contributed by Grant Benns

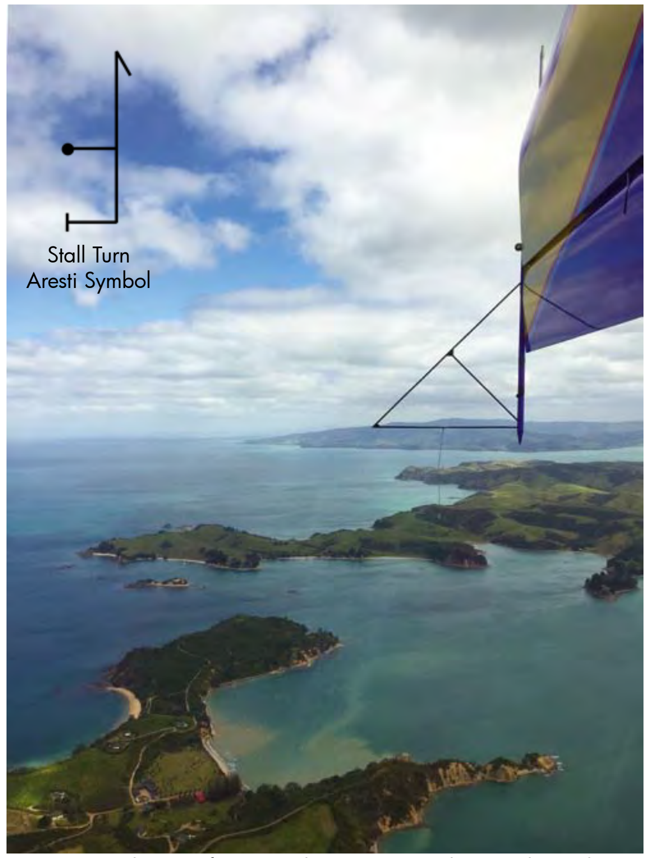
Stall Turns and Hammerheads

NO DOUBT you have heard of a hammer. You probably have one in your shed. Examining the shape of a claw-hammer, does it resemble an aerobatic manoeuvre? Apparently, in some parts of the world, yes! In our part of the world – in fact, the whole world outside of the USA - we refer to the manoeuvre we shall discuss in this article as the Stall Turn.

It would seem that both terms don't really describe the manoeuvre too well. For a start, by calling it a Stall Turn, you would expect at some point in the manoeuvre the aircraft would stall - but, if flown correctly, this is not so. And what if your tool-box hammer is the ball-peen variety, rather than a claw…?

There are many ways to change direction in flight, but the Stall Turn would have to be one of the most spectacular. If level-flight medium turns, wing-overs or half-cuban-eights don't float your boat, this is the manoeuvre for you! Of-course, you will need an aerobatic aircraft, preferably with a good-sized rudder, and a reasonably good-sized engine too. If you are really clever, you can do this in flying machines without engines, e.g. gliders, but having a 'blown' rudder certainly makes life easier.

There are a few ways the Stall Turn can go wrong, which I shall describe latter, therefore more-so than most aerobatic manoeuvres please get some quality instruction in a two-seat trainer before attempting this yourself.



Going straight up, referencing the wingtip aerobatic sighting device

Left wing low

Left wing high

The manoeuvre

As with many aerobatic manoeuvres, the Stall Turn should be a geometrically 'square' manoeuvre, particularly if you are flying it in aerobatic competition. When you look at the Aresti symbol (the international language of aerobatics) for the Stall Turn you will see the vertical line is just that - vertical. This is the same from both directions of viewing the manoeuvre - both the pitch-attitude of the aircraft (technically the zero-lift axis of the wing) and the yaw-attitude should be at 90 degrees to the horizon. You might be thinking "what about the effect of wind?" - any wind must surely affect the flightpath of the aircraft when at any attitude other than straight-and-level (assuming the wind is horizontal, which it normally is). In competition flights, the judges must ignore the effect of wind, and consequently flight-path, and must only judge the attitude.

The manoeuvre is commenced from an appropriate speed - at least looping speed… maybe more - with a wings-level, balanced 'pull' to the vertical attitude. Keeping in-balance is important throughout this initial stage, as any yaw will result in the wings not being level when the aircraft achieves vertical. Likewise, any bank angle introduced through the 'pull' will also result in the wings not being level when getting to the vertical. Prevention is better than the cure!

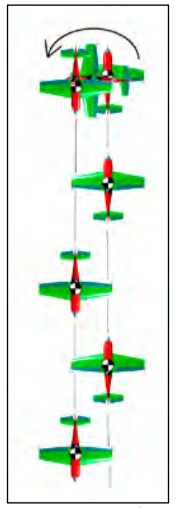
Having an aerobatic sighting device out on the wingtip, or even marked with tape on the side of your canopy, will give you a good reference for determining the accuracy of your vertical line. If you are sitting under the wing of a Cessna Aerobat or Citabria, the flat underside of the aerofoil will give you a good reference - the cambered top surfaces of a low-wing aircraft, such as the Robin /Alpha, will require some interpolation! The most important part is to be looking in the right place, at the right time. Commencing the pull-up, you should be looking over the nose to detect any un-wanted roll or yaw. Once you can no longer see the horizon over the front you need to turn you head to the side and look at the wingtip to determine the vertical attitude of the aircraft. If you have time, a quick glance out both sides is even better, to ascertain the relative position of the horizon to each wingtip, before re-tuning your reference to just one wingtip.

