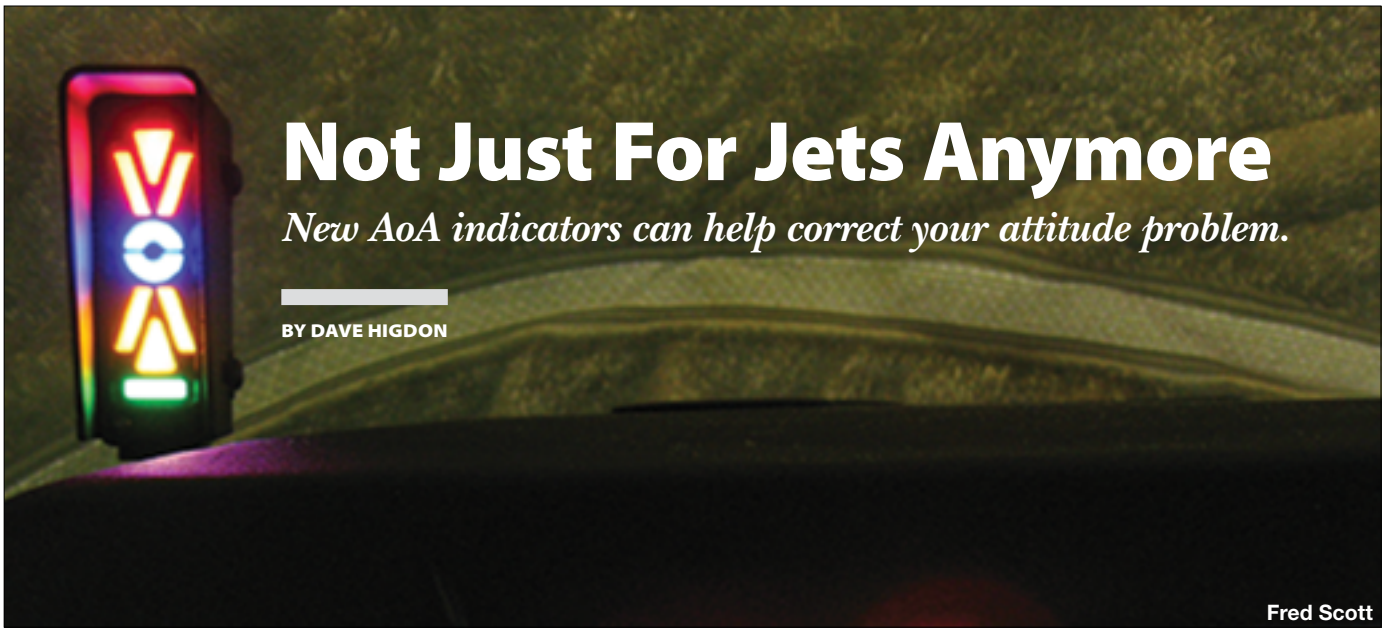

Not Just For Jets Anymore

New AoA indicators can help correct your attitude problem.

BY DAVE HIGDON

Fred Scott

Forty percent. In any context that's a sizable percentage. In ours, 40 percent represents the share of fatalities aviation-safety advocates pin to one category of crashes: loss-of-control accidents (LOC). Reducing LOC accidents and their fatalities led the FAA to put two available tools at the top of its 2013 list of most-desired general-aviation safety enhancements. The winners? Airbag seatbelt systems and angle-of-attack (AoA) indicators.

The FAA and industry cite solid evidence that airbag seatbelt systems hold significant potential to reduce injuries and fatalities when accidents occur. (For more on airbags in the cockpit, see the article in the August 2010 issue of *Aviation Safety*.) Meanwhile, using AoA indicators, supporters contend, can reduce LOC accidents. Now, new products are available, and relatively simple installation and approval processes mean aircraft owners can more easily use AoA systems for safe pitch control.

