Also, if operating close to cloud either vertically or horizontally ensure their lookout is good.

Soaring in wave: Draw the students' attention to maintaining station in lift and how to keep track of wind strength and direction, particularly in the absence of cloud. Also, how to conduct a logical search for better lift. If there is wave cloud then point out how to track along it, whilst keeping a focused lookout for friends doing the same in the opposite direction.

A task unique to wave soaring, assuming one didn't start in the primary, is to transition forward. Typically, if we start out from the top of our climb our glide forward, which should ideally be directly into wind, will probably be longer than a typical glide between cumulus with, at times, considerably more sustained sink. If the lift is strong then the sink can be very strong – fly as fast as is safe. Also, the wind at height can be very strong. Prodigious amounts of height can be lost! If possible, always make the jump at the end of a bar or at a weak point.

When transiting between cumulus on a thermic day the wind has no influence on our speed to fly, because we are operating within a moving airmass. In wave the lift or sink aren't moving with the airmass so we need to fly faster than our 'Best Speed to Fly' in the prevailing headwind, if we are to make best progress forwards to the next lift. This can result in very high speeds and we need to be aware of our Rough Air speed and the possibility of encountering rotor. If in doubt limit yourself to your rough air speed.

Ensure your student understands how to tackle a transition to the wave into wind. If you have climbed well above cloud then the lift ahead will likely be over the next lenticular cloud and given strong wind and sink falling into it is easy. Ensure your student understands this and that when you set out forwards you monitor your progress relative to the top of the cloud ahead.

To improve the probability of a successful transition get your student to track along the lift until you have either gained more height or found an area of weak lift and move forward from there. The weak lift should be behind the weaker sink. An extension of this idea is to keep going until you effectively travel off the end of the system, go forward and then move back into the system having, hopefully, evaded the sink altogether. This won't reduce the headwind, but may make progress into wind possible if your glider has limited performance. The student needs to understand the significance of the high-speed performance of their glider in this type of soaring.

Make sure that the student fully understands the significance of anoxia and the necessity of using oxygen equipment above 10 kft. Don't be tempted to take your student higher without it.

Exiting wave: If your wave exercise has been modest, you are only a few miles from home and in clear air a few thousand feet up, then safely getting home won't be much of a challenge. Conversely if you and your student are 20 miles upwind at 20kft with an increasingly large amount of cloud below and airspace to be evaded then you have a significant task on your hands.

Firstly, it takes time to get down, so make sure your student can make a good estimate of how long it is likely to take. Make sure they know how to check when sunset is and understand that if it is sunset at height then it may be really dark when they get home, particularly if cloud obscures the western horizon. Further, make sure they understand the risks of a really swift descent. Particularly of taking a very cold airframe into moist air. Collecting a layer of ice on the airframe and canopy will not assist with a safe recovery. So, encourage them to stay clear of cloud on your return and leave a little time in hand allow any condensation or ice issues to clear and to assess conditions at home before landing. Whilst still at a safe height, check the airbrakes haven't frozen shut.

Students usually understand that the most obvious way of descending is to open the airbrakes and speed up. However, they may not appreciate how they can also achieve a good rate of descent by flying into the down of the wave. Some students may produce a good descent but neglect to get home first, particularly if most of their experience is very close to home. Ensure that they understand that they should try to hang on to plenty of height until close to home. That way they will have energy in hand to allow for any navigational uncertainties or outmanoeuvre any inconveniently placed cloud.

As with all exercises ideally, we should conduct the Air Exercise & Glider Briefings as described in Chapter 3 of the existing IM, ensuring that the student is ready to get the best from the Airborne Lesson. A reminder of the forthcoming exercise(s), who will be flying what and when and particular points to look out for. Any safety issues, peculiarities or common problems should also be covered here. The instructor may also want to give an idea of how long or how many flights will be required on this particular exercise before they are likely to be signed off.

However, in practice given the comparative rarity of useful wave at most clubs it may be expedient to fly the exercise whilst the wave is working and catch up on the Pre-flight briefing with the De-briefing.

Further, when attempting to instruct the various techniques of wave flying considerable doubt will inevitably exist in the mind of the instructor as to what will be possible in the forthcoming flight, particularly as many of us (instructors) may be inexperienced at instructing in wave techniques. This is probable if one's club isn't one of the dozen or so in the UK frequently favoured by wave. If you are confident that you can aerotow with your student directly onto wave then, depending on your understanding of their knowledge, you can brief for the launch, tow, initial & subsequent climbing, moving around in the wave and ultimately exit and recovery from the wave. How much of the handling the student can manage will depend greatly upon them. However, it's quite likely to be a windy day so even if they are already solo, or even licenced, they may not be up to the aerotow should you encounter rotor.

