BASIC STICK AND RUDDER SKILLS... – HAVE WE LOST TOUCH?

*In an ultra-safe industry, the loss of control in-flight (LOC-I) type of accident may be rare but **on average it accounts for one quarter of all fatalities** in scheduled commercial air transport. -* ICAO Website

This is a 'Food for thought' article following from an earlier piece entitled 'Know your AoA'. The basic thesis is that while modern aircraft design has made aircraft safer and easier to fly, the corollary is that there is less demand on handling skills. Loss of control is increasingly evident in fatal accidents across the spectrum of aircraft types from light GA to airlines. Angle of Attack awareness is key to avoiding Loss of Control, new AoA devices are becoming standard fit on many aircraft types. However, training methods should change to stress the concept AoA throughout Flying Training at all stages – even on aircraft not fitted with AoA devices. This article suggests ways to introduce the concept of 'AoA' in conventional basic and advanced flying training so the benefits (and limitations) of new AoA measuring devices are more readily understood. .

Aircraft design has come a long way

Over the past 100 years aircraft design has come a very long way, modern aircraft are easy to fly; sophisticated aerodynamics, vast advances in electronic processing & displays as well as the universal acceptance of GPS as a reliable tool have benefited everyone that flies. ‘Vice free’ aircraft handling, easy navigation, good situational awareness displays and wonderfully reliable autopilots are all taken for granted in everything from basic trainers to the most modern sophisticated airliners. The more sophisticated (= easy to fly) we have made our aircraft the less demanding they are to fly. This is great for those that want to learn to fly quickly, or for airlines that want to hire lots of new young pilots who don’t necessarily need vast amounts of expensive training. Simulators can be used to teach procedures and how to deal with emergencies; costs are minimised, everyone is happy... Or are they?

Modern wonderfully-designed hugely automated aircraft

Actually, I don't think so... Ironically I believe modern, easy to fly trainers, combined with a generation of instructors 'brought up' on such benign aircraft mean that today, most newly-qualified pilots actually possess very limited handling skills. They go on to fly wonderfully-designed, semi-robotic aircraft that are hugely automated & spend 99% of the time on autopilot. These pilots have probably rarely flown above 45 degrees angle of bank or 20 degrees of pitch and probably spend most of their time airborne at low arousal levels, sometimes fighting to stay awake. This is not their fault, the industry has driven this situation and most of the time it works; modern aircraft are extremely reliable, simulators are wonderful training devices, autopilots are no doubt better than humans at keeping everything smooth and on track for hours on end. However, when the 'computer says no' what might have been a minor inconvenience in the past to those brought up on 'traditional trainers' demanding 'old -fashioned stick and rudder skills' is proving, in some cases, to be major drama today. In short, we have 'dumbed down' the need for piloting skills to an extent that when things go badly wrong for whatever reason, fully-trained pilots are understandably startled and poorly equipped to deal with basic flying skill demands. We need a fundamental change of emphasis in flying training to fix the 'loss of control' problem that exists worldwide. Upset Recovery Training (UPRT) is the new industry 'buzz word' with all the major airlines starting to introduce programs to try to prevent the unacceptably high rate of LOC-I accidents. Most systems and procedures training will be done in simulators, however, even the most sophisticated cannot simulate 'G' – without this pilots are missing out on training in an important handling skills area. Some airlines are starting to realise this and have begun sending their senior instructors for appropriate training in light GA aircraft. 'Upset Recovery' Training is starting to be mandated in commercial pilot training courses, an 'Upset' being an unintentional excursion outside normal pitch, roll or speed values for a transport aircraft.

