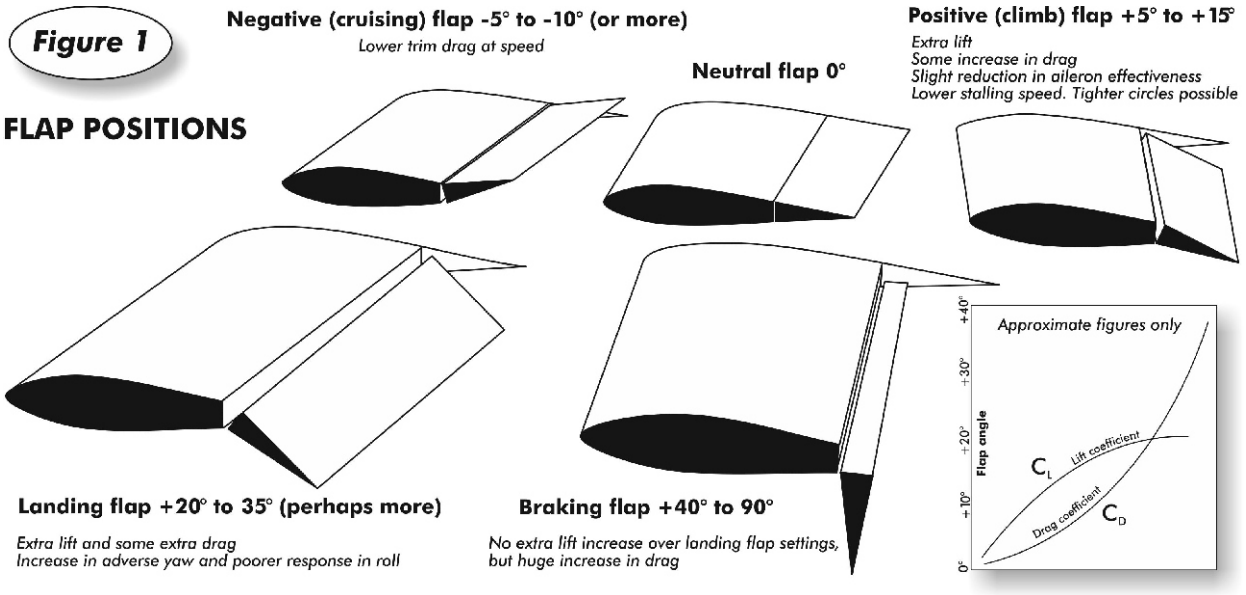
21 - FLAPS



Aerofoil sections optimised for thermalling don't operate efficiently at inter-thermal cruising speeds, and vice versa. Trailing edge flaps address this fundamental problem by giving the pilot the ability to change an aerofoil's camber and characteristics so that it works efficiently over a broader range of speeds than a comparable unflapped section.

The 'simple' flap is the most common type. It has a fixed area, is easy to manufacture, and is cost effective. The majority of modern flapped gliders use simple flaps with a typical operating range of about 40°, from, say, -10° to +30°. A few gliders, such as the Blanik, use Fowler flaps which increase the wing area by sliding back and out as they deflect downwards.

Small positive flap deflections provide a large increase in lift and a minimal increase in drag (C_L and C_D, inset figure 1). As the positive flap deflection angle is increased, drag starts to rise noticeably and the lift increase starts tailing off.

Lowering or raising flaps usually changes the glider's trim and alters both its attitude and the flight path. The more positive flap is used, the bigger the difference between the attitude and the flight path. This adds a slight complication to controlling the speed 'by attitude', but it's no worse than similar changes created by use of the airbrakes.

It is important that instructors understand flap aerodynamics, and how to operate the specific type fitted to the glider in which they are instructing, or to which they are converting either the trainee or themselves.

Flapped two seaters are fairly rare in general club training, but they are ideal for demonstrating flap characteristics and effects. If appropriate, the trainee should be taught how to operate them effectively through all phases of flight, and the instructor should make certain the trainee appreciates how the various settings affect the glide ratio and the penetration.

Whilst the details of flap operation don't vary much between glider types, always read the flight manual to find out how the designer intended they should be used.

