15C – WAVE FLYING

SPL Syllabus: Exercise 15C Wave Flying			
(i)	**Look-out procedures**	**(iii)**	**Speed limitations with increasing height**
(ii)	**Considerations and techniques for wave access and exit**	**(iv)**	**Considerations for use of oxygen**

INTRODUCTION

For BGA clubs situated in Scotland, Wales and Northern England useful wave is 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 trainees enjoy. The range of knowledge of trainees is likely to be very wide, depending 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 safely.

THEORY BRIEFING

What conditions are required for wave to form?

In brief, wind over hills can form wave. However, that alone will not necessarily produce usable wave. Bigger hills and stronger wind usually produce better wave, but the other important factor is the state of the atmosphere. Orographic Lee Wave (the correct terminology) requires an unstable layer at low level, a stable layer above and an unstable layer above that. There should be wind increasing with altitude and little change in direction.

Wave is common, but usually too weak, high or localised to be of any use for soaring. It may interfere with thermal conditions or suppress ridge lift, making the ridge unsoarable. Wave has its downside.

A wave may be set off in the lee of a slope, but the topography downwind may cancel out useful wave further downwind. Conversely, it may boost subsequent waves. Very often, the waves downwind of the original source are better than the primary. Where wave systems from different sources converge, interference patterns will be formed. When the characteristic long lenticular clouds are present, a satellite picture will show the wave patterns, which can stretch across very large areas.

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.

How to soar in wave?

Unlike the meteorology behind wave, the principle of soaring in wave is straightforward. Find the line of rising air and fly along it. When conditions are good and the wave is marked by smooth lenticular clouds it is simple. However, sometimes very good wave can occur in blue skies and with no visual clue

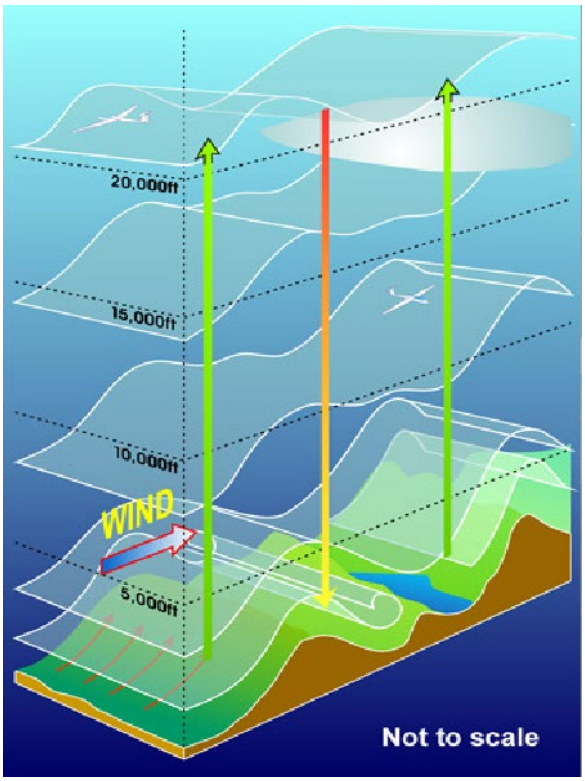

Figure 1. Wave – Typical Arrangement.

to its position, so soaring it is more challenging. Even more commonly, the wave clouds can be ragged, with gaps and changes of direction, depending on the terrain. Disappointingly, most usable wave is not suitable for high climbs or travelling great distance, but it can still provide interesting soaring.

Although often referred to as 'standing wave,' the lift is rarely completely static. Usually, the position of the best lift moves a little, slowly 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?

Most Gold & Diamond height climbs are achieved in wave and, as the wave is often better when there is no thermal interference, it can provide some good, albeit cold winter soaring. If the wave bars are long, it is possible to cover great distances, sometimes at considerable speed. Waves often re-occur a number of times downwind of their trigger (i.e. propagated wave), so having gained height it is possible to jump between wave bars to progress up or downwind.

