

Angle of Attack: Selecting, Installing and Operating an AOA System



by Charles Lloyd

Last month, in my article “Angle of Attack: Who needs it, and What is it?” I discussed why angle of attack is an overlooked aerodynamic concept that can help make flying safer. This month I will examine the details of installing and operating an AOA system in a single engine aircraft.

One of my favorite pastimes at EAA AirVenture is to wander around the exhibitors’ buildings to see what new aircraft accessories are available to put under the Christmas tree for *Bill*, our pampered Cessna 182. The Alpha Systems Angle of Attack (AOA) package immediately caught my eye.

The optional displays have evolved over time, and today Alpha Systems offers a variety of choices. This AOA system features the major components of the more sophisticated business jet AOA installations for significantly less cost.

Introduction

Since my own flying experience is a balance between GA piston aircraft and AOA-equipped Citations, it is probably no surprise that I wanted the same level of safety and situational awareness in my Cessna Skylane.

After researching various AOA packages, Alpha Systems’ AOA offered me the best combination of function and installation with minimum complexity. Below is my experience with AOA sys-

tem operation, and the installation and calibration of an Alpha System AOA in a Cessna Skylane.

Available Models

Alpha Systems offers nine models. The original mechanical model (three versions) includes a straightforward di-



The Legacy Vertical LED Indexer system from Alpha Systems.

al-type angle of attack display (similar to the one shown in photo, pg. 25).

There are six electronic models (photo, pg. 27) that offer displays for a panel-mounted dial, vertical and horizontal light bars (two sizes) and the Legacy model, a glare shield-mounted chevron display. Prices start at \$600 for the mechanical models, and \$1,600 for the Legacy (chevron indexer) electronic model.

Display Model Selection

My aircraft, *Bill*, has over 35 STCs and field modifications that make it rather unique. Key aerodynamic components include STOL mods from Horton, Inc. and a Flight Bonus speed kit that make its handling characteristics more like a later-model Skylane.

Display locations are in the panel or on the glare shield, plus light bar orientation (vertical or horizontal) is the installer’s choice. The first installation was the 16-light, four-inch vertical indexer. When flying a visual approach I want my head outside the cockpit looking at the runway touchdown zone, not inside looking at a gauge on the instrument panel. The glare shield location helps keep your head out of the cockpit when maneuvering close to the ground in the landing pattern, and the display’s lights are on the right side in your peripheral vision.

The light bar starts at the bottom of the green and as the angle of attack increases, the display continues to add lights into the yellow, blue (optimum alpha, maximum lift) and the red as the wing’s angle of attack approaches a stall and loss of lift.

This installation fulfilled my primary objective for a heads-up display, offering immediate lift information where I needed it during the takeoff and landing phases of flight. I was delighted to have



Above, left: The original models of the Alpha Systems AOAs included straightforward dial-type displays. Above, right: The control module is mounted near a duct.

this installation. I suggested to Alpha Systems some of my own ideas to further improve the utility of the system, and much to my delight, the display that you see today in the Legacy Vertical LED display reflects this feedback. After seeing the Legacy indicator, I knew this was the display I wanted in my Skylane.

As airspeed decreases, the indexer's yellow chevron appears (pointing up) which implies that you can increase aircraft pitch and thus angle of attack. The green donut tells you that you are right on optimum alpha (approximately 1.3 Vs) for the aircraft's flaps-up configuration. When you see the red chevron pointing down, this should create a reflexive movement in the pilot: push the control wheel forward, plus add power to decrease the angle of attack immediately before you stall.

The Legacy indicator displays seven light combinations including yellow, yellow-green, lower green, green donut, upper green, green-red and red chevrons.

These seven light combinations show the same angle of attack range as the vertical display's 16 LEDs, which mean the 16-light display is twice as sensitive to changes in angle of attack. So, the choice is yours. Do you want more lights, or the chevron logic as your AOA indicator?