NEW, IMPROVED, CHEAPER

Key to the potential acceptance of these devices are their relative simplicity, lower costs and straightforward installation: Installation documentation can be as simple as a logbook entry. Freeing operators from the FAA's Form 337 field approval or supplemental type certificate processes avoids adding costs unrelated to safety.

> *"A functioning AOA system gives you the parameter-corrected indication instantly, so all you have to do is obey its indication. When its arrows or indicators point down, they're not kidding...lower the nose, pronto."*

How much does it cost to install a new-generation AoA indicator in a CAR 3/FAR 23 airplane? Estimates from several avionics shops—using a nominal $1550 retail system price—tell us total flyaway cost can be in the $2750-to-$3500 range. Those are good numbers, confirmed Kent McIntyre, owner of Wichita avionics shop Bevan-Rabell.

The expense is, of course, a relative thing. Compared to previous AoA systems available for certificated aircraft, the latest products are 60- to 100-percent less costly to acquire and install than the more complex existing systems. But little of that matters if pilots fail to understand the advantages of using AoA while maneuvering instead of indicated airspeed.

The consensus view today—and there are ample statistics supporting it—points to pilots too often failing to remember the limitations of airspeed indicators when maneuvering. When that maneuvering occurs at relatively low levels—like in the traffic pattern—relying on the airspeed indicator alone has led many a pilot into the weeds, sometimes with fatal consequences.

The regulatory changes underlying the new crop of AoA indicators comes courtesy of an ongoing, joint FAA/industry effort to identify, categorize and mitigate various types of fatal accidents. After studying hundreds of related accidents, formal recommendations to the FAA advocated reducing or eliminating economic and regulatory barriers to installing AoA indicators.

To simplify and standardize the

AIRSPEED ALONE WON'T TELL YOU WHERE THE STALL IS

Aeronautical engineers and flight-test pilots refer to the wing's angle-of-attack as the letter "alpha," typically written as the lower-case Greek α. There's no Greek, however, to the basic takeaways from our primary flight training:

- **Angle-of-attack—alpha—controls airspeed;**
- **Power controls altitude;**
- **A stall occurs at that alpha where airflow over the wing separates; by definition, where lift stops.**

In practice, however, most of us use an airspeed indicator as a proxy for depicting and setting alpha. From landing-configuration V_{S1} stall at the lower end of the white arc all the way up to V_{NE} and the red line, we look for speeds that correspond to a desired pitch angle. Best-climb-rate; best-angle-of-climb; minimum-controllable airspeed; maximum maneuvering speed—those airspeeds we learn correspond to the alpha we want. In this way the ASI is a proxy for alpha.

We're also taught those speeds on the dial match the tested number only when the aircraft flies in unaccelerated, level, standard-day conditions, or rarely. In other words, the airspeed indicator doesn't compensate for anything much beyond pressure. Meanwhile, the airplane's true stall speed, we learned, varies with attitude, G-loading and density altitude. None of these conditions are reflected directly on the airspeed indicator.

Increase the G loading—say, in a turn pulling 1.5 or 2 G—and stall speed increases; pull just a little more when near the wing's critical alpha and true stall speed rises quickly above aircraft stall speed, even if well above indicated Vs, and without greatly moving the ASI needle.

Make this pitch change too close too the ground to salvage? Bad things result, and they're called LOC accidents. Stalls in the pattern and on landing approach make up a majority of that 40 percent of LOC-accident fatalities. Hence the ongoing focus on increasing AoA use to help pilots avoid LOC events and, in turn, reduce LOC accidents overall.

Above, the two uppermost Alphas Systems AoA indicators pictured are designed for mounting atop an airplane's glareshield. The round display at bottom is for in-panel mounting. Each uses the same basic sensor and associated components. Other AoA manufacturers offer similar displays and an array of mounting options, as does Alpha Systems.

devices, ASTM International established what it calls "functional operation and minimum performance requirements for simple systems that provide angle-of-attack information to a pilot." The standard, known as ASTM F3011-13, covers basic operation, stall indication, control accessibility and software. Yes, there is some fine print and, yes, the AoA systems installed in this manner must be used as "advisory" or "supplemental" to existing aircraft systems. Specifically, and quoting from BendixKing's documentation for its KLR 10, "The system will not be used in lieu of the airspeed indicator or aircraft stall warning system."