Cruise/Climb flap

Cruise flap is often referred to as negative flap. It reduces trim drag and allows the glider to fly somewhat faster (6kt or 7kt usually) in the glide, with no performance or handling penalty. A typical cruise flap setting would be -5° at 70kt.

Climb flap. Small amounts of positive flap (between +5 and +10), reduce the stalling speed by an amount dependent on the aerofoil, but typically by about 2kt. Given accurate speed control, climb flap allows slightly tighter turns in thermals, and usually - but not always - a slightly better minimum sink rate; useful when ridge or wave soaring, but again, only with accurate speed control. It also allows slightly lower approach speeds.

Even when used in small amounts the main drawback of positive flap is a slight deterioration in the handling. Adverse yaw increases, and rudder and aileron coordination are more difficult. Tip-stalling or wing rocking can be an irritating side-effect. The roll rate is worse, particularly in larger gliders. As an added bonus the glider will spin more readily.

Cruise/climb flap only has a beneficial effect on performance if used correctly.

Landing flap

Landing flap is, in effect, climb flap, but more of it; anything between +20° and +90°, depending on the glider type.

Landing flap creates large amounts of drag, and can reduce the stalling speed by about 3 or 4kt, allowing steeper approaches, slower touch-down speeds and shorter landing runs. The change in the aerofoil's camber can give the glider a markedly nose down attitude. The forward view on the approach is improved, but by comparison with straight flight and 'normal' flap settings there may then be a big difference between the glider's attitude and its flight path. This is especially the case with flap only gliders (PIK20b), or those with very powerful (last resort) landing flaps. When landing flap is deployed it is essential to monitor the ASI and maintain airspeed.

Landing flap generally makes all the drawbacks associated with climb flap (as previously described) a lot worse. The glider may also become less stable in pitch and even easier to spin. It is also far more likely to drop a wing during the ground run.

Despite the large amount of drag that positive flap can create, the limiting speeds associated with the different settings can often be surprisingly low, so, once again, the airspeed needs monitoring. The flap deflections may also be G limited. Refer to the flight manual or the placard.

Additional comments

The ergonomics of some flapped gliders leaves much to be desired. Thorough familiarity with the controls and their operation is essential.

The increased lift created by lowering the flaps can cause noticeable bending and twisting of the wings' outer panels. The flap limiting speeds take account of this and should be strictly adhered to.

Use of positive flap during the slower parts of the ground run, take-off or landing, can result in a wing drop. Unless there is plenty of wind negative flap may be needed during these slower phases to give the pilot some aileron control.

Landing and cruise/climb settings are normally operated by a single lever, but there are some exceptions. The Kestrel is one of them. It has two levers, one for landing flap and the other for cruise/climb. There is another lever which looks exactly like a flap lever, but deploys the braking parachute.

Flaps require a good deal of maintenance and need to be well sealed if they are to work at their best.

Use of flaps - general principles

Before flying make sure you **read the relevant section of the flight manual**, look at the **placard** and generally acquaint yourself with the flap limiting speeds and/or associated G limitations. Exceeding the limits can cause serious damage to the wing structure. Some gliders with trailing edge airbrakes, have flap and airbrake limiting speeds which are much lower than V_{NE}, and operating the trailing edge airbrakes above the published limiting speed can cause catastrophic damage to the rear spar.

The circuit, approach and landing

The circuit, approach and landing settings and when to use them are broadly similar for most flapped gliders, but again, always check with the glider's flight manual.

