Fly STOL – safely

Jonathan Porter looks at STOL flying, something he did while in the West Africa. He believes in practice, practice and more practice – alongside good airmanship to minimise risk while obtaining maximum performance…

Short Take Off and Landing (STOL) flying is an art that has a long history. The liaison aircraft such as Piper Cubs and Austers demonstrated such techniques at hastily carved out jungle airstrips or unprepared fields near the front lines in Europe during WWII. More recently, extreme STOL performances can be seen on YouTube videos at STOL competitions, such as the annual event at Valdez in Alaska, and naturally these have raised the profile of this particular aspect of flying.

As the UK agents for the Zenair range, here at Metal Seagulls we sell the two-seat STOL CH701, which has been in production since 1986, and more recently, has been joined by the larger two-seat STOL CH750. Our friends at Avalanche Aviation, like us, based at Sleap Airfield in Shropshire, also sell a specific STOL machine, the SuperSTOL from Just Aircraft. There are also kit variations on the Cub theme available, such as the CubCrafters Carbon Cub EX-2, a very nice example of which has recently flown.

Flying a specific STOL aircraft generally means giving up some of the cruise benefits in return for short field capabilities. But of course, getting any aircraft out of, and in to, its minimum runway requirement demands some of the same techniques, albeit that they will have their own limitations.

Like all aspects of specialised flying, getting the minimum take-off and landing performance out of an aircraft, and specifically a purpose designed STOL aircraft and, more importantly, operating them safely whilst doing so, demands skill sets that are barely touched on in the PPL syllabus.

Main The competitive types at events like Valdez, in Alaska, have some quite extreme STOL aircraft.

Top The later CH750 is larger and can use more powerful engines than its CH701 sibling.

Above Nice shot of a CH701 climbing out at a STOL competition in New Zealand

By its nature, STOL means getting into the low and slow regimes of flight and this is particularly risky for the uninitiated. Please, 'do not try this at home', as they say, not before you have had some expert tuition. And always practice new techniques at a safe height so that if it all goes a bit pear-shaped, you have the safety net of ample height to recover.

Most of my flying hours are low level, STOL operations. Not the air show type STOL 'spectacular' departure type demonstrations, but real life STOL flying in the West African bush – a place where the slightest mistake can cost you more than you bargained for!

Consequently, my approach to STOL flying is a little different to the spectacular competition and show-style of flying. Remember though, as with display aerobatics, you don't need to go to the extreme to master the art, good airmanship is about minimising risk while obtaining maximum performance.

Gizmos and gadgets

STOL aeroplanes come in many shapes and sizes, and with a variety of gizmos and gadgets to make the most of high lift features. Whether that is slats/slots or vortex generators (VGs), or great big droopy flaps or flaperons, each aircraft type requires specific understanding and handling, and that all important flight coaching by somebody familiar with the type.

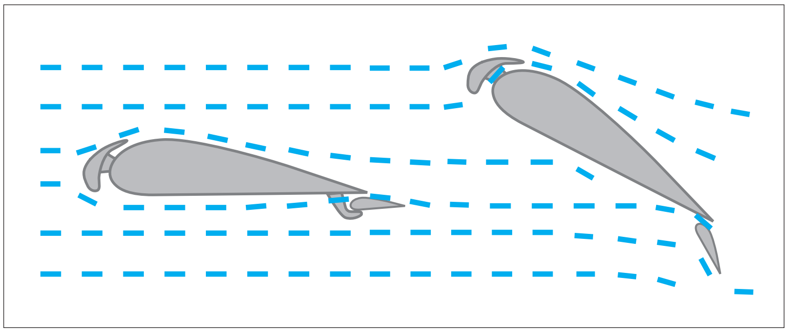
Whichever aircraft you are flying, consider the take-off as a tug-of-war between drag and lift – one you only win if you use the right tactics.

To get the most productive take-off roll possible (not the most spectacular) you need to accelerate as quickly as possible to the speed at which you can lift the wheels ▶

off of the ground, making the most of ground-effect. This rarely requires standing on the brakes and has never required yanking back on the stick, looking like a dog begging to be let off of the runway. It requires thinking about the lowest drag profile you can achieve.

In aeroplanes with manual flap(eron)s that can be dropped quickly, this may mean starting with no flaps; with electric flaps, it may mean setting about half flaps, or none at all! On a taildragger, it means getting the tail up and the wing 'neutral' as quickly as possible, and on a tricycle gear it means only lifting the nosewheel to an inch or two above the grass… think reducing drag to allow best possible acceleration.