THE AOA DIFFERENCE

So, what's the big deal? Is AoA suddenly the new, must-have gadget in your cockpit, like Loran was in the early 1990s, or electronic charting in 2008? Yes...and no. Unlike the airspeed indicator alone, a properly calibrated AoA system always correctly reflects pitch changes, regardless of variables like airplane attitude, G-loading or density altitude. Even power changes. That's because the AoA systems meeting F3011-13 standards provide visual and aural alerts to high-alpha, low-airspeed conditions before a stall occurs.

An informal survey of military- and corporate-trained pilots, institutional training-company instructors and safety experts indicates those with experience prefer an AoA system as a more-accurate indication to establishing and maintaining safe pitch attitudes. But this value hinges on adherence to three conditions: accurate calibration, training specific to the system and practice.

Above, Alpha Systems' Eagle AoA kit is pictured and includes everything necessary to install, approve, calibrate and fly an AoA indicator in certificated or experimental airplanes. Various optional indicators are available from the company, as is an adapter providing HUD-like transparency.

WHAT'S THE BIG DEAL?

"To reduce the risk of inadvertent stall/departure resulting in LOC accidents, the GA community should install and use AOA based systems for better awareness of stall margin," said the General Aviation Joint Steering Committee (GA-JSC) panel report focusing on LOC accidents in approach and landing phases. That 2012 recommendation applied to both newly manufactured and existing aircraft.

A proposal was developed in 2013 and the FAA in early 2014 accepted a new industry-developed consensus standard for new AoA systems. It's known as ASTM F3011-13 and tracks with the steering committee recommendation that the agency promote AoA-system adaptation in GA with the new, simpler, lower-cost systems meeting the standard. The AoA systems approved under F3011-13 can be installed, relatively easily and inexpensively, without a field approval or supplemental type certificate. Install it, log it, fly it.

Alpha Systems, maker of several new and legacy AoA systems, offered up a list of reasons for installing angle-of-attack guidance, taken from a recent article in a National Association of Flight Instructors' publication. Consider these points, also mirrored by other providers and pilots who regularly fly with an AoA indicator:

• AoA lets you know immediately whether the wing will support the aircraft or not. Put another way, it shows the reserve lift available before stall onset.
• At high angles of attack, accurate airspeed indications are difficult due to position error.
• AoA is not affected by gross weight, bank angle, load factor, speed or density altitude.
• AoA will indicate proper approach speeds under all conditions of weight, CG, flap position, air density, turbulence or angle of bank.
• AoA can instantly detect wind shear, immediately suggesting a solution.
• When properly used, AoA can identify exact pitch attitude for best angle or rate of climb.
• AoA can also indicate optimum long-range-cruise pitch attitude.

The sidebar on page 20 includes additional material—and links—to help you research AoA indicators and, perhaps, find one meeting your needs. But we'd be remiss if we didn't refer you to a BendixKing Web site, klr10.app.bendixking.com, which features a well-done application simulating the KLR 10's operation.

The goal of training is to expose the pilot to the full range of indications, alerts and warnings while learning how the aircraft responds to following and ignoring the alerts.

Former military pilots relate they use AoA to maneuver and avoid shoulder-launched missiles and dodge ground fire, without worrying about flying into a low-altitude stall. U.S. Navy pilots train to use their aircraft's AoA indication in many situations. They can instantly pitch to a best-climb angle, make precise pitch adjustments on instrument and carrier approaches and fine-tune their aircraft's in-cruise attitude to minimize fuel burn by maximizing lift. They also can use AoA to match the desired delivery angle for a gravity weapon—a "dumb" bomb, for example—a capability many of us flying personal airplanes may want from time to time but will never need.

