To Flap Or Not To Flap

How and when to apply flaps for better takeoffs and landings

by ALAN BRAMSON

■■ They have been putting flaps on aircraft since Nelson lost his eye yet few pilots really understand what they provide, how they provide it, why they are fitted in the first place, and how they should be used. And that is a pity, because the flap can make life easy for the pilot who knows how and when to apply it.

In essence, flaps give us increased lift and increased drag. To a considerable extent, the amount of increase and its relationship may be controlled by the pilot because initial application of flap predominantly increases lift until a point is reached when further depression adds mainly drag. The maximum lift position (relative to minimum drag increase) usually occurs between 15° and 25° of depression according to flap design (Figure 1).

Thinking back to student pilot days you may recall that thick, highly cambered wings generate more lift per square foot than do thinner ones at the same airspeed. So by varying the camber we can increase or decrease the amount of lift for any given speed. And if the flaps are depressed to the point where profile drag is added to that which is a by-product of the lift increase we get an airbrake effect.

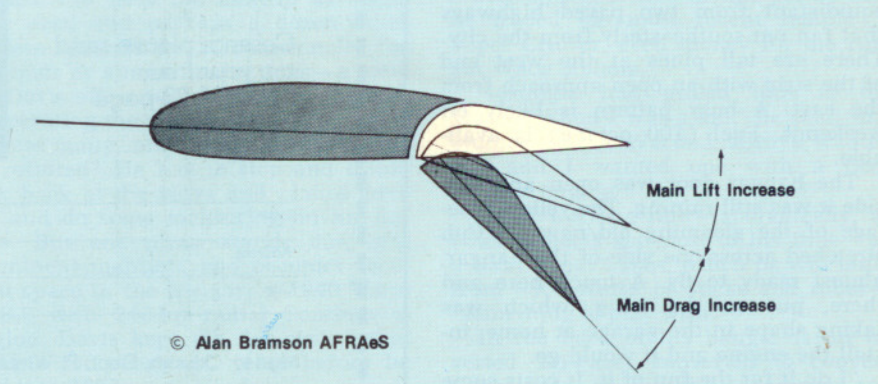
There are many types of flap but the more common ones are illustrated in Figure 2. The figures quoted represent percentage increases in maximum lift over the basic airfoil, but at this stage it is perhaps worth mentioning a little about the flaps I have illustrated.

The plain flap, sometimes known as a simple or camber flap, is no more than a hinged surface inboard of the ailerons. It is not very efficient either as a lift producer or as an increaser of drag. Slightly more effective is the slotted flap which is hinged to open up a small gap between the flap leading edge and the wing, the idea being to preserve the flow over the top of the flap by spilling high pressure air from under the wing. While this type of flap is in common use on many light singles and twins, it is little better as a lift increaser than the old split flaps and not as good at providing extra drag when it is needed during the approach and landing.

Without doubt the split flap was very effective in its day; many WW-II planes had them and the Cessna 310 still remains loyal to them.

The Fowler flap has the advantage over most other types of adding wing area as well as camber. It achieves this by moving back along tracks before depressing to create extra drag. In a slightly more complex form incorporat-

FIGURE 1



While flap characteristics vary according to design, the main lift increase occurs during the first 15° to 25° of depression. After that, lift increases more slowly and drag builds up at a faster rate.

ing one or more slats this is the type of high-lift device fitted to most of the modern passenger jets and some high-performance light twins.

Simple versions of the Fowler flap may be seen on the Aerospatiale Rallye range of light singles and Cessna singles, although, for some reason, this manufacturer refers to them as slotted flaps. Call them what you will, Cessna flaps move back some seven inches adding five or six square feet to the wing area and that must surely take them out of the slotted class.

Without doubt Fowler flaps, particularly the multiple slotted variety, are very effective indeed. However, whatever the type of flap, extra lift is attained by increasing the camber (and the wing area in the case of Fowlers), while the continued lowering of flap beyond the maximum lift increase position will provide a little more lift and a bigger increase in drag.

In the biplane days when aircraft were designed with a built-in headwind, gliding angles were steep and a pilot could clear obstacles on the approach. Also, wing loadings were low. Then along came monoplanes without struts and, having low drag, the new breed had a very flat glidepath. Soon wing loadings went up and up and so did stalling speeds, which in turn demanded higher approach speeds.