Below Keeping the wing in a neutral attitude reduces drag and increases acceleration.



Once at a speed that allows us lifting into ground-effect you can, if appropriate, drop the flaps and get yourself off the ground, but whatever the configuration, plan to remain firmly in ground-effect and continue to accelerate. It is amazing how quickly this all happens… but it is not spectacular – there is no sudden leap into the air or extreme angle of attack – it is far more a ballet of aerodynamics versus gravity.

It is rare to get to look inside the cockpit for any more than a brief check on power achieved, that of making sure that the engine has reached full power. It is essential to remember that our air instruments (ASI, Altimeter and VSI) have a lag time, and that is where 'feel' comes in with the fast-changing dynamics of a STOL machine.

Once we have a comfortable, stable situation with enough speed on, we must decide when it is time to climb, remembering that increasing climb angles may not only decrease speed but also will increase drag – often far more than you imagined. Those draggy high lift slats might well be put into effect, and the loss of ground-effect will have an impact on energy returns.

The temptation is to pull back to dial the nose high – and make the crowds cheer at your ballistic trajectory through the sky. But it carries with it a number of

Francis Donaldson's top ten tips for STOL flying

1. While STOL aircraft may appear simple flying machines, with a single engine, usually a fixed pitch prop and fixed-gear undercarriage, STOL aircraft have their own nuances and 'gotchas', particularly if you choose to explore their slow speed potential to the full – and frankly, unless you want to do this, why have a STOL aircraft?

2. It's particularly worth bearing in mind that the ability to fly very slowly with power on doesn't translate into an ability to land very slowly with power off. The propeller slipstream acting on the inner parts of the wings greatly enhances the wing's lift. Cut the power and all that extra lift is lost. With all the drag from everything 'hanging out', the STOL aircraft decelerates immediately the power is cut, further reducing the lift and needing harsh forward stick to regain the speed – much like a winch-launched glider having a cable break.

3. Notwithstanding the above, STOL aircraft can sometimes 'glide' at a low indicated airspeed – but what's the rate of descent? Try this near the ground and you'll see that you're dropping with a glide angle scarcely better than a half-brick. If you get an engine-out, trying a 'parachute descent' right down to the ground will certainly collapse the undercarriage and wipe out the aeroplane for the rest of the season. To keep the aeroplane in one piece you need to approach at a speed sufficient to roundout and flare to achieve a zero rate of descent at the point of touchdown. This may mean approaching at twice the indicated stall speed, to avoid running out of energy, especially with all the drag of huge balloon tyres to contend with. Approaching at the oft-quoted 1.3 times the stall speed simply won't be enough – you'll 'plunk on'.

4. Below a certain height above the ground (perhaps 300ft) if you choose to fly power on slowly, or to do 'zoom climbs' from ground level and the engine should fail, even if you stuff the nose down straight away, you won't be able to achieve a high enough speed to flare. In these circumstances, however skilled your flying, it's a matter of simple physics that you will inevitably hit the ground hard – it's the equivalent of flying inside a helicopter's speed/height avoid curve.

5. Backside of the drag curve – An aeroplane designed for STOL flying generally has devices to allow the wing to create more lift at a given speed than is possible in a conventional aircraft. Slats do this by keeping the airflow over the top of the wing attached at angles of attack beyond those where it would otherwise have separated, and raising the wing stalling angle of attack of the wing from a typical 15° to 25° or more, with lift continuing to increase as the wing moves into this new extreme high angle of attack regime. Flaps work by increasing the wing's camber, increasing the angle that the wing deflects the air downward as it passes, and so increasing its lift.

Unfortunately, both types of device, when acting to increase the wing's lift, also create substantial amounts of extra drag. The result is that flying at very low speeds making use of these devices most likely puts you 'on the back of the drag curve', where contrary to the situation in normal flight, to maintain height at a slower speed needs more, rather than less power than when flying at a higher speed. So, if you allow the speed to get too low, the wing is still able to provide enough lift to fly but it takes full throttle just to maintain height, and any further reduction in speed will result in the aircraft losing height even with full throttle.

