HOW TO USE ANGLE OF ATTACK (AOA)

A follow up to the article "Why Fly Angle of Attack?" that appeared in the January 2016 issue of MU-2 Magazine.

by Ron Renz

THE IMPORTANT PREMISE FROM MY LAST ARTICLE ON AOA BEARS REPEATING...

Angle of Attack (AOA) systems increase safety by indicating and alerting the pilot when entering a critical phase of flight which might result in LOSS OF CONTROL due to a stall or spin unless immediate and appropriate action is taken. An AOA system does this by increasing pilot awareness of the MARGIN FROM STALL.

Also repeated here is the most important graphic from that article. The Lift Coefficient vs AOA graph (Figure 1) provides important details about the airplane flight characteristics which an AOA indication system provides to the pilot.

So how does one make the best use of that information? Comments made in this article are general in nature, but the details refer directly to the AOA system that has been developed for the MU-2B.

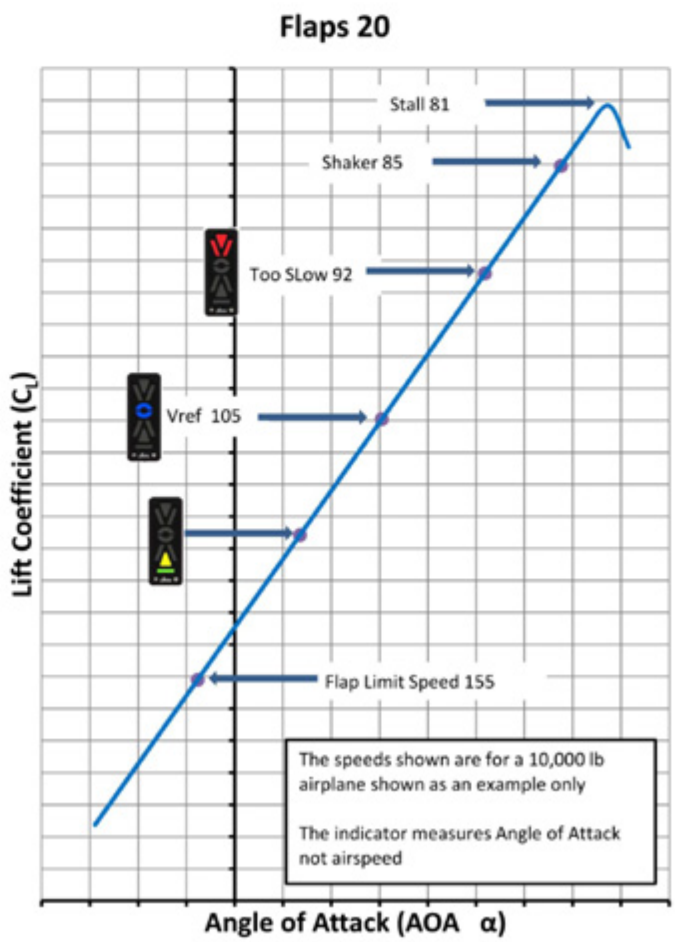

Figure 1 Lift Coefficient vs AOA

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Normal Operations:

Let's start with normal operations. Use the AOA indicator's blue donut to verify $\mathbf{V}_{Ref}$, i.e. use it as a cross check for the Checklist-specified speed. ($\mathbf{V}_{Ref}$ will be used in this article to describe the recommended threshold crossing speed from the FAA Accepted Checklist tabular data.) If a large difference exists between AOA indication and the checklist $\mathbf{V}_{Ref}$, verify the gross weight and recheck your $\mathbf{V}_{Ref}$ calculation from the checklist. If the weight/$\mathbf{V}_{Ref}$ calculation is not causing the discrepancy, then you must disregard the AOA indicator, because the FAA has determined that the AOA system is a secondary instrument only and the airspeed indicator is primary. As always, for gusty crosswind conditions, add ½ the steady stated wind plus all of the gust, but not to exceed 10 knots to your $\mathbf{V}_{Ref}$ airspeed. This is about 3 to 4 AOA segments. Therefore, in the worst case crosswind adjustment, fly the segments shown as $\mathbf{V}_{Ref}$ + 9 or $\mathbf{V}_{Ref}$ +12 knots (Figure 2.)

Now, fly the speed just verified with the AOA indictor using the airspeed indicator as the primary reference, especially during IFR approaches, since the Glideslope and Localizer indications are on the instrument panel near the airspeed indicator. The big benefit here is that the pilot now knows the margin from stall at the current weight and configuration. Refer to Figure 1, the Lift Coefficient vs AOA graph. This shows that at $\mathbf{V}_{Ref}$, there is a comfortable margin from stall. This knowledge provides confidence in the numbers rather than arbitrarily adding 5 knots for the wife, 5 knots for the kids, and 5 knots just for good measure. At minimums, begin the transition outside; keep AOA in your peripheral vision with the goal that by 50 feet above touchdown, you will be at the target speed and AOA. At 50 feet, start a normal deceleration and be aware that, at touch down or just before touchdown, you may hear the "TOO SLOW" message. If you train yourself to fly this way, you will automatically become a more precise pilot, become much more in tune with the airplane, and enhance your ability to fly according to the numbers. This will help reduce wear and tear on the airplane, tires and brakes, and provide comfort that landing distances will be achieved reliably.