How to 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. Most UK sites do not often see too many obvious, well organised wave systems, so frequently we have to fight our way up through weak and often broken lift to get into the wave proper.

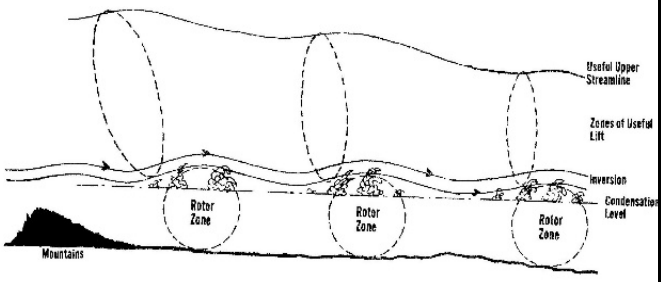

Figure 2. Wave Cross Section.

If it is too rough to aerotow, you are airborne when the wave starts, there is no tug available, or you are just too mean to pay for an aerotow, then hard work, cunning and above all patience, can be employed instead. It is 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, to climb up and try again, which is useful, as many attempts to get into wave fail.

If the ridge is working better (or much worse) than you think it ought to, 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, that's great. 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 bright patch on the ground and frequently, that will be in the lee of high ground. On cloudy days, the appearance of a wave 'slot,' or clear gap in the overcast, may be an indication of wave setting up.

Whilst assessing the situation, try 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. If you get a good height, then try a straight glide to any likely looking gap upwind of a cloud. With luck you may fly into the beginnings of wave lift at the edge of the cloud. In the absence of clouds, push into wind, but on most attempts you will be disappointed.

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 much more frequently than others, so evidently it is not entirely down to chance. With practice, persistence and patience, we can get better at getting into wave.

Successful attempts are often preceded by having found a thermal significantly stronger and rougher 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.

If you get into the bottom of a wave system, then the first bit of the climb is critical. Initial climb rates are often poor and the lift is not necessarily smooth. This is an area where the thermals and wave are mixed. Be patient and stick with it, even if only climbing very slowly. If good lift is above, it should improve and smooth out as you climb.

Often, having taken a thermal at the edge of the 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 other gliders playing the same game!

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 important whilst flying 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.

The sharp edge to the 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 isolated wisps forming lower down. Even the tiniest and most transient cloud wisp is valuable information. It is best to keep moving around the windward edge of them. Normally, as you do this another will form into wind from you, and another, and so on. You can sometimes see a pattern forming as the wisps line up. It is easy to linger too long, particularly if the wind is brisk and end up engulfed in cloud. This is extremely dangerous and must be avoided. Disorientation in cloud happens very quickly and a small deviation from heading directly into wind will track you back into the cloud towards the sinking air, and the cloud can sometimes be thousands of feet deep. Wet or iced up wings add to the danger. Usually, once you are above cloud, the wave pattern can be seen much more clearly.

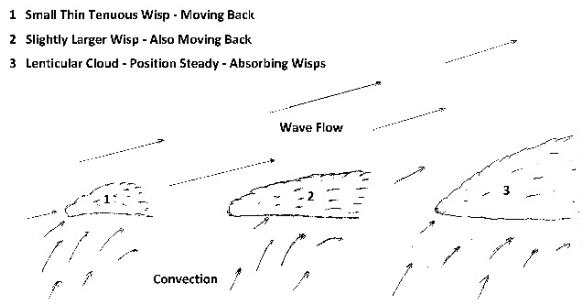

Figure 3. Wave Wisps in Section.

If it is blue, with no cloud to guide you, a moving map snail trail provides a reference in space which is very useful because 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 is 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.

Moving map displays can also provide a good measure of wind strength and direction, enabling progress back into wind to be made efficiently. They are usually essential if there is any airspace to be negotiated.

Safety issues are associated with wave flying

Oxygen: Regulations (UK Sailplanes Rulebook AMC1 SAO.OP.150) state that, oxygen should be used above 10,000ft When the pilot-in-command cannot determine how the lack of oxygen might affect the persons on board.