- fly the circuit using whichever flap setting gives the best L/D. This can be glider dependent, but for aerodynamic reasons it's most likely to be 0°
- once established on the diagonal or base leg, lower the flaps to an intermediate positive setting, such as the second stage of thermal flap. This gives you an opportunity to get used to any significant changes in trim and attitude, as well as judging how the reduced glide angle is affecting the approach picture
- once you know you're going to make the chosen landing area easily - usually after the final turn - lower the flap to the landing setting. What the flight manual will label and describe as landing flap, and the actual amount you'll use for a landing aren't always the same thing. The so-called landing (maximum positive) setting on some gliders (eg. DG500) is rarely used because it results in very sluggish aileron response, and a tendency to drop a wing at, or just before touchdown. Pilots of these gliders tend to select the next lowest setting. Not every glider using full landing flap will drop a wing at round-out. Again, refer to the flight manual
- if you're running out of height in the circuit leave the flaps in zero (best L/D configuration). All flapped gliders can be landed in zero flap if necessary
- monitor your airspeed (counter for any trim change) and use the airbrakes, as normal
- don't alter the flap settings during the final turn
- with the glider safely established on the approach, leave the flap settings alone (but see NOTE below)
- in order to maintain aileron effectiveness and prevent a ground loop in a cross wind, you may need to raise the flap to a negative setting during the 'jogging along' part of the ground run. Since you'll almost certainly have to let go of the airbrake lever to alter the flap setting, the airbrakes may close and you'll briefly take-off again, so wait until the glider is firmly 'stuck' to the ground first.

NOTE: Lowering the flaps from 0° to, say, +20° , increases the aerofoil's lift coefficient (C_L), and reduces the stalling speed, as previously described, but when the flaps are retracted again the stalling speed and the C_L return to their original values. If the attitude is kept constant while the flap setting is reduced below about +20°, the changes in AoA and lift can cause the glider to start to sink rapidly. The resulting sensations can be confused with stalling and are very marked if there's a wind gradient.

As a result of the above, pilot's are often advised not to retract the flaps during the approach, come what may, but there is no reason why they shouldn't if, say, an undershoot is developing, but there is one very important proviso - that the speed before retraction is ABOVE the stalling speed for 0° flap (or whatever lower setting is selected), preferably by a reasonable margin. Given that flaps don't decrease the stalling speed by much, if you genuinely stall when you retract them then you were probably flying far too slowly in the first place. However, if the speed is sufficient, the increased sink rate and accompanying sensations of imminent disaster as the flaps are retracted can be removed by raising the nose an appropriate amount. Monitor the airspeed.

The winch launch

Unless the flight manual says otherwise, plan to use the first thermal flap setting for the launch. One advantage of this setting is that if you have a low level launch failure, you're not obliged to change the flap settings at a critical moment. In the event of a launch failure higher up, there will be more time and you may then want to lower more flap to steepen the approach path.

If you don't have to, don't alter the flap settings during the take-off roll or the first 500' of the launch. Keep your left hand on the release, as usual. The suggested practice for some gliders is to start the ground run in zero or negative flap if the initial acceleration is likely to be slow, or there is little or no wind and the winch isn't particularly powerful. This may mean changing the flap setting to zero or a few degrees positive during the last part of the ground run. The drawback here is an increase in the pilot's workload at just the wrong moment, and if a wing drops his hand may be nowhere near the release.

The aerotow

To ensure maximum roll control during the initial ground run and subsequent tow, **consult the glider's flight manual for recommended practices and flap settings**.

If the recommendation is to adjust the flaps to a positive setting during the ground run, make changes gently and be aware that if you leave them rather late, or make them too abrupt, the glider can take-off very suddenly and get too high.

In free flight

The optimum flap settings vary from type to type, and with the wing loading. On average days cruise between thermals in zero flap, occasionally using the first stage of negative flap, but rarely barrelling along with full negative flap.

Don't deploy positive flap as soon you pull up into lift. If you've been going fast beforehand the drag rise will be unnecessarily high. You won't gain quite as much height and manoeuvrability will suffer just at the point you need it. Pull up, wait for the glider to slow, then lower the flaps to the first positive setting. The second positive flap setting is only worthwhile if you're well centred, the lift is reasonably smooth, and you don't need to manoeuvre much. The second setting may also be useful if you want a slightly tighter circle without having to speed up.

Small amounts of positive flap can be used in wave or ridge lift to give a marginally lower rate of minimum sink. Modest experimentation may be needed to determine the optimum flap setting, particularly in wave. In some cases zero, or even a small amount of negative flap may give a lower rate of sink than the small amount of positive flap that's usually suggested in flight manuals.