Understanding AoA is fundamental

Angle of Attack AoA is the single most important parameter in determining whether a wing flies or not. Most large transport aircraft sense AoA, they use it to help control the aircraft when everything is working, yet until recently it was considered an 'optional extra' to display it to the crew. *Understanding Angle of Attack is fundamental to understanding of what is happening when we pilot an aircraft*. Lift and drag are directly related to speed and AoA – nothing else. We tend to be obsessed with speed, however, AoA is the more fundamental concept to grasp. Stall is related to AoA alone, the concept of a 'stall speed' is highly limited - usually straight & level at a particular mass. AoA instrumentation is coming for both large and GA-type aircraft, but we need to start thinking how to use this so the information will result in tangible benefits to Flight Safety. The following are my thoughts on the matter, I don't profess to have all the right answers, but I believe the industry needs to address this issue if we are to make the most of the emerging technology.

Right now, without the use of AoA instrumentation, I believe Flying instructors must maximise their students' learning experience by subtly introducing the concept of Angle of Attack (AoA) at an early stage in Flying Training. All the way through the training syllabus there are golden opportunities to introduce AoA without taking anything from the traditional teaching points and 'patter' established by the great Smith-Barry and refined over the years. These will form the basis of understanding that will last a lifetime.

<u>Effects of Controls – Elevators</u>. I believe it is entirely reasonable to teach the primary effect of elevator thus: *Stick back, **AoA of wing increases**, lift increases, therefore aircraft climbs.* Secondary effect: *Stick back, **AoA of wing increases**, drag increases, therefore speed decreases.* Similarly, one could easily reinforce the lift equation (speed Vs AoA relationship) during high and low speed flight demos by mentioning *'High speed, low AoA, Low speed High AoA'*. A building block progression is obvious, introducing the difficult concept of 'flight on the back of the drag curve' in slow flight becomes easier to demonstrate when one thinks *'same lift, more AoA, more drag'.*

<u>Effects of Controls - Ailerons</u>. Friese Ailerons are common on most modern light GA aircraft; they make for safe easy handling with little demand for rudder input. Yet these are in my experience, one of the greatest source of both poor understanding and complacency in aircraft handling. Take your average modern trainer; friese ailerons **mask or reduce** adverse aileron yaw, (the tendency for the aircraft to yaw opposite to roll inputs). This causes a problem for your average instructor attempting to demonstrate the secondary effect of aileron which is yaw, in the opposite direction to the input roll. There has been confused thinking for years surrounding adverse aileron yaw. Some textbooks, since friese ailerons have become the norm, have even suggested the secondary effect of aileron is yaw *in the same direction as the input aileron!.* Of course this is 100% wrong; after a bank is established, in the absence of any other control inputs, an aircraft will first slip then yaw in the direction of the input roll - <u>while this is happening the ailerons are actually neutral</u>. Any slip and subsequent yaw is not an effect of aileron control input but an effect of angle of bank and stability. Ailerons change **the local angle of attack on the wing** changing lift and drag in their area. A really useful exercise is to look at a wingtip and, **without any rudder input**, gently apply left and right aileron 'rocking the aircraft over and back. As the wing rises say to yourself *'(more aoa), more lift, more drag'* as the wing goes down say *'less lift, less drag'*. The whole concept of AoA becomes obvious as the wing rises (more lift), retreats (more drag) then falls (less lift) and advances (less drag) due to the effect of ailerons on the 'local AoA' of the wing. The natural progression is to then learn how to co-ordinate rudder inputs so one can rock/roll the aircraft from side to side while keeping the nose rotating about a fixed point on the horizon. This is a really useful exercise for all pilots, one I understand is common among the glider fraternity when first flying a new type to assess how much rudder is needed to fly efficiently. Anyone who flies a floatplane will be aware that adverse aileron yaw can be used to 'steer' and aircraft on the water. Most people use into-wind aileron during a crosswind take-off – whether they know it or not, the prime benefit is to use effect of adverse aileron yaw to counter the weather cocking tendency of an aircraft as it tracks along the ground in cross-wind.