Thus a light biplane of the 1930s would have a wing loading of around 7½ lb/sq ft while hot biplane fighters of the day would have 14-16 lb/sq ft. Today a light four-seat tourer like a Bonanza carries just under 20 lb/sq ft while the Concorde has a wing loading over 103 lb/sq ft. The Concorde is a special case because it has no flaps, but the figures are quoted to give some idea of the problem.

The stalling speed of a modern passenger jet may be reduced by 50 knots or more when the flaps are lowered and this is one of their prime functions. Why, you may ask, is it that we are only likely to see a reduction of 5-10 knots on modern light singles? While there are aerodynamic reasons for this, in simple terms it could be said that even the best of flaps can only be expected to reduce the stalling speed by a percentage of that at the clean stall.

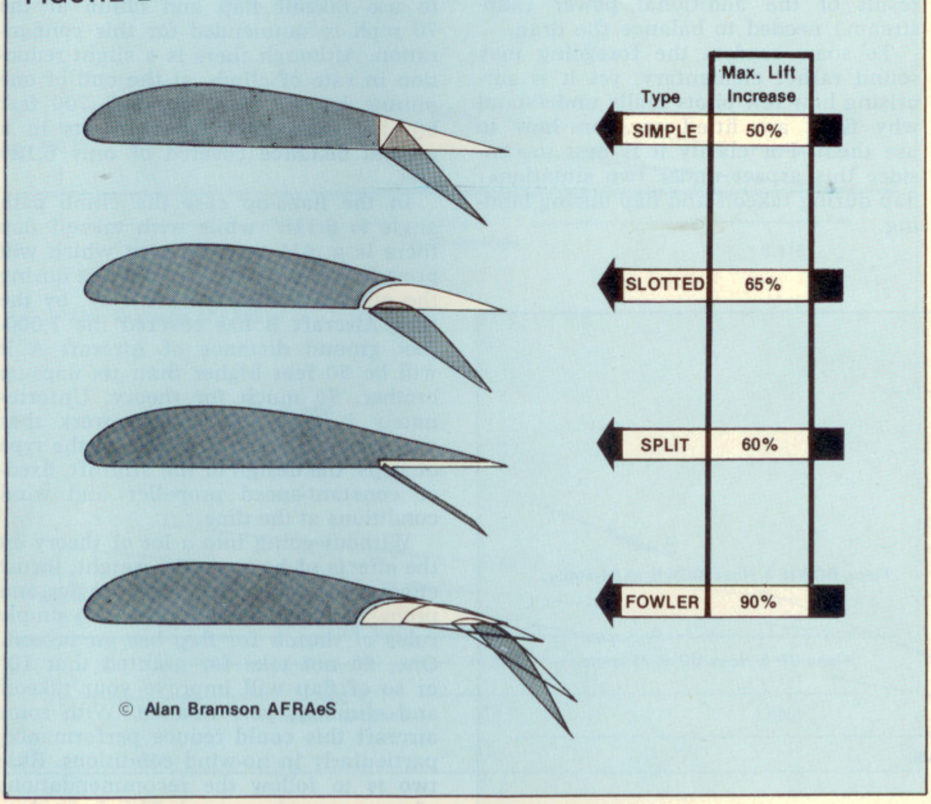
Since, even flaps up, most light singles have a relatively low stalling speed, it is a case in which a percentage of a low number can only be a still lower one; hence the modest reduction in stalling speed conferred by the flaps on most light aircraft. However, this aspect of flaps is of prime importance to large, heavily loaded civil and military aircraft.

Then there is the problem of clean design and the difficulties this may provoke on the approach. Put in practical terms, an aircraft with a high lift/drag (L/D) ratio (a sailplane is an extreme example) will descend on a flat glidepath. In order to approach at a low airspeed the pilot must hold up the nose, thus obscuring the view ahead. So with tall trees and power lines to cross, the flapless pilot is stuck with a flat glidepath and little forward vision. Not good. But when flap can be lowered we are, in effect, increasing the angle of attack without having to alter the longitudinal attitude of the aircraft.

As soon as we do this the view ahead is improved and, if we depress the flaps into the drag range, our L/D ratio is reduced. The rate of descent increases and, because of the steeper glidepath, those trees or wild giraffes standing so foolishly in the line of approach may be cleared without overshooting the runway.