The **symptoms** of hypoxia such as headache, or fatigue may be insignificant or non-existent, so consequently the pilot is unaware of them. But the **effects** such as confusion, euphoria, inability to concentrate, impaired decision-making, impaired psychomotor performance, and eventually loss of consciousness are dangerous and potentially devastating.

Make sure you are familiar with the equipment, that it is functioning properly and adequately filled **and use it!**

Cold: Even in summer it will 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. 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 often feature a turbulent 'rotor' structure under its crests. In the mountains and strong winds significant, sometimes severe, turbulence can occur which may or may not be marked by cloud. Aerotowing through it is very challenging and encountering it at more than manoeuvring speed is inadvisable. The wave system may create rotor over the airfield with very significant turbulence and an entirely different wind direction on the descent and approach.

True Air Speed: TAS is always higher than IAS (indicated air speed) and the difference is significant at high altitude. To avoid the possibility of flutter, gliders have a reduced (indicated) VNE with altitude. This is detailed in the Flight Manual and should be placarded in the aircraft.

Being blown downwind: wind increases significantly with height in wave, so may necessitate flying in windspeeds above those that we are accustomed to: 60 kts plus can be encountered. A rough estimate is that true airspeed increases by about 2% per 1,000ft. Therefore at 10,000ft, TAS will be 20% greater than indicated airspeed (IAS) 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 on a downwind run, many sites in the UK are only minutes flying time from the sea!

Unlandable territory: Climbing in wave implies there is hilly or mountainous terrain upwind. Having gained significant height, the next step may be to jump forward and climb again. However, if you push forward, fail to climb you may find yourself low over hostile terrain. If you are pushing forward through sink, things can go wrong quickly. It is important to think ahead and make sure that you have sensible landing options.

Look out: Above cloud, some of the joys of wave flying 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 variometer can be quite soporific, lowering one's guard. It can also be quite difficult to spot gliders approaching as white gliders do not stand out well against gleaming white cloud. The best lift tends to be confined to a fairly narrow band, so it is not surprising that we encounter other gliders despite the huge volume of operating space.

FLARM is very useful given the limitations of our lookout, but it has limitations. FLARM indicates the direction of the threat relative to the glider's track, not its heading. In a strong wind there can be a big difference. See Figure 4 and the example below. Consciously look in the direction of track.

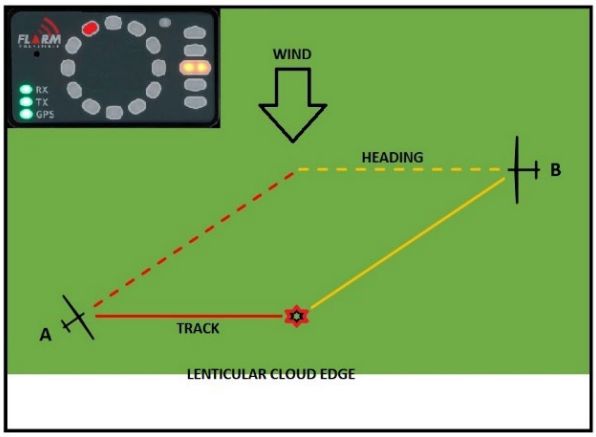

Figure 4 FLARM and Crosswinds.

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 to the right of your heading. However, if the collision actually occurred, it would come from the left of the glider's track and the FLARM would 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.

Airspace: In the UK we are limited to FL100 without a transponder. However, the BGA negotiated a number of non-transponder areas above FL100 and up to FL195 in parts of Wales and the West Midlands, much of Northern England and all of Scotland. These are detailed as exceptions in the UK AIP under ENR 1.1 and 5.2 and there are various local Letters of Agreement. There are also wave boxes permitting even higher flight when enabled. 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.

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. Start the descent in good time.

Operation above cloud: Whilst it is possible to operate above 8/8ths cloud with moving map equipment, it is highly imprudent. The cloud base below you may have reduced since you climbed, perhaps to below the height of the hills. A descent through cloud is challenging even with the right instruments and experience – without these it is suicidal. Operating above partial cloud cover may be safe enough, but it is essential that a clear way down to a safe landing area is always available. If high in wave the reducing size of a gap 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!