When leaving a thermal, accelerate while still in the lift by smoothly moving the flaps to the setting appropriate for the speed at which you expect to fly through the sink. It's important to time this right so that you aren't trying to accelerate a draggy glider through heavy sink that you were expecting five seconds later.

Conversion to a flapped glider

The majority of points made in the DG500 section below are applicable to all flapped gliders, single or two seat, as are the principles and general use described previously. However, note the following additional points:

- if the glider is operating at a high wing loading, failure to use positive flap at the correct point during the aerotow ground run can result in the tug becoming airborne well before the glider
- the AUW of most flapped GRP two seaters, even without water ballast, is high. Regardless of the wing loading an aerotow ground run in light or no wind conditions can be a very prolonged affair, and obstacle clearance may be a critical consideration. Use all of the available run.

Example conversion/use of flaps (DG500)

Normal type conversion considerations apply, but note the following:

- for aerotow take-off begin the ground run in negative flap to improve aileron control. Have your left hand on the release. At 25kt IAS move your left hand to the flap lever and select positive flap (usually +5°) to reduce the take-off speed
- during the ground roll the nose will tend to pitch down. Some back pressure will be required to prevent this and to maintain the optimum take-off attitude
- the glider is sufficiently heavy enough to make obstacle clearance on take-off a more critical consideration than in other gliders you will have flown. Use all the run available
- unlike the Janus or the Duo-Discus, the DG500's airbrakes are very powerful. The wheel brake operates at the end of the airbrake lever's travel
- an approach speed of 55kt is sufficient in nil to light winds
- the span is 22m with low ground clearance. The glider will readily drop a wing on take-off and landing
- for best aileron control during the landing run, don't use landing flap. It severely reduces the effectiveness of the ailerons. Use 0° to +10° flap. Don't alter the settings during the landing run.

Use of thermal flap

- trim the glider for 50kt in zero flap
- prompt the trainee to carry out the 'rolling on a heading exercise' using aileron and rudder together, and to note stick forces, rate of roll and rudder limitations
- select thermal flap, trim for 50kt, and roll on a heading again. The trainee should note greatly increased aileron drag and insufficient rudder to counteract the adverse yaw. More perceptive trainees may also note further disadvantages to thermalling flap; the slightly increased stick forces, reduced roll rate and a more nose-down attitude for the same speed
- to demonstrate the advantages, reselect zero flap and do an unaccelerated stall. Note the stalling speed. Select thermal flap and repeat the exercise. The trainee should note that the two differ by between 2 and 4kts, a difference small enough to go unnoticed if either stall is accelerated. The instructor may have to demonstrate the stalls to achieve a sufficient degree of accuracy
- emphasise that the reduction in stalling speed is the only gain from using thermal flap, and that the setting should only be used to reduce the radius of a thermalling turn, or occasionally, when flying straight at minimum speed, through very strong lift.

Use of negative flap - better performance at high speed

- select zero flap and accelerate to 85kt. Stabilise the attitude and trim to maintain that speed. Give the trainee sufficient time to recognise the new attitude
- select -5° flap and maintain 85kt airspeed. Allow time for the glider to stabilise in the new attitude, and further time for the trainee to recognise it. He should notice a much less nose-down attitude in negative flap
- emphasise that much of the changed attitude is due to a change in the direction in which the glider is pointing. Any change to the glide ratio is less significant than suggested by the change in attitude. The demonstration's point is that although negative flap does improve high-speed performance, the improvement is actually quite small, and the temptation to fly flapped gliders faster than similar unflapped gliders should be resisted
- when reducing speed the nose of a glider of the DG500's performance needs to be raised significantly and left there for an appreciable amount of time for the speed to reduce to the 45-50kt appropriate for thermalling. Simply, you gain more height in the pull-up.

Use of landing flap

- in zero flap trim the glider for 55kt (normal approach speed)
- direct the trainee to monitor and/or maintain the attitude and then select landing flap. If the original attitude is maintained the speed will decay to about 40kt in roughly 10 seconds.

Draw the trainee's attention to the reduced airspeed and ensure that he understands the potential danger, in particular that landing flap would normally only be selected below about 500'. Instruct the trainee that in lowering landing flap he should monitor the airspeed and lower the nose accordingly.