Ideally, you have pulled a perfect 1/4 loop to the vertical - in-balance, with no roll - and the aircraft is now shooting straight up, like an arrow. Depending on the speed/power/energy you have available, this vertical line may be very long (think FA/18 Hornet in afterburner) or very short (sorry, C152, Robin etc.). Short lines do have some benefits - the judges on the ground have less time to view your less-than-ideal vertical line!

A couple of things happen on the up-line, which will need compensating by the skilled pilot:

1. For a fixed power-setting, any change in airspeed will result in a yaw due to the effects of slip-stream over the fuselage and fin. As the speed is rapidly decaying, this effect is quite pronounced - you will need to feed in rudder, progressively more as you climb and the speed decays, in order to stop the nose yawing off-vertical. But don't look over the nose to judge this - you will only see blue sky! You must judge this by keeping the wing tip in the same place relative to the horizon from when you first entered the vertical. In a Lycoming or Continental powered aircraft, you will need progressively more right rudder. Alternatively, don't think about which way the prop turns and instead think 'keep straight with rudder'.

2. The twisting slipstream from the propeller and torque of the engine will create a roll, which will subtly increase as the speed decays. Once again, there is no point in looking for this roll over the nose, so keep looking out the side at the wingtip and keep it stationary using aileron input.



Up, around and down.

Your first experiences of flying the stall turn will be an assault on the senses, and in particular the strange sensation of deceleration while in the vertical plane - you feel like you are light on the back of your seat, due to the slowing of the aircraft while going vertically up. If you didn't complete this manoeuvre with rudder at the appropriate time, you would be momentarily weightless at the top of the vertical line, before the ensuing tail-slide!

With practice, you will become more aware of the various sensations you experience on the up-line. Sensibly, as the speed decays the noise from the airflow decreases, as does the effectiveness of the controls - these are subtle cues for the impending need for rudder to commence the 180 degree yaw at the top of the vertical line.

Now, here we discover the misnomer in the name 'Stall Turn' - you don't (or shouldn't) stall!

While flying your perfectly vertical up-line, with the wing in the zero-lift attitude, your angle-of-attack is… zero. Can a wing stall at zero degrees angle-of-attack? No!! By carefully maintaining the attitude to achieve zero degrees angle-of-attack before and after the yaw at the top, you will not stall the wing, even with zero airspeed in the dial. Likewise, you can use the ailerons with impunity, knowing they will not affect the stall - there isn't one! - in order to control unwanted roll at the top of the manoeuvre. Of course, if you have a slight positive or negative AoA as the speed approaches zero, that is not so good - so don't, okay?!

Every plane has the perfect time and speed in which to kick in full rudder to commence the yaw - the more power and/or the bigger the rudder, the later you can leave it. Dedicated aerobatic planes can literally leave it until almost zero airspeed, resulting in a perfect pivot around the vertical axis of the aircraft. With less power and/or rudder authority, the rudder will have to go in a little earlier, before the airflow over the rudder diminishes to the point of ineffectiveness. The flight manual and plenty of practice will determine the right time and speed. Another often misunderstood point here is that you don't reduce power - you need all the airflow over the rudder that you can get. Once again, you are not 'stalling' in the traditional sense.

With the application of full rudder, in a powered aircraft, we discover an interesting phenomenon - gyroscopic procession. Making that big gyroscope - the propeller - out the front of the plane yaw at a high rate results in a gyroscopic force acting on the crankshaft, and thus the aircraft holding the crankshaft, which is 90 degrees in the direction of rotation of the propeller. In plain-language, a rapid yaw to the left results in a nose pitch-up moment, thus we must simultaneously push the stick forward and use the slipstream over the elevator to counteract this - just enough forward, but sometimes all the way if you have a big prop spinning fast.

The other effect of a rapid yaw rate is the change in relative airspeed over each wing. Up till now the left and right wing have been traveling at the same speed - now approach zero - but with a rapid yaw one wing is now going faster and the other one slower, or even backwards! Differential speed equals differential lift, so you can expect a roll to develop. We have ailerons to help out here, albeit they are not very effective at this speed so you might need anything up to full-aileron to stop the plane rolling on its back.

So here you are, kicking in full rudder (to the left in your Lycoming powered plane) and easing the stick all the way forward and all the way to the right, until such time as you want the yaw to stop for your down-hill run. Time all of this just right and the aircraft stays perfectly in the vertical axis, at zero degrees AoA, with no unwanted pitch or roll. Nice!


Aim at a point on the ground.