6. The reason why STOL aircraft need to be highly powered is not only so that on take-off they can accelerate to flying speed in a short distance, it's as much to overcome all this extra drag during a very slow landing approach. Without enough spare power in hand, any attempt to go-around from a very slow 'back of the drag curve' speed will simply result in the aeroplane sinking to the ground, despite the pilot using full throttle, or skimming along in ground-effect, unable to climb away.

unacceptable dangers. Think about the high angle effects on fuel and oil systems, as well as the engine's need for cooling air to flow through its fins and/or over its radiator(s) and to reach the air inlet, especially at full chat!

Also, if during your Vs+1 climb, you were to encounter the slightest issue with a change of wind speed or direction, or a blip in engine power (not to mention an engine failure), you are close to the ground and a lot of stick push away from pointing in the right direction to trade any available gravitational potential energy back into airflow over the wings. The higher we are the more gravitational energy we have, ready to trade for speed in the case of loss of thrust but by climbing at close to stall speeds we reduce our safety margins unnecessarily. It is often in this scenario that we see the aircraft losing responsiveness of control surfaces and driving into the ground fairly flat, with varying degrees of damage to the aircraft and crew.

Reserve speed

It is far better to fly the aircraft with a bit of reserve speed. Knowing that the slightest blip can cost you inertia within a second or two, with incipient stalls waiting to catch you out. Keeping a few extra knots in the bag can make the difference between a successful recovery and a visit to the local hospital.

If you have a large obstacle at the end of the runway, it may be best to accelerate more in the ground-effect and do a short 'hop' above the obstacle, allowing the aircraft to retain enough energy to clear the obstacle and then reduce the angle of climb once clear of risk of collision… If there is any power loss during the acceleration phase, there could be a better chance of transforming your risk into an aborted take-off rather than a crash!

Let's put this into some numbers, based loosely on a Zenair CH701. Assume we have a clean (no flaps) stall speed of 35kt indicated (indicated is often a fair bit off the actual in my experience), a dirty (flaps out) stall of 28kt indicated, and we have manual lowering flaperons. There are fixed leading edge slats and it is a tricycle aircraft.

We line up to give as much available runway as possible, even if it means shutting down, getting out and pushing the aircraft back a bit, particularly on very short strips. After thorough checks (and you should check more than usual when on a real STOL flight), make sure that flaps are up and swiftly apply full power and lift the nose to approximately 50mm (two inches) off the

7. Pitch control authority – the effectiveness of aerodynamic controls (i.e. rudder, ailerons and elevator) in controlling the path of the aircraft depends on the amount of airflow flowing over them. Even at low forward speed, the propeller slipstream generally makes the rudder and elevator still have reasonable 'bite' but this beneficial effect is lost if the engine isn't running. If you approach at very low speed without power, or the engine quits on you on short final, you'll have to contend with not only a high rate of descent and not much 'spare lift' in hand to achieve any sort of flare, but also controls that have become soggy and ineffective in creating that pitch-up you'll need to release that 'spare lift' at just the right instant. All of which is very much a recipe for 'thumping on' and collapsing the undercarriage.

8. Directional control – it's common to find the ailerons, located outboard on the wings and outside the slipstream, become very ineffective if the slow flying speed capability of a STOL aircraft is fully exploited. This is especially so since the adverse yaw generated by aileron deflection tends to increase as the airspeed reduces, so that more and more co-ordinating rudder has to be used to keep the aircraft in balance and to allow the ailerons to generate any roll rate at all. With some aircraft, aileron effectiveness at slow speed is limited by full rudder input being inadequate to keep the ball centred. With such aircraft, it may be necessary to add 10kt or 15kt to the final approach speed over and above what would otherwise be OK, just to ensure adequate control of direction during this critical phase – especially if going into a narrow strip or through gaps between trees.

9. Flaperon equipped aircraft also tend to suffer from reduced roll effectiveness when the flaperons are lowered as flaps – partly because of the inevitably exaggerated adverse yaw problem and partly because of the maximum available 'down' deflection for aileron action being naturally restricted if their starting (neutral) point is already deflected 'down' for flaperon action. If you have a tricky approach to make in a flaperon-equipped aircraft, consider not using the flaperon 'droop' function, to give improved lateral control and accurate control over direction.

10. It is also worth bearing in mind is the exaggerated effect of wind shear when flying a slow speed approach.

Good practice points for STOL aeroplane pilots – all carried out a safe altitude!

Check the amount of RPM needed and the nose attitude to maintain level flight at airspeeds from normal cruise to 5 knots above the stall, and the amount of rudder required to keep the slip ball centred in each case. Try the same thing with flap.

