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Angle of Attack Indicators

Making them work for you

BY CHARLIE PRECOURT

ANGLE OF ATTACK INDICATORS have been in wide use in military aircraft for decades but never had a lot of play in general aviation until recently. The March 2015 Advocacy and Safety section of *Sport Aviation* highlighted studies by the General Aviation Joint Steering Committee that found loss of control to be responsible for 40 percent of GA aircraft fatalities. The GAJSC also prioritized angle of attack (AOA) indicators as a top recommended safety enhancement for both new and existing aircraft. The FAA has now taken steps to make it easier for these systems to be retrofitted into our existing fleet; they can be a great addition to the cockpit for enhancing situation awareness and avoiding flight too close to stall. Like any other cueing device, however, they must be understood and used properly to be effective.

"AOA systems are not in wide use in GA. The GA community should embrace to the fullest extent the stall margin awareness benefits of these systems. To help the GA community understand the safety benefits of AOA systems, a public education campaign should be developed by industry and the FAA. GA aircraft manufacturers should work to develop cost effective AOA installations and retrofit systems for the existing GA airplane fleet. Owners and operators of GA aircraft should be encouraged to install AOA systems in their aircraft." GAJSC: Loss of Control, Approach and Landing, Final Report

In many military high-performance aircraft the weight of fuel and weapons can be a significant percentage of the gross takeoff weight. We flight-tested the F-15E to a gross weight of 81,000 pounds. Of that about one-third was fuel, and another third was external weapons capability, which meant the appropriate speed to fly final approach varied dramatically depending on how much fuel and weaponry you had remaining.

Even the much lighter T-38 at 12,500 pounds' gross weight had nearly a third of that weight in fuel. Final approach speed at nearly full fuel calculated out at 185 knots—but for normal end-of-mission fuel levels we flew final at 155 knots, a difference of 30 knots. We typically calculated the approach speed before each landing using a memory aid, based on fuel remaining, but with the AOA indicator on board we flew final at the same AOA indication regardless of the weight or configuration differences, dramatically reducing pilot workload and keeping us constantly aware of our margin above stall. We trained to cross-check the expected airspeed with the AOA indicator, giving us independent confirmations we were where we wanted to be on approach.

Even if most GA aircraft don't have very large variations in optimum final approach airspeed with gross weight and configuration changes, we can still extract the same benefit of increased awareness of stall margin. AOA systems typically have three

PHOTOGRAPHY COURTESY OF **ALPHA SYSTEMS AOA** elements of importance to the pilot: the AOA indicator gauge, the AOA indexer, and an AOA-driven stall-warning device (horn or stick shaker, for example). Not all systems will have all three of these elements, but the best ones will. A minimum system often has only the indexer, which is an illuminated display normally mounted on the glare shield in the pilot's view.

The AOA gauge typically will display a range starting from the zero lift angle of attack up to stall angle of attack, or the angle of attack for maximum lift coefficient. Most do not show the actual angle of attack value in degrees, but instead are calibrated in units that make it easy for the pilot to see where the aircraft is between the two extremes. In the T-38 that range went from 0 to 1.1. The F-15 went from 0 to 45, and the F-4 went from 0 to 30. But each had markings calibrated to show where optimum approach speed AOA was, as well as where stall was.

The significance of the differences has to do with the calibration of the AOA installation, which is also an important aspect of installation of the AOA devices now available for retrofit on GA aircraft. Since the AOA sensor probes are sometimes on the fuselage or on the nose of an aircraft and sometimes on the wing leading edge, a calibration has to be made that ensures the gauge displays the zero lift, optimum approach, and stall angles of attack correctly (the better systems available on the market also accommodate input for gear and flap position, but not all do). Once the calibration is made correctly, the gauge and indexer will

always show where the aircraft is on the AOA scale regardless of weight or load factor.

One benefit of this kind of system is its ability to show margin from stall even in accelerated, turning stalls. We often think of stall as a certain "speed," as an airplane in level flight will typically stall at a speed that we learn during training. We also learn that increasing load factor, *g*, will cause a stall at a higher speed (accelerated stall), but at the *same* angle of attack in either case. So the angle of attack gauge automatically compensates for load factor for you.

Along with the gauge, the AOA system will often have a visual indexer that shows the current AOA condition relative to optimum approach speed AOA. A circle in the center indicates speed, while a chevron below indicates "fast" (lower than optimum AOA) or above indicates "slow," warning that AOA is getting excessive. Many systems will be calibrated such that "on-speed" is 1.3-1.4 times stall speed (V_S) and "slow" is 1.15 V_S for the current flight condition. The indexer allows a pilot to have a heads-up view of his AOA while focusing attention outside the aircraft.

The final element on some AOA systems is the AOA-driven stall-warning device. On most systems I have flown it was a tone in the headset. Some designs have a slow, low-pitch beep that comes on while slowing down from cruise to on-speed. The tone would then go steady when on-speed, and if you got slow it would beep at an ever-increasing frequency and chirp loudly at stall. The F-4 had particularly nasty post-stall behaviors, so they added a tactile warning device in the left rudder pedal, which would vibrate vigorously under your left foot as you got close to stall. If you missed that slew of cues and got too deep into the stall, the only way out was to deploy the drag chute.

As with all systems, and AOA is no exception, you can miss what they are telling you if you become task-saturated. But AOA takes the error out of stall margin associated with load factor *g*, and makes it more obvious how close you are to stall than the airspeed indicator.

The beauty of any AOA system in a GA aircraft whether it be just an indexer or it includes gauge and stall-warning device is a separate set of cues to warn the pilot of impending stall. Beyond that there are a couple of unique uses one can make of the gauge. Many systems add further calibrations to show where maximum endurance and optimum cruise AOA values are on the gauge and/or indexer. The two values are very helpful cross-checks of aircraft performance settings that are otherwise set from indicated speed tables. If you haven't considered AOA for your flying, do yourself a favor and look into it—they've become much more available and affordable to install.

Fly safe out there! EAA

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