

Angle of Attack:

by Charles Lloyd



Installing and Operating an AOA System in Piper Aircraft

Last month, in my article “Angle of Attack: Who needs it, and What is it?” I wrote about why angle of attack (AOA) 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, and two Piper owners’ experiences with AOA systems in their aircraft.

One of my favorite pastimes at EAA AirVenture Oshkosh is wandering around the exhibitors’ buildings to see all the new avionics and aircraft accessories. The **Alpha Systems**, Inc. Angle of Attack (AOA) package immediately caught my eye.

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

After researching various AOA packages, **Alpha Systems’** AOA offered me the best combination of function and price, and installation with minimum complexity.

Available Models

Alpha Systems offers nine models. The original mechanical model (three versions) includes a straightforward dial-type angle of attack display.

There are six electronic models (see photo at top left, pg. 56) that offer displays, vertical and horizontal light bars (two sizes), an instrument panel dial gauge, 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 in-dexer) electronic model.

Display Location and Light Bar Choices

Display locations vary. The display can be placed in the panel, or as head-up display on the glare shield. Light bar orientation (vertical and horizontal) is the installer’s choice.

Vertical Display

John Valldejuli’s 1979 Archer II has a vertical indexer between the attitude indicator and airspeed indicator (photo

in lower left of series, pg. 56). Valldejuli feels that this location groups all the instruments in one area where he can quickly see indications of aircraft lift.

Legacy Display

Don Vreuls’ immaculate 1961 Comanche is a restoration started in 2003 which is now essentially complete (see photo, pg. 59). In addition to new paint, upholstery, and the recent avionics upgrade (adding a second Garmin GPS and TCAS), the Comanche now includes an **Alpha Systems** Legacy AOA Indicator in the panel, also situated close to the attitude and airspeed indicators (see photo, above).

This display’s seven light combinations are a combination of yellow chevron, yellow-green, lower green, green-donut, upper green, green-red, and red chevron. These seven light combinations show the same angle of attack range as the vertical display’s 16 LEDs, which means 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?

Display Location

My installation initially included a glare shield-mounted 16-light, four-inch vertical indexer. I recently replaced it with the Legacy chevron indexer (see photos, pg. 57). 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 of your peripheral vision.

The light bar initially displays all lights at 80 knots. The lights start turning off in sequence at the bottom of the green, and as the angle of attack increases, the display continues to drop lights into the yellow, blue (optimum alpha, maximum lift) and then red only as the wing's angle of attack approaches a stall and loss of lift.

With the Legacy indexer, as airspeed decreases, the indexer's yellow chevron (pointing up) appears, 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 for the aircraft's flaps-up calibrated configuration. When you see the red chevron pointing down, this should create a reflexive push forward of the control wheel to decrease the angle of attack immediately and simultaneously add power to accelerate before you stall.

Placing the AOA indexer next to the airspeed indicator puts all the instruments in one tight cluster. Mounting the instrument in your landing vision line of sight lets you see this information without having to glance into the cockpit. This is also where business jet OEMs mount the display.

Operation

VFR Landing Patterns

AOA is a big plus for VFR landing patterns. Comanche owner Vreuls says, "I wanted the AOA system in my Comanche to increase safety going into fields that are 2,000 feet or less. Since the AOA installation, my landings are more consistent."

Valdejuli, owner of the Archer II, states, "The entire vertical bar light displays as I enter the downwind initial point. Turning base, the target is four

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

Original models included dial-type displays.



Above, left: The vertical indexer is situated between the attitude indicator and airspeed indicator in this 1979 Archer II. (Photo: John Valdejuoli) Above, right: A control module, shown here mounted near a duct.

yellow lights; and on final, three to four yellow lights; and short final, three yellow lights. With the AOAI do not float in the flare. I am flying my patterns slower and landing with improved consistency.”

Optimum Alpha and Flap Position

The Installation Manual describes calibration of optimum alpha (green donut or blue light) in the flaps-up position. What happens when lowering the flaps? Extending flaps reduces the stall speed and flight tests indicated a higher margin over stall at optimum alpha. The error is toward the conservative side of indicated airspeed.

Alpha Systems’ AOA system calibration is for one wing configuration: flaps up. For thousands of dollars more, business jets have flap position compensation built into their AOA systems, but the

Alpha Systems AOA 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 slowly with the yellow chevron showing, roll slowly into a 60-degree level bank and watch the indexer display the increased angle of attack. First, you see the green donut, and then the red chevron, and a stall is imminent.

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 a 50-knot normal stall is approaching 70 knots. You may say, “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 anyone of us.

The AOA display is a safety awareness tool to aid you as the wing approaches critical AOA at any speed or bank angle. 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 Alpha System AOA arrives in a box with an indexer, control module, probe, wiring with connector and tubing. The documentation comes in paper form and with two CDs (Installation and Operation), plus an FAA document and Advisory Circular reference library.



Examples of vertical light bars from Alpha Systems AOA.

The seven Installation and Operation sections in the guide describe the detailed steps necessary to install, calibrate and operate the AOA. Some of the discussions 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. Control Module
3. Indexer

Probe Installation

The first step is to decide where to install the probe (photo, pg. 59). It must be in undisturbed air that is clear of the prop blast and in a location clear of other wing structural members. The probe mounting plate is a rectangular aluminum assembly that requires trimming to use a standard eight-inch inspection hole.

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 (lower rightmost photo, pg. 56). If you have a

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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 (Indexer)
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.

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

Mounting the indexer next to the air-speed indicator is logical for the reason that pilots are used to glancing in this area for confirmation that airspeed is on target for landing.

Connecting the Pieces

A blue and white sense line connects the probe to the control module. The 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. 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 indexer cable connects the control module to the display via a cable behind the panel radio installations. If you want a glare shield mount with a round dial in the panel, this is possible with an optional dual-cable connection.

**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 the indicator's day/night bright-



Don Vreuls' immaculately restored 1961 Comanche includes an **Alpha Systems** Legacy AOA Indicator in the panel. (Photo: Don Vreuls, Fred Scott, Jr.)

ness. 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 air-speed until the stabilized aircraft will no longer climb when increasing pitch. You are now at optimum alpha. I correlated this setting to my aircraft's flaps-up calibrated stall speed in the flaps-up position and found the ratio to be slightly above 1.3 ($V_{\text{Optimum Alpha}} / V_s$). This is similar to business jet approach speed ratios above stall.

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 margin above stall to increase slightly to 1.4 in my aircraft.

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

Conclusion

With the installation complete and calibrated my airplane's **Alpha Systems**



The AOA's probe must be located in undisturbed air clear of the prop blast.

AOA installation gives instant AOA information for safer flying. There is no better way to understand your aircraft's wing lift condition than with an AOA system.

Encourage your local flight instructor to become familiar with the AOA manual, and then go out and practice steep turns at altitude to better appreciate angle of attack. After that, you can perfect your landings using AOA. You will be pleased with the information an AOA system provides to increase safety.

Charles Lloyd has logged 10,000 hours since his first flying lesson in 1954. He worked for Cessna Aircraft for 16 years, and retired as captain for a major fractional aircraft ownership company. His personal aircraft is a great business tool for his real estate investment company. Send questions or comments to editor@piperflyer.org.

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