Have a look at Figure 3. Aircraft A is descending, flaps up, at 70 knots, nose up, visibility restricted and a candidate for the tree tops. On the other hand the pilot in Aircraft B has found the flap lever, the nose has gone down to maintain the speed (which can now be lowered safely in view of the de-

FIGURE 2



The most common types of flap in general use. More complex versions of the Fowler flap, using one or more slats in conjunction with the main flap, can increase the maximum lift by up to 120%.

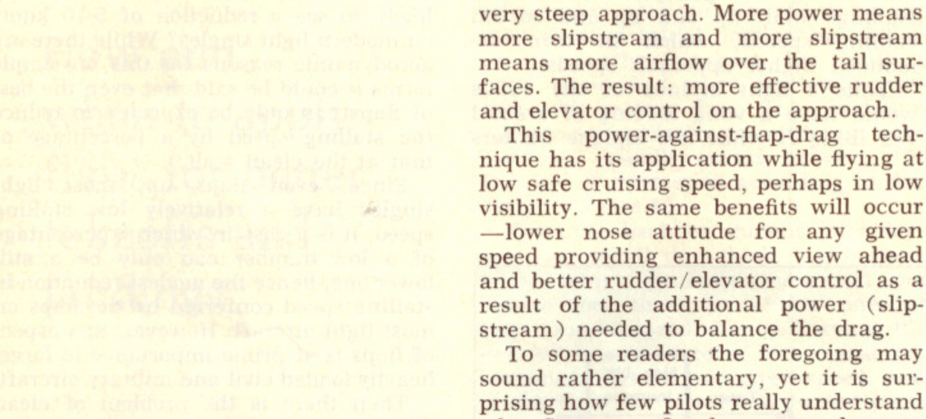
crease in stalling speed), his forward vision is improved and he now enjoys a steeper approach path which will keep him out of the trees.

There is also a bonus because, by lowering flap and increasing drag, a fair amount of power will be needed to control what could otherwise become a very steep approach. More power means more slipstream and more slipstream means more airflow over the tail surfaces. The result: more effective rudder and elevator control on the approach.

This power-against-flap-drag technique has its application while flying at low safe cruising speed, perhaps in low visibility. The same benefits will occur —lower nose attitude for any given speed providing enhanced view ahead and better rudder/elevator control as a result of the additional power (slipstream) needed to balance the drag.

To some readers the foregoing may sound rather elementary, yet it is surprising how few pilots really understand why flaps are fitted or even how to use them. For clarity it is best to consider this aspect under two situations: flap during takeoff and flap during landing.

FIGURE 3



The value of a steep approach path is of great importance when landing in a small, confined area. The improved forward visibility is an added asset at all times.

I regret to say that over the last 10 years or so many private pilots and even some instructors in the U.K. have formed the habit of using 10° of flap for all takeoffs, irrespective of conditions or aircraft type. You see them in their Cessna 150s, lined up on a runway fit for a jumbo jet, a 15-knot headwind blowing and down goes 10° of flap. If you ask why, the reply is a vague "you get a cleaner liftoff" or "the angle of climb is better." The first belief is utter nonsense and the second one is, at best, only half true. The theory is well known but for clarity we have illustrated it in Figure 4.

Aircraft A is climbing after takeoff, flaps up at its recommended 80 mph. It has a 750-fpm rate of climb; therefore, at the end of one minute it will have reached 750 feet and the ground distance covered will be 7,000 feet (ground distance, not flight-path distance).

The pilot in Aircraft B has elected to use takeoff flap and climb at the 70 mph recommended for this configuration. Although there is a slight reduction in rate of climb, at the end of one minute he will have attained 700 feet but his reduced airspeed results in a ground distance covered of only 6,120 feet.

In the flaps-up case the climb path angle is 6.115° while with takeoff flap there is a .41° improvement which will provide better obstacle clearance during the climbout. Put another way, by the time Aircraft B has covered the 7,000-foot ground distance of Aircraft A it will be 50 feet higher than its flaps-up brother. So much for theory. Unfortunately it does not always work that way because much depends on the type of flaps, the design of the aircraft, fixed- or constant-speed propeller and wind conditions at the time.

Without going into a lot of theory on the effects of horsepower, weight, thrust effects, aerodynamics, climb angles and propeller types, we will offer two simple rules of thumb for flap use on takeoff. One, do not take for granted that 10° or so of flap will improve your takeoff and climbout performance. With some aircraft this could reduce performance, particularly in no-wind conditions. Rule two is to follow the recommendations of your owner's manual. This is particularly important when taking off from a small field, even if the pilot has measured it by walking the length of the intended takeoff run.