Check the roll authority in level flight at airspeeds down to 5 knots above the stall - and get used to the increasing amount of rudder input needed to keep the slip ball centred when making large roll control inputs. Do the same thing with and without flap, and power on and power off.

At altitude, try carrying out simulated power-off approaches to land with different flap positions and explore using different airspeeds to find out what would be the optimum indicated approach speed to use in a genuine engine-out landing with no power available to cushion the landing. Make sure your simulated flare actually does momentarily reduce your sink rate to zero in a controlled fashion – check the ROC indicator – and you're not just raising the nose above the horizon while still sinking at a high rate. Twice the stall speed is a good starting point.

ground. Accelerate to around 33kt, dropping the flaps and jumping into the ground-effect at the same time (yes, that will take some practice). Speed dropping from adding the drag of the flaperons should be balanced against losing the drag of wheels on leaving the ground, but we may have a loss of speed – hence waiting until midway between the clean and dirty speeds before we dropped the flap (Note you don't really look at the instruments, you have to learn to feel this whole process).

Holding the aircraft in ground-effect, accelerate to around 60kt before entering the climb, looking for 56kt to 60kt (double the stall speed) – more if you have the space. Lower speeds are equal to higher angles and reduced forward visibility, so a balance is needed.

Always start learning this technique with longer strips and higher speeds, until you feel comfortable. Under the right conditions I have climbed out at 50kt, but rarely less than that.

In flight, STOL aircraft are little different to conventional aircraft – the differences return when we look at landing and emergency procedures.

Below top A SuperSTOL making a STOL landing, note the high angle of attack – great care is needed to prevent a high sink rate.

Below middle Jonathan landing a CH701 on a strip in West Africa.

Bottom A Super Cub in the Alaskan wilderness, the ultimate dream for STOL pilots. Sadly, the UK offers limited *ad hoc* off-airfield access.

Coming in to land it is often preferable to ADD a little power as you come over the hedge, the reason being, as you roundout, your drag curve will rapidly increase due to the effects of your high lift devices, coupled with the possible low inertia of many LAA machines.

As you pull the nose up, the slats grab at the air, and with it your nice planned speed decay has descended into a rapid speed bleed, and with it a vertical speed vector increase!

Conventionally, we often expect to see an approach speed of roughly stall speed x 1.3 in many aircraft. When learning in your STOL aeroplane, it may be best to approach at speeds as high as stall speed x 2 to start with (check your POH), gaining an understanding of the feel and behaviour of the aircraft as you work down the speed range. Much as I would coach learning to approach the CH701 at 60/65kt to start with, and still see nice, short landings, that would not work on a really short strip.

Little bursts of power

So, if I had to land on a really short strip, what would I do? Well, it depends a lot on the approach and departure (go-around) obstacles. However, I would probably bring the aeroplane in at around 40kt-50kt indicated, and be 'hot' on the throttle, adding little bursts of power to adjust for the effects of little disturbances on the approach. My mantra would be: 'stick = speed and throttle = rate of descent'.

As I roundout, I would be using power to control my rate of descent as my nose comes very high, getting the aircraft as slow as possible, often adding more power than would seem appropriate as I battle the growing drag of the wings, slats and flaperons. Smoothly reducing power, I would drop the aircraft onto the ground and keep the nose high, using the wings as airbrakes, before dropping the nosewheel to the ground and gently applying toe brakes, always ready to apply full power and go around.

Coming into land with an engine failure, the procedure is rather different. You may use the 'parachutal descent' of holding the nose up and letting the wings act like a parachute, giving a nose high but steep descent at relatively low horizontal and vertical speeds. But always convert your gravitational potential energy into forward movement and lift well before reaching the ground, starting the recovery from at least 300ft above the surface.

In such an engine out scenario, you can approach at speeds as high as 70kt, knowing that as soon as you roundout the speed will bleed away, and the ground roll will be relatively short. Application of flaperons would be done as speeds decay – to suit the situation. Since you cannot add power at roundout, you must have enough energy in hand to allow a controlled roundout without a sudden vertical component biting you.

Clearly, every aircraft is different, every pilot is different, and every landing is different. What is most important as a STOL flyer is you must know your aircraft and practice, practice, practice, because you never know when your STOL skills will be needed for a genuine 'aircraft carrier' landing.

Needless to say, start by flying with a coach or instructor who understands STOL techniques. Initially learn techniques like high angle of attack descents, converting the energy to forward speed and reduced descent rates at a safe height, with plenty of room for recovery. ■