

A.O.A.



INSTALLATION AND OPERATIONS MANUAL

FOR THE

**“LEGACY”
ANGLE OF ATTACK
(A.O.A.)
INDICATOR**

October 28, 2010

Part Number: IOM-Legacy, Rev. D

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1.1 Introduction:

Congratulations, by adding an angle of attack indicator to your aircraft you have immeasurably increased your awareness of the performance envelope in which you fly. You will be free of the momentary and unsettling concern of not being exactly sure that you are safely achieving the maximum performance from your aircraft. By making this investment it demonstrates a strong commitment to safety, for that we congratulate you. We would also like to **thank you** for purchasing an Alpha Systems Angle of Attack System.

1.2 Objective:

Don't get scared / frightened at the size of this manual. There is a lot of information that is repeated and shown in different ways to help explain all steps of installation through calibration and help with the FAA required paperwork. Think of this manual as a written journey, to give you as much detail as you want.

This manual is designed to take you step by step through the planning, installation, documentation and calibration for your Alpha Systems Angle of Attack System. If you follow the instructions through the entire process, the installation can be completed correctly the first time. We have attempted to balance the need to include all relevant information and the need to keep it as brief as possible (so we don't put you to sleep).

1.3 Background Information By The Numbers:

AC23.1309-1C has a stated objective ***“to improve the safety of the airplane fleet by fostering the incorporation of both new technologies that address pilot – error and weather related accidents and those technologies that can be certified affordably”***.

14 CFR part §21.93a states in part ***“a minor change is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics or other characteristics affecting the airworthiness of the product”***.

14 CFR part §43.13(b) states in part ***“each person altering an aircraft shall do that work in such a manner and use materials of such a quality, that the condition of the aircraft worked on will be at least equal to its original or properly altered condition”***.

What does all this mean?

- The FAA is encouraging modifications that improve operational safety. The Alpha Systems Angle of Attack System is considered to be such a modification.
- A determination needs to be made by the person installing the angle of attack system that it is either a major or minor installation. Alpha Systems believes that installing its angle of attack system in most aircraft is a minor alteration; however this determination is ultimately the responsibility of the person performing the alteration and returning the aircraft to service.
- Alpha Systems believes that installing its angle of attack system in most aircraft meets the requirements of 14 CFR §43.13(b) if done in accordance with this installation manual, AC43.13-1B, AC43.13-2B and AC23.1309-1D. Again this determination is ultimately the responsibility of the person performing the alteration and returning the aircraft to service.

1.4 References:

For those of you that desire more information we have included references with the instructions. These references may be used as acceptable data when documenting the installation. A “CD” containing complete copies of the applicable regulations and advisory circulars are included with your installation kit.

1.5 Disclaimers:

Alpha Systems Angle of Attack System will perform well in a large variety of aircraft. For this reason the instructions were written in a general format that will work for most aircraft.

We understand that the referenced regulations and advisory circulars may not be applicable to all aircraft; however we feel that they offer excellent guidance for this installation and should be followed.

Alpha Systems Angle of Attack System is not produced under 14 CFR §21.303 and therefore is NOT FAA approved and is not intended to be installed in type certificated aircraft **HOWEVER**, Alpha Systems AOA has not specified any limitation prohibiting such an installation.

1.6 Page and Subject Numbers:

Pages in this manual are assigned a two part page number. The first number always specifies the chapter number. The last number always indicates the page number. Subjects within a chapter will be numbered with the chapter number first then the subject number.

1.7 Revisions:

When a revision is required of this manual the manual will be revised in its entirety. The revision number is located immediately after the manual part number. The current revision number may be found on our web site after joining the “**Owners Club**” at www.alphasystemsaoa.com once an authorized user number has been assigned.

1.8 Technical Support:

Call Toll Free: **1-877-571-3770**, Office #: 763-506-9990 or Email **AOA@depotstar.com**.

1.9 Warranty Information:

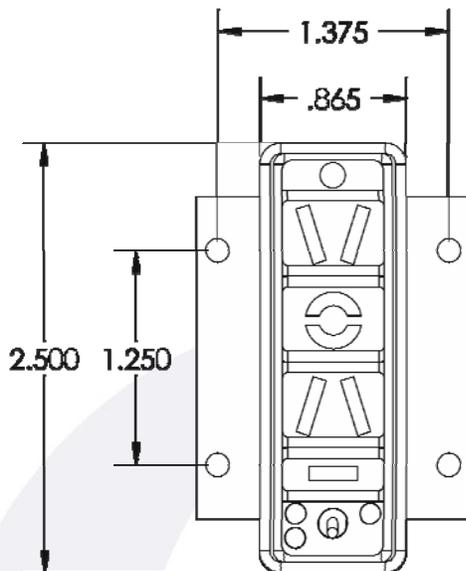
LIMITATION OF REMEDIES AND LIABILITY: If this Alpha Systems AOA product is proved to be defective, **THE EXCLUSIVE REMEDY OF ALPHA SYSTEM AOA’s / DepotStar, Inc. OPTION SHALL BE TO REPAIR OR REPLACE THE DEFECTIVE COMPONENT.** Alpha System AOA / DepotStar, Inc. shall not otherwise be liable for loss of damages, whether direct, indirect, special, incidental or consequential, regardless of the legal theory asserted, including negligence, warranty or strict liability. **If you cannot accept these terms, return the uninstalled unit along with the receipt for a refund.**

Included in the documentation package is the **Warranty Registration Form**. This form **must** be completed, signed and returned to Alpha Systems AOA / DepotStar, Inc. to activate the product warranty.

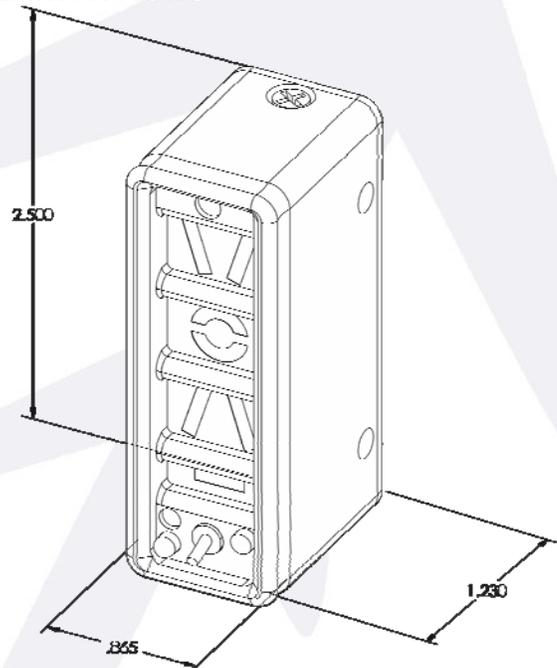
1.10 Specifications:

Alpha Systems AOA, "LEGACY" chevron styled, LED driven AOA system has the dimensions of 2.5" long X .860" wide X 1.250" deep and weighs .300 LBS with the electronic cable. The display can be mounted anywhere in the cockpit and comes with angle brackets when needed for instrument panel mounting. Other optional mounting kits are available for glare shield mounting, vertical dash mount kit or the vertical swivel flush mount for the aircraft that has a sloping glare shield, allowing the display to be positioned to be seen in the pilots' peripheral vision.