In the pattern, keep the AOA indicator in the scan. AOA will help in maintaining proper stall margin, especially when turning. In a turn, the load the wing must carry increases, and in order to maintain altitude, AOA must increase and the margin above stall must decrease. However, even with stall margins slightly decreased during level, circling turns, margins should still be more than adequate, and above the blue donut, if proper profile airspeeds are maintained. Of course, anticipate adding small amounts of power during level turns to maintain proper airspeed as per the SFAR profiles. Use the AOA indicator as a guide to help determine how much power to add during the turn. Note that airspeeds called for in the SFAR 108 profiles

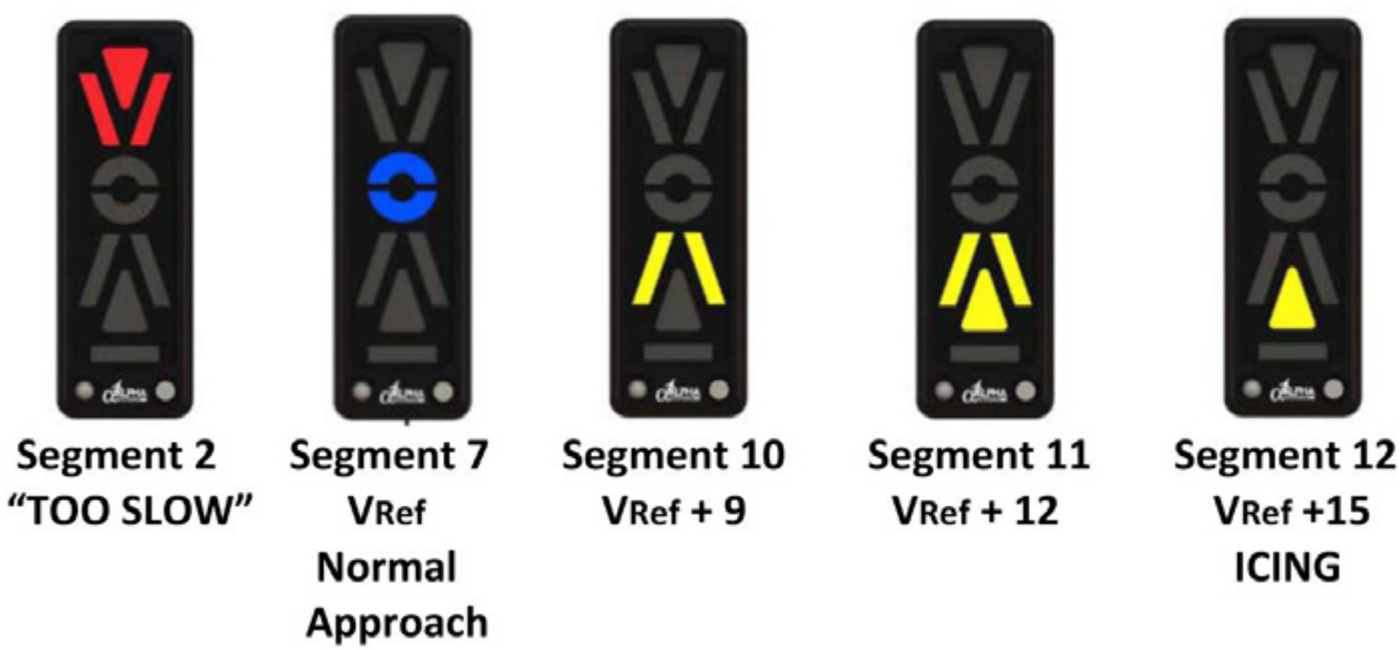

Figure 2 Selected AOA Segments

provide adequate margins above stall as long as bank angles do not exceed 30 degrees.

On descent to landing, AOA can help fly a precise glide path. Use AOA to help control the pitch angle and airspeed, and use power to control descent rate. Remember the pneumonic that your instructor used during IFR training? "Pitch controls airspeed, power controls rate of descent." This really means pitch controls AOA, and now you know why this is important. As you learn to use AOA, remember to point the nose in the direction the AOA arrow indicates. For example, when slow, the shapes of the AOA indications point in a downward direction. Therefore, proper response is to push the nose down. Conversely, when fast, the AOA arrows point up, telling you to raise your nose. AOA is an intuitive indicator.