Operation VFR Landing Patterns

I use the AOA indication primarily in VFR landing patterns. On downwind I slow to a 95-knot flap limitation speed, then lower to 10 degrees. The speed will bleed off to 80 knots and the yellow chevron appears with one to two adults in the cockpit and with 15-20 gallons of fuel remaining.

Turning base and extending flaps to 30 degrees will slow to 70 knots with the indexer showing the yellow chevron and lower half of the green donut while descending 500 fpm. Turning final, the increased bank and angle of attack may change to the green donut only indicating 65 knots. The pilot can pitch down and increase power to decrease angle of attack.

This is the point where overbanking to final with low airspeed is the cause of major stall/spin accidents. You are too close to the ground for recovery options. An AOA system with audio is a great tool to help prevent this situation. To paraphrase a South Louisiana aviation philosopher, you only have to use the AOA system once—for saving yourself—to justify its cost.

At this point two miles out and 600 feet above the touchdown zone, at typically 70 knots, -0/+5 knots provides a stabilized approach showing the yellow chevron lower donut display. This is a

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three-degree approach angle (300 fpm descent).

On final approach, pitch manages the AOA at the yellow chevron lower half-green donut and power manages sink rate. The indicated airspeed depends on the landing weight but usually is 70 knots for yellow, lower half green.

The AOA Indexer considers the aircraft landing weight and adjusts airspeed to the correct airspeed for the yellow lower-green AOA. All you need to do is fly the AOA indexer (photo, pg. 24). Managing approaches in this manner provides consistent aircraft performance and landings at the planned landing point.

Optimum Alpha and Flap Position

As described below, the optimum alpha (green donut) is set in the flaps-up position. What happens when lowering the flaps? The stall speed reduces with the increased wing camber and the green donut is now slightly faster than actual optimum alpha for this wing configuration. The error is toward the conservative side of your indicated airspeed.

Alpha Systems' AOA system calibration is for one wing configuration: flaps up. For thousands of dollars more, Citation jets have flap position compensation built into their AOA systems, but the Alpha Systems AOA installed on my Skylane is close enough—in any flap configuration—to fly consistent, safe approaches to the intended landing spot every time.

Steep Turns to Final

Staying out of trouble in the over-banked turn to final is another safety feature for this AOA system. Flying at a 70-knot approach speed with the yellow chevron lower half-green donut showing, roll slowly into a 60-degree bank and watch the indexer display the increased angle of attack.

At 60 degrees the aircraft is now pulling 2 gs and the stall speed is 1.4 times higher than a normal stall. This means the Skylane's 50-knot normal stall is approaching 70 knots. You may be saying, "Hey this will never happen to me," but what about a high-workload situation such as an abnormal or emergency situation? That can happen to any one of us.

The AOA display is a safety awareness tool to aid in keeping you out of trouble. In addition, if you use the control module audio option, when you miss the red chevron you will get an audio command giving you an additional alert.

Documentation and Installation

AOA Kit

The Legacy Vertical LED Indexer system arrived in a box and looked just like the picture at the beginning of the article (see photo, pg. 24). The documentation comes in paper form and with two CDs (Installation & Operation), plus an FAA document and Advisory Circular reference library.

The seven Installation and Operation sections in the guide describe the steps necessary to install, calibrate and operate the AOA. Some of the discussions included under the General, Planning and Installation sections overlap; this is not meant as a criticism since there is a large quantity of new information to absorb in order to complete all the necessary installation steps and to understand how to interpret what you will see when flying your AOA display in various flight regimes.

Components

The installation has three major steps. These steps are installing the:

1. Probe
2. Air Data Computer
3. Cockpit Indicator

Probe Installation

The first step is to decide where to install the probe. It must be in undisturbed air that is clear of the prop blast and in a location that would not be blocked by a pitot probe, antenna or strut. The probe mounting plate is a rectangular aluminum assembly that requires trimming to use a standard eight-inch inspection hole. There are numerous inspection holes on the underside of a Cessna wing. The reason for the location for my installation (photo, pg. 28) was that it met the general criteria, and situating the probe above the wing strut minimized its "head-knocker" hazard.