Unwinding the crossed-up controls is relatively straight-forward, compared to all the hard work on the up-line. Just before the nose reaches the vertical down-line, kick full opposite rudder to arrest the yaw, then centralise the rudder to maintain a vertical down line. Simultaneously, return the stick to the middle and adjust as necessary to maintain a vertical down-line (zero lift - zero-degrees AoA) with no roll. A quick glance out to your wingtip will confirm the attitude, while returning your eyes back over the nose will give you a target far below to confirm any roll. With practice, you will tell by 'seat-of-pants' how good your down line is - anything other than vertical will have you either hanging in your straps or sitting in your seat.

The height of your up-line will most likely determine the time you spend on your down-line, but with the power on and speed increasing the ground seems to rush up, resulting in a temptation to commence the pull out early. Resist the temptation - wait for the speed to increase a little before commencing the in-balance, wings-level 'pull' back to straight-and-level. All going well, you should be heading in the reciprocal direction to where you started.

Where it can go wrong

1. A Stall Turn should be a very geometrically clean manoeuvre, so keeping the wings level and the tail exactly behind the nose is critical, especially if judges are watching.

2. Not putting in enough control deflection as the aircraft slows will result in the aircraft wandering off in its own direction - be the pilot, fly the plane!

3. Any - ANY - angle of attack at the top of the up-line (positive or negative) is likely to result in a pitching, rolling departure from what you are intending - this could end up in a spin, either upright or inverted. If it does, recognise it early and make a standard spin recovery. You should be very comfortable with spinning before starting stall-turns! And you should be up high enough when starting your practice of stall turns to recover from any unintentional spin.

4. Delaying the kick of rudder may result in a partial or full tail-slide. Good fun, with practice and in the right aircraft, but potentially damaging if the control surfaces get banged against the stops due to the reversal of airflow. If you sense this is about to happen, close the throttle then put both hands on the stick and lock it in the central position - do the same with the rudders. And wait. When the nose is pointing back down hill, with speed increasing, recover.

A perfectly executed Stall Turn is a sight to behold and very satisfying to get right, particularly considering the complexities of the aerodynamics as described above. Surprisingly, with the right guidance and a bit of practice they are easy to master - find a plane, find an instructor and give it a go.

Footnote: *These articles are intended to whet appetites for advanced flying and to offer tips to aerobatics beginners. Dual instruction and observance of CAA rules is a must-have - especially for safety and also for learning correct techniques and finesse of manoeuvres for the particular aircraft you are flying. For more information, enquire about aerobatics instruction at your local aero club or go to www.aerobatics.co.nz*

Competition Aerobatics Events Calendar 2016

February 23-28	**March 16-19**
Flying NZ Nationals	NZ Aerobatic Club Nationals
Mid Canterbury Aero Club, Ashburton	Hood Aerodrome, Masterton

For more details check out the events page at: **www.aerobatics.co.nz**

Planes of the NZ Aerobatic Club

Extra 300L

THE first and only Extra aircraft in New Zealand, the Extra 300L operated by XFlight at Parakai, north of Auckland, has been the Advanced-category mount for owner Wayne Ormrod since 2008.

Hundreds are flying worldwide, with the type being particularly popular around their place of birth Germany, as well as in the USA. With most of the two-seater versions being type-certified, this opens the door for passenger joy-ride operations with the type - many aerobatic flying schools also operate Extra 300Ls as advanced aerobatic trainers.

Developed in 1981 by Walter Extra, a successful German aerobat competitor, the first version was a single-seater with a wooden wing and a four-cylinder, 230hp engine. In the quest for more performance, this was joined by the 260hp Extra 260 in 1987 and the first two-seat EA300 in 1988. All of these aircraft were mid-wing designs, however access was not easy so the 1992 300hp Extra 300S single-seater and 300L two-seater went to a low wing design, and all the various Extra models have remained that way since. Currently, there is a selection of single and two-seat models available, from a 200hp trainer, several versions of the 300-315hp two-seater, and the ultimate competitive machine - the Extra 330SC. This last model is regularly on the podium at International competitions and came 1st and 2nd at the 2015 World Unlimited Aerobatic Championships in France. There were actually seven Extra 330SCs in the top 10!

A truly 'composite' plane, the wing is all carbon-fibre, as are the tail surfaces. The main fuselage structure is a steel tubular frame, covered mainly in composite panels but also with good ol' fabric on the lower rear fuselage. Whilst not the lightest aerobatic plane about, it is quite possibly the most sturdy, with normal aerobatic 'G' limits of +/-10G. To fly, the aircraft is both solid and nimble - a great roll rate combined with excellent control harmonisation and a real feeling of slicing through the air. With the big 300hp 6-cylinder Lycoming up front, turning an MT 3-bladed propeller, the sound is great from the ground and super-smooth from the cockpit.

Being somewhat expensive to own and operate, it is unlikely there will be another Extra joining ZK-XRA in NZ any time soon, but Wayne is happy to take you for a ride in his, and this Extra 300L should be a sight at NZAC events for many years to come.