As the airplane accelerates on takeoff, keep the AOA indicator in your peripheral vision and plan to accelerate past the Blue Donut into the yellow range as the airplane climbs away from the runway.

Non Normal Operations, the Real Safety Benefit:

Where the AOA will most likely have the most marked safety benefit is the circling IFR approach. Imagine you've just shot a great minimums approach, and now you need to circle. Where is your attention focused? Often, you're outside the cockpit keeping the runway environment in sight. Then, out of the corner of your eye the AOA display transitions to the red chevrons. You notice this. If you are circling to the right, AOA will be in your direct vision, and if circling to the left, AOA will still be in your peripheral vision. Red chevrons should bring you back to the cockpit instrument panel and alert you to the threat of low airspeed and possible low altitude, thus providing time for you to correct the situation while there is still plenty of margin from stall. If you don't notice the display, the next indication will be the voice alert "TOO SLOW" in your headset. Tests conducted on the M-2 show that there is ample margin at the voice alert to correct the situation if prompt action is taken. Abandoning the landing, and executing a missed approach may be the safest action to take.

Let's assume that an engine failure occurs shortly after liftoff. With runway remaining, the pilot can focus outside and execute an emergency landing, while keeping the AOA indication in his peripheral vision and keeping the airplane flying with adequate stall margin during this critical maneuver. If there is not enough runway remaining, while transitioning to single engine climb, if the speed deteriorates, the AOA indictor can help in several ways. If the airspeed or AOA deteriorates away from best climb toward stall, the red chevrons will be the first indication, alerting the pilot to take action. Lowering the nose to increase airspeed is the appropriate response. If the red chevrons are not noticed, the next indication would be the voice alert "TOO SLOW," bringing attention to what is now a critical problem. At the "TOO SLOW" alert, the airplane is at or near the minimum control airspeed and well below $\mathbf{V_{YSE}}$, requiring immediate action to rectify the situation. Lower the nose and reduce drag prior to potential loss of control. Feather the engine when time permits. Check gear position and landing lights. Leave flaps in their takeoff position until clear of obstacles, at which point accelerate and retract flaps on schedule. Once rectified, the climb can continue.

During a missed approach or go around, either multi engine or single engine, a potential loss of control is again lurking nearby. AOA can again help alert the pilot if loss of control is imminent. The scenario is virtually identical to the engine failure on takeoff, except that if flaps are at 40 for landing, immediately select 20 and establish a climb attitude.

These are just three potential scenarios where the AOA system may mean the difference between loss of control and a non-event. In each, information is available to alert the pilot of a potential loss of control in the form of a visual indication in his field of view, and, possibly, a voice alert of "TOO SLOW" in his headset. The response is always the same - focus back to the cockpit instruments, lower the nose, reduce drag, add power (as appropriate) and maintain control of the airplane.

Icing:

Icing will change the Lift Coefficient to AOA characteristics. A wing covered with ice will require a higher AOA to provide the same lift, and the stall angle of attack will be reduced compared to a clean wing. The MU-2B Checklist says: "When landing with any ice accumulation on the wing, increase the computed $\mathbf{V_{Ref}}$ by 15 knots." This quantifies what happens to the wing lift characteristics for the MU-2B. Use AOA segment 12 shown in Figure 2 when determining the proper speed to use for the approach. On the MU-2B installation, AOA probe heat is provided whenever the right hand pitot heat is turned on. Like all airplane systems, this needs to be verified functional before relying on it in icing conditions.

Other:

There will be an AOA for best climb, both V_X and V_Y. Testing conducted for the MU-2B AOA system did not determine these data points. Each pilot can determine the AOA for V_X and V_Y, but they will be among the higher yellow segments.

Conclusion:

AOA can provide a substantial safety advantage when used by a trained pilot, providing ample warning of deteriorating flight situations. The FAA has determined that adding AOA as a supplemental system can significantly reduce loss of control mishaps.

IMPORTANT POINTS TO REMEMBER:

Keep the AOA indicator in your peripheral vision to monitor lift reserve, especially during head-out-of-cockpit flying.

If below Blue Donut, it is time to do something. Actions to take are:

- Decrease bank and/or lower nose
- Increase airspeed
- Increase power as required in a coordinated manner
- Be aware that if the airplane is turning, all these actions will result in the turn radius increasing. If you are in the landing pattern, is the airplane too close to the runway?
- If on approach to a runway you may need to consider a go around.
- Execute a go around if a stable adequate airspeed or reasonable bank angle cannot be maintained.
- At voice alert “TOO SLOW,” immediately reduce bank angle and/or lower nose and, after accelerating, add power.
- If on approach, go around?
- The “TOO SLOW” aural warning will typically sound prior to the stick shaker, so earlier warning of an impending stall is provided.