<u>Washout</u> Washout, where the AoA at the wing tip is markedly less than that at the root, is another common safety feature which on the one hand increases the safety of an aircraft's handling characteristics, but on the other causes instructors headaches when trying to teach good handling techniques. Even though one is taught not to 'pick a wing up with aileron at the stall', the technique works with most modern GA aircraft that have washout. (Aircraft with no washout are distinctly different and will 'bite' if provoked thus!). In your average modern trainer or GA aircraft with washout, the ailerons are in 'low AoA' airflow and work as advertised right up to (and sometimes through) the stall; one needs to grossly mishandle the controls before a wing drop or incipient spin occurs. The

result is undoubtedly safe handling, however, occasionally things go wrong, and when they do, it is such a shock that pilots revert to instinct and invariably their inputs make matters worse. There are 2 realistic scenarios I believe should be part of all advanced stall/spin awareness training, and an integral part of all instructors' training to demonstrate that even aircraft with a high degree of washout will bite if provoked.

1. The Departure stall (NB practice this at a suitable height with a knowledgeable instructor if you are not confident with High AoA operations. Do not exceed yours or your aircraft limitations). The scenario is a go-around from a baulked short field landing. Typically flown at full power, Vx or less, with recommended flap for a go-around. **Neglect to input rudder**. The effect of this in most ('clockwise engine turning') GA aircraft is that right aileron is instinctively (& probably unknowingly) input to keep the wings level. The aircraft is behind the Drag curve, AoA at both tips is high (outside slipstream), but crucially, because of the right aileron input, the local AoA of the port wingtip area is considerably higher than the same area on the starboard wing. Assuming the stall warning is either not working or not noticed (a common problem, audio warnings are often 'filtered out' by a highly stressed brain) all it takes is a small left rudder input or a 'global demand' for more lift (more AoA) to start a gentle left roll and yaw caused by critical AoA starting to be exceeded on the left wing. Instinctive right aileron input now will complete the picture that leads to a control reversal and possibly disaster close to the ground.

2. The Skidding turn onto finals (Please don't try this unaided if you are not confident with High AoA and certainly not close to the ground). The scenario is a tightening crosswind turn onto final causing a potential overshoot. Training emphasis has always been on minimising bank in the circuit close to the ground so while limiting bank angle to somewhere near 30 degrees, a boot-full of rudder into the turn is wrongly applied. Now think about what is happening with the ailerons: let's say we are in a left turn, left rudder has been applied to 'tighten' the turn while keeping the bank angle low, right aileron will instinctively have been input to avoid bank increasing, so we have more lift & more drag at the **inside wingtip**, less lift, less drag at the **outside wingtip.** *Ready for action!* Now a 'global' demand for more AoA (or a gust) may tip the inside wing in the area of the aileron beyond critical AoA, lift starts to fail, more aileron is instinctively input, result = control reversal and possible disaster close to the ground. If you must lose energy in a turn onto finals then 'slipping turns' (using 'top' rudder) are OK, (if you over-cook it, at least the aircraft will roll out of the turn allowing a recovery before the nose drops) but 'skidding turns' ('bottom' rudder) are definitely not a good idea!

Top rudder!

<u>Keep the ball in the middle</u> The **real significance** of the 'ball' not being centred is that *the ailerons will be deflected*. One wing is operating at a higher AoA than the other, if a global demand for lift occurs leading to the wing approaching critical AoA, the one with the down-deflected aileron will stall first. There is more going on here than at first meets the eye, again, it's all AoA-related. Because of the dihedral effect, if an aircraft slips (ball not in the middle), the 'forward going' wing will actually be at a slightly higher AoA than the 'trailing' wing causing a lift imbalance hence a roll towards the 'trailing' wing. Aileron deflection to 'level the wings' causes the local AoA at the tips to change – the 'global' lift on both sides is, however, the same since there is no roll. This all sounds a little complicated, it's actually easy in practice - at a safe height, do a straightforward stall with the 'ball in the middle'. Just before you reach critical AoA look at the ailerons, they should be more or less neutral. Then approach a stall with, say, left rudder applied. Before the stall, the ball will be deflected to the right and the port aileron will be 'down', compensating for the tendency for the port wing to descend. Local AoA is higher there than on the Starboard side. One would therefore expect the port wing to stall before the starboard wing.