There are far too many accidents resulting from the mistaken belief that 500 paces means 500 yards (with most people 500 paces is more likely to be 350 yards or even less) and the almost unshakable conviction that all aircraft respond kindly to using flap for takeoff. Only some of them do.

The odd thing about the flap-for-takeoff fraternity is that often they are loath to apply full flap for the landing, although this is the very time when they are of most value to light aircraft. Why the reticence? The manufacturers have provided a Cessna 150 and a Cherokee with up to 40 degrees of flap so why not use them?

Those on the Cessna range are particularly effective and there is a case for not allowing pupils in early training to lower more than 25°-30°, primarily because of the trim changes involved during a go-around. But, crosswinds excepted, there is no point whatsoever in not using full flap for a normal, engine-assisted approach and landing. In fact it is bad practice not to use them to the full.

Take a look at the lightplanes landing at your local airfield. How many of them belt in, high and fast, part flap lowered, only to touch down perhaps a third or more down the runway? Of course they get away with such bad airmanship at a proper airfield but how do they make out when faced with having to land at a small strip?

The problem is usually two-fold; a reluctance to apply full flap compounded by an approach at too high an airspeed. So often the speed selected is that recommended for best glide (best L/D speed) or even faster, whereas the aim during an engine-assisted approach should be to reduce speed below that for optimum glide so that rate of sink is increased. Power may then be used to control the glidepath using the position of the touchdown point as a visual cue.

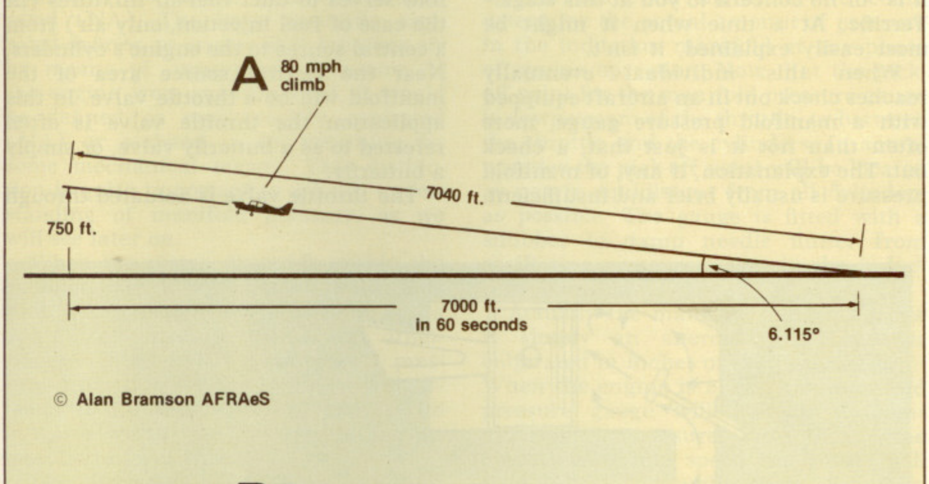
On the base leg and during the early part of the approach half flap is sufficient and normal glide speed will usually prove convenient. But on short final full flap should be lowered and the speed could, with advantage, be allowed to decrease by 10 knots in most light aircraft.

The exercise must not be allowed to degenerate into a long, flat approach with millions of rpm on the clock; this can only result in poor obstacle clearance, reduced view over the nose and a touchdown perhaps in the middle of the field followed by an expensive encounter with the far hedge. With full flap on, at the correct airspeed, and with the aircraft under moderate power, it is then possible to control the approach path and subsequent touchdown point to fine limits by using minor throttle adjustments. But remember to leave on a little power right down to the roundout, for if you close the throttle too soon a heavily loaded aircraft will most likely drop in.

Having landed, leave the flaps alone until you have stopped. There is no real evidence to support the belief that full flap detracts from brake effectiveness (part flap might) and one day you could raise the undercarriage in error—it has happened several times. It is far better practice to wait until you have cleared the runway before carrying out the post-landing checks.

"To flap or not to flap, that is the question—" might have asked Captain Shakespeare. And being a good professional he would have looked for the answer in his owner's manual. □

FIGURE 4



The climbout with and without flaps. The illustration assumes that rate of climb with flaps (aircraft B) remains similar to the flaps-up performance, otherwise there is no advantage, although forward speed is lower.