If you believe you can climb straight off a ridge into wave then unless the student is particularly inexperienced it is likely that they will only require verbal assistance to make the transition.

If you intend to thermal into wave then, unless your student has a fair amount of ability in thermals and can respond promptly and accurately to guidance, you may very well need to do quite a bit of demonstrating, if the opportunity of wave flying is not to be missed. Regardless of how you contact the wave, if climbing becomes problematic, it will be prudent to take over and demonstrate the techniques required, at least until some height has been gained and you are a little more secure.

Not every wave flight will involve all aspects of wave soaring, so obviously we need to restrict pre-flight briefings to those aspects we expect to encounter. As before any flying exercise the instructor should discuss Threat & Error Management, along the lines of the following. It is proposed to include a wider discussion of TEM in chapter 6.

TEM

Threats:	**Mitigation:**
Collision	Maintain thorough Lookout
Failure of Navigational equipment	Monitor performance of equipment and have back up plan
Failure of Oxygen equipment	Understand your equipment and monitor its performance
Finding yourself above 8/8 cloud	Descend if you see the gaps closing below you
Errors:	
Running out of height for appropriate circuit	Monitor height & position
Climbing too high without Oxygen	Carry & use Oxygen equipment above 10kft.
Being blown downwind	Use appropriate navigational equipment and maintain awareness
Inadvertent penetration of airspace	Use appropriate navigational equipment with current airspace files
Over speeding at altitude	Monitor airspeed against table of speed restrictions at altitude

AIRBORNE LESSON

Describe how you envisage the flight being conducted, along with likely variations if conditions do not prove as anticipated. Discuss how much flying you anticipate the student doing and what if any demonstrations you anticipate flying.

Draw attention to the Common Difficulties as per the end of this chapter and any local issues if they exist. Include advice on how to deal with particular issues you anticipate encountering.

MANOEUVRE LESSON

The intention of this lesson is to give the student experience of wave soaring and to practice the manoeuvring, decision making and required airmanship.

As with other exercises wave soaring is best taught in bite size chunks. However, unlike the aircraft manoeuvres we teach, turning, launch failures, etc. the exact exercises we teach will depend heavily on the conditions available. We can start by teaching them the various parts, getting in to wave, climbing in wave, travelling in wave and exiting wave. However, exactly how this is done will vary considerably and we can only demonstrate dealing with the conditions that prevail. Hopefully that and a proper briefing covering the wider aspects of wave will serve them well when they encounter other conditions.

As always, if the student does not manage to fly appropriately, then identify what the problem area is, re-demonstrate if required and let them try again. Similarly, if their decision making is flawed then that must be discussed when back on the ground.

DE-BRIEFING

The content of the debriefing will be driven by how well the flying went. In the case of wave soaring, it will not be just a commentary on how the glider handling went. It is important that the student is encouraged to practice as much of the decision making as possible. Therefore, a two-way discussion on how that went will be helpful, as will discussion of associated aspects of wave that may not have been encountered on the flight. Whilst it is possible that all the requirements of the SFCL SPL Syllabus for Exercise 15C may have been covered in one flight, it is not credible that any student will now have progressed to the point they can learn no more. Therefore, it would be useful to construct a next lesson on wave soaring ready for use at the next opportunity.

COMMON DIFFICULTIES

Students may find aerotowing difficult if conditions are windier than they are accustomed to or if rotor is encountered.

Students inexperienced in thermalling may well struggle with the characteristically tight and rough thermals associated with those squeezed close to the upgoing wave.

On first acquaintance with wave some students struggle to keep track of the wind direction and may well require both assistance and reminders to do so effectively. Further, they may well require similar assistance and encouragement to progress into wind without wandering off in less helpful directions.

Students and some experienced pilots struggle to navigate whilst at considerable height and are prone to being 'blown' backwards out of the lift.

The very bright conditions well above cloud can result in time and the need to be back on the ground in daylight being overlooked.

References:

1. The Soaring Engine Volume 2. By G. Dale. ISBN 978-0992827021

Notes regarding this draft:

All illustrations are provisional or worse!

Figure 1 is a Steve Longland picture.

Figure 2 is taken from 'Advanced Soaring' by John Joss. It has been somewhat modified and I regard it as a prototype for a more talented illustrator to develop.

Figure 3 I have attempted to show the interface between the convective layer and wave where the wispy clouds form and drift back into the lenticular.

Figure 4 illustrates the Track/Heading issue with FLARM in the context of wave.