The initial probe angle was greater than 50 degrees due to its location near the wing's leading edge. A straight edge along the lower wing surface aided in



There are six electronic models that offer displays for a panel-mounted dial, vertical and horizontal light bars (two sizes), and the Legacy model.

creating a 50-degree angle with this surface, which was approximately 55 degrees with the mounting plate assembly. If the probe angle is not set properly, don't worry, because later the new Air Data Computer software will check this function for you and inform you if the angle is too high or low.

Control Module Installation

Having an aircraft with many pilot

aids mounted on the aft side of the firewall is both a blessing and a curse: there was no room under the left side of the Skylane's instrument panel to mount the control module. The only place available was on the right side above the heater duct (photo, pg. 25). The standoff plate mounded to the firewall helps air circulation around the unit.

If you have a similar setup, use caution to insure that the tubing is clear of

any heater ducts. (The blue tubing in the original installation touched the black heater duct below, and over time the heat melted a hole in the tubing.) This orientation facilitates connecting and disconnecting the two electrical connections on top and the probe sense lines on the bottom.

Legacy Display Indicator Installation

The Chevron Indexer is near the glare shield center, with the optional Swivel Mount Kit. In this location the indexer lights are in your peripheral vision when looking straight ahead. During turns to final and on final approach, the indexer is easy to see.

The optional swivel mount kit includes a glareshield to keep the chevron lights from washing out in bright sunlight. The swivel capability permits adjusting the display for viewing from either seat.

Connecting the Pieces

A blue and white sense line connects the probe to the Control Module. The

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The probe was installed here to minimize the "head-knocker" hazard.

probe and computer have clearly marked connectors for the blue and white sense lines.

The power cable connects to a panel-mounted circuit breaker. This circuit breaker location was part of the instrument panel design—and seemed to be waiting for the right time to install the Alpha System AOA. Yes, you can use an inline circuit breaker, but I prefer to have a panel-mount design to see popped CBs and have the ability to isolate a system.

The Legacy display cable connects the control module to the display via a cable behind the panel radio installations through the glareshield vent to the display.

Calibration Ground

Calibration starts on the ground and the documentation—in both words and a flow chart—is easy to follow. If you have questions, Alpha Systems' technical support is just a phone call away. The ground steps are to zero the system and adjust indicator's day/night brightness. After this, a display light sensor automatically adjusts brightness.

Flight

The in-flight calibration requires smooth air at or above the safe altitude for stalls and recovery. Using two people—one crewmember to fly the airplane and the other to perform flight calibration—the first step is control module verification. You must ensure that the probe is set to the correct angle.

With the flaps up, power, and trim set

for level flight, continue to reduce airspeed until the stabilized aircraft will no longer climb when increasing pitch. You are now at optimum alpha which is also best-lift-over-drag angle of attack.

Flap Position?

The control module does not have flap position compensation to display optimum alpha angle for all flap positions. With the system calibrated in the flaps-up position, what happens when the flaps extend to 10, 20, or 30 degrees? Comparing the optimum alpha green donut indication to the airspeeds at various flap configurations showed optimum alpha to be a few knots higher than the flaps-up ratio to stall speed at optimum alpha.

Even if the AOA system does not compensate for other flap position, the Skylane installation is close and provides consistent information. While calibrating optimum alpha is independent of airspeed indications, I recommend cross-checking your airspeed calibration against your aircraft's stall numbers.

Conclusion

With the installation completed and calibrated, my Skylane's Alpha Systems AOA installation gives instant wing lift information, making for safer flying. There is no better way to understand your aircraft's wing lift condition than with an AOA.

Charles Lloyd has logged 10,000 hours since his first flying lesson in 1954. He worked for Cessna Aircraft for 16 years. Lloyd retired as captain of a Citation Encore Plus for a major fractional aircraft ownership company. He flies a tricked-out 1966 Cessna 182 —also known as Bill—that is a great business tool for his real estate investment company. Send questions or comments to editor@cessnaflyer.org.

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