<u>Spin training,</u> I am of the opinion that most spin training is probably not of much value in preventing Loss of Control or Stall/Spin accidents. Canada is the only country in the world as far as I am aware, that still requires a student to demonstrate a recovery from a full spin as part of the flying training syllabus. The Canadian statistics show no appreciable difference in the occurrence rate of fatal stall/spin accidents when compared with the rest of the world. Most fatal inadvertent stall/spin accidents occur too low for a successful recovery to be initiated. Prevention is the answer, deep understanding and the sort of realistic scenario-based stall training incorporating AoA awareness described above is needed to prevent fatal GA loss of control accidents.

<u>Can you feel the force?</u> Most steep turn training these days seems to be done at 45 degrees AoB. I have no issue with this, however, I believe instructors should also insist on regular training at 60 deg AoB. It is a great opportunity to demonstrate that the increased lift required demands an increased

AoA; stick back further, more lift = more drag so we must also apply power. Secondly, and probably more importantly, it 'calibrates' pilots' bodies to what 2 'G' feels like. Most aircraft do not have 'G meters' and 2 'G' is comfortably within the normal category 'G' limit of any aircraft. An unusual attitude or 'Upset Recovery' can be safely flown without the risk of airframe damage using 2 G. The concept of 'G' is also important to link with lift and AoA. If a pilot can feel 'G' then the aircraft is producing lift. The relationship between stick position, angle of attack and 'G' is very useful in determining energy state. Whether you are in a Cessna 150 or a large transport aircraft, if you pull the stick back and feel 2'G' then you must be producing enough lift to fly, you are not in danger of stalling unless your energy state changes (ie speed reduces), and can, given enough altitude and the correct technique, recover from an otherwise confusing situation. If you don't 'feel the force' then that's a big clue... you need more speed (or less AoA) for that lift equation to start working again!

Twin V_{mc} training Multi-engine students are required to see a 'V_{mc}' demo as part of their training. This involves flying a light twin, at a suitably safe altitude, with a simulated failed (windmilling) engine in the post take-off phase at decreasing speed (increasing AoA) with up to 5 degrees AoB towards the 'good' engine. Speed is allowed to decrease (AoA to increase) until lateral control is about to be lost, i.e. it is no longer possible to stop an uncontrolled yaw towards the 'failed' engine' without closing the throttle on the 'good' engine. Most people think about rudder authority and some of the factors that influence V_{mc} are indeed related to this, for example, the further aft the C of G is the less effective the corrective yaw moment is. This is a relatively routine demo, carried out regularly and a necessary part of multi engine training. However, think about the AoA of the wing with the failed engine for a moment. It starts to get high as speed decreases and the aircraft strives to stay level. It has no 'induced airflow' whereas at least part of the opposite wing has both 'forced air' and probably a lower AoA from the engine at full power. Because of the dihedral effect and asymmetric thrust (let's assume the left engine has failed), the aircraft wants to roll left. The pilot instinctively inputs right aileron. The AoA of the port wingtip area is now considerably higher than the same area on the Starboard tip outside the 'good' engine. Even more aileron deflection is required to achieve a 5 degree bank towards the 'good' engine. Traditional theory emphasises that at V_{mc} there is a battle between thrust on the good engine & drag on the bad engine side yawing the aircraft 'into the failed engine'. These forces are (mostly) opposed by yaw force generated by the fin and rudder. When lateral control is lost (i.e. you run out of rudder) the 'bad' forces overcome the 'good'. Few texts ever mention the effect of '**Asymmetric AoA'**. Adverse aileron yaw is adding to the 'bad' forces (in this case right aileron produces left yaw) and a twin at the point where lateral control is lost on a V_{mc} demo is in fact possibly closer to an incipient spin than most realise. Beware!


Twin VMC? – Think AoA!