For more mundane operations, in aircraft such as business jets and turboprops, direct-measurement AoA information is used as a data source for automated systems to help manage auto-throttle control systems, in stick-shaker activation systems and as stall-warning devices. They operate independently of airspeed indication, as well.

Numerous professional pilots told us of their preference for AoA systems when in maneuvering flight at any altitude. Several, most of them with military backgrounds, consider them valuable for everything from maximizing fuel efficiency in cruise to guarding against inadvertent high-alpha situations...at any altitude.

One pilot related the usefulness of the AoA in a Pilatus PC-12, calling it "key to safely flying maximum-performance maneuvering." An active charter pilot noted he stays sharp using an AoA for climb and approach control by occasionally, for

THE AOA INDICATOR AT WORK

As an example of how AoA systems perform, consider the table at right, adapted from BendixKing's Pilot's Guide for the KLR 10 lift reserve indicator. First introduced in 2013 and initially only for experimental and non-certificated aircraft, the KLR 10 now is available for any CAR 3/FAR 23 airplane, along with offerings from Alpha Systems and Garmin. All three product lines meet the consensus standards of ASTM Standard F3011-13, so they display and behave similarly.

Once calibrated and in operation, the KLR 10 and similar devices display an optimal cruise angle and an optimal approach angle and also advise when the alpha starts to cut into the aircraft's lift margin. The color coding and audio annunciation capability AoA indicators provide should be self-explanatory: Try to fly to the blue donut when landing. Any higher AoA will be reflected with some red; a lower AoA will bring yellow.

SEGMENT	CONDITION
	**Green Bar** with no other segments indicates Cruise set point, (lots of lift).
	Single lower Yellow Bar with no other segments indicates slowing/moderate AOA.
	Double Yellow Bars with no other segments indicates pattern entry/increasing AOA.
	Single upper Yellow Bar with no other segments indicates Base leg/increasing AOA.
	**Single upper Yellow Bar with Blue lower Half Circle** indicates Final/slightly fast.
	**Blue Circle / Donut** with no other segments indicates Optimum Alpha Angle (AOA).
	**Single Red Bar with Blue upper-Half-Circle** with no other segments indicates slightly slow/below OAA.
	**Red Bar with inverted Red Chevron** with no other segments indicates too slow (level 1) KLR 10 annunciates "**Check AOA".**
	**Red Arrow with inverted Red Chevron** with no other segments indicates too slow (level 2) and KLR 10 annunciates "**Caution. Too Slow".**
	**Flashing Red Arrow**, with no other segments indicates critical AOA (level 3) and KLR 10 annunciates "**Too slow! Too slow!"**

his own training, covers the ASI and flies solely on the AoA. Never, of course, on a revenue flight.

VOICES OF EXPERIENCE

Among the suggestions AoA-experienced pilots and instructors offered came these pearls, most of them suggested as training steps while flying with a safety pilot and all of them for use only after completing the system's prescribed calibration process:

1—Start simply, slowing the aircraft a knot per second while maintaining altitude, then watch how the AoA indicator behaves as airspeed deteriorates, all the way through and past the stall-warning system response.

2—Watch the AoA indication change as you recover from the stall and make a note of how early the AoA system started suggesting a pitch-down action.

3—Flying at a safe-for-recovery altitude, practice pattern work (well out of a real traffic pattern, please), repeating the above exercises while maneuvering through the turn from downwind-to-base and from base-to-final. Note how the AoA indicator starts alerting you well ahead of when the ASI needle nears the airplane's published stall speed. Continue tightening the turn until the AoA indicator reaches maximum alert and the aircraft stalls in the turn. Note that the airspeed indicator remains above the stall-speed mark and the stall horn remains silent. Now, cover the ASI and consider it "INOP" for the remainder of the session.

4—Practice using the AoA to establish climb angle independent of the ASI, then practice again during a rejected-landing exercise and watch how quickly pitch can approach critical alpha when transitioning back to climb from the landing attitude, one of the culprits in the LOC accident stats.