AIR EXERCISE & BY GLIDER BRIEFINGS

The intention of this lesson is to give the trainee 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, exactly how this is done will vary considerably and we can only demonstrate dealing with the conditions that prevail. Teach them the various parts, getting into wave, climbing in wave, travelling in wave and exiting wave. This combined with a proper briefing covering the wider aspects of wave, will serve them well when they encounter other conditions.

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 trainee doing and what if any demonstrations you anticipate flying.

Draw attention to any local issues if they exist. Include advice on how to deal with particular issues you anticipate encountering.

Aerotowing into Wave:

If at a site where wave conditions allow, take the trainee 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 the wave is.

Remind the trainee of:

- the implications of aerotowing in strong wind/wave conditions, particularly rotor turbulence.
- The variometer as a method of spotting suitable release conditions.
- The importance of lookout, and specific issues of lookout in the wave environment.

Soaring into wave:

If planning to try to climb directly off a ridge into wave, brief the trainee how to best use the usual ridge soaring techniques to get as high as possible and push forward where the lift is best. With luck a seamless transition from ridge lift into the wave will occur.

If you do not have a ridge, but it is possible to stay aloft in thermal, then thermalling into wave, the most difficult method of entry, can be attempted. If the trainee is to do the flying in this exercise, they will have to be competent at thermalling.

If operating close to cloud, either vertically or horizontally ensure the lookout is good.

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. There is a wider discussion of TEM in chapter B.

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.
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 MANOEUVRE LESSON

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 the club is not one of the dozen or so in the UK frequently favoured by wave.

If you are confident that you can aerotow with your trainee 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 trainee can manage will depend upon the skills they have. It is quite likely to be a windy day so even if they are already solo, or even licensed, they may not be up to the aerotow, particularly if you encounter rotor. Guide them as required to get established in the climb. If they were brought up in a thermalling environment they may 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.

Soaring in wave: If there is wave cloud then point out how to track along it, whilst keeping a focused lookout for gliders flying in the opposite direction. Draw the trainee's attention to maintaining station in lift and how to keep track of wind strength and direction, particularly in the absence of cloud.

Demonstrate how to conduct a logical search for better lift.

If possible, demonstrate how to tackle a transition to the next wave bar upwind. If you have climbed well above cloud, then the lift ahead is likely to be over the next lenticular cloud and given a strong wind and sink falling into it is easy. As you set out forwards, monitor your progress relative to the top of the cloud ahead.

If uncertain about pushing directly forward to the next climb, without penetrating cloud or falling out of the bottom of the system, 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 which 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 may make progress into wind possible if the glider has limited performance.

Exiting wave: If you are only a few miles from home and in clear air a few thousand feet up, then safely getting home will not be a challenge. Conversely if you and your trainee are 20 miles upwind at 20,000 ft with an increasingly large amount of cloud below and airspace to be evaded, it requires more consideration.

Key points:

- It takes time to get down from height so make sure your trainee can make a good estimate of how long it is likely to take. If it is sunset at height then it may be really dark when they get home, particularly if cloud obscures the western horizon.
- A really swift descent has risks due to taking a very cold airframe into moister air e.g. forming a layer of ice on the airframe and canopy; it may also damage the gel coat of the wings if the airframe temperature changes rapidly.
- 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.

The obvious way of descending is to open the airbrakes and speed up. However, trainee may not appreciate the alternative is to achieve a good rate of descent by flying into the down of the wave.

Do not undertake a good descent but in doing so neglect to get home first. i.e. keep plenty of height in hand until close to home to allow for any navigational uncertainties or to outmanoeuvre any inconveniently placed cloud.

DE-BRIEFING

It is important that the trainee is encouraged to understand as much of the decision making as possible. 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.

COMMON DIFFICULTIES

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

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

Some trainees 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.

Trainees 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.