5—Spend some time working the opposite direction—nose-low situations—to gain experience with the AoA system suggesting you pull up.

RESOURCES

At this writing, three companies offer systems under ASTM F3011-13: Alpha Systems, BendixKing and Garmin:

ALPHA SYSTEMS (WWW.ALPHASYSTEMSAOA.COM)

Alpha Systems has been around a while, and offers a wide range of compliant AoA indicators and accessories, including an adapter providing a heads-up display. Pricing ranges from $1050 for one of its early LED-based kits to $1995 for an indicator like the one shown on page 16.

BENDIXKING (WWW.BENDIXKING.COM)

BendixKing's KLR 10 (pictured) was introduced in 2013, but only for non-certificated airplanes. With the FAA's recent acceptance of ASTM F3011-13, the KLR 10 now is available for CAR 3/FAR 23 airplanes. The BendixKing KLR 10 package's street price ranges as low as $1395; adding a heated probe is an extra-cost option.

GARMIN (WWW.GARMIN.COM)

Garmin is offering its GI 260 indicator as an add-on to existing non-certificated aircraft equipped with its G3X glass panels. A complete system will be available later this year for installation aboard all airplanes. In addition to the GI 260 indicator, the complete Garmin AoA system includes a GSU 25 air data computer and a GAP 26 probe. The complete Garmin AoA system will retail for $1695.

Per the ASTM F3011-13 standard, all of these AoA systems are designed for simple installation, which can run another $1000 or so on up, depending. The sensor ideally mounts to an existing inspection cover under the wing. (Alpha Systems and BendixKing supply a trim-to-fit mounting plate, an example of which is pictured on page 18.) Install the pitot tube-like sensor, run the wiring and mount the indicator on the glareshield or elsewhere in the pilot's field of view, and you're done.

If a suitable inspection cover isn't available and mounting the sensor requires drilling or cutting a hole in the wing or fuselage, the logbook-entry approval process gets more complicated, and either a field approval or supplemental type certificate may be required.

Once the paperwork is complete, you'll need to calibrate the system, which is a relatively simple procedure and one of the reasons the safety-pilot concept was invented.

6—Practice using the AoA indicator alone for pattern flying, approaches and landings, with the ASI still covered and your safety pilot alert for traffic and any mistakes.

FOLLOW THE FLASHING ARROW

The value of an AoA is unquestioned among the CFIs and flight-training-company cockpit and sim instructors who talked with us (as well as current and former military pilots, as detailed earlier). Those three populations share significant overlap.

"When you don't have the time to calculate that your stall speed on a high DA (density altitude) day at a 1500 msl airport—and in a 1.5-G turn—you can get it wrong in a split second and forever change your flying," one multi-type-rated business-turbine contract pilot and CFI/I told *Aviation Safety*. "A functioning AOA system gives you the parameter-corrected indication instantly, so all you have to do is obey its indication. When its arrows or indicators point down, they're not kidding...lower the nose, pronto."

Last year, Embry-Riddle Aeronautical University announced it had installed AoA indicators from Alpha Systems in its entire fleet of 61 Cessna training aircraft at both its Daytona Beach, Fla., and Prescott, Ariz., campuses. At the time, Dr. Jackie Luedtke, Director of the Robertson Safety Institute at the university's Prescott Campus, said, "This device is a direct measurement of energy. It lets pilots know at a glance how much lift is available regardless of an airplane's speed and altitude." That's one of the best endorsements for an AoA indicator we've seen.

Does this mean you should drop everything and install one of these devices? It depends. If you're flying a Super Cub in Alaska and find yourself low and slow spotting game, we'd recommend it. Same answer if you're active in aerobatics, or other maneuvering flight. If you're a typical owner, who uses the airplane for cross-country work, you'll still find it a valuable addition. And with better attitude references, maybe pilots everywhere will start dialing down their LOC accident pace. That's the bottom line.

Dave Higdon is a Wichita-based aviation addict who writes about and photographs aviation subjects to fund a flying habit picked up during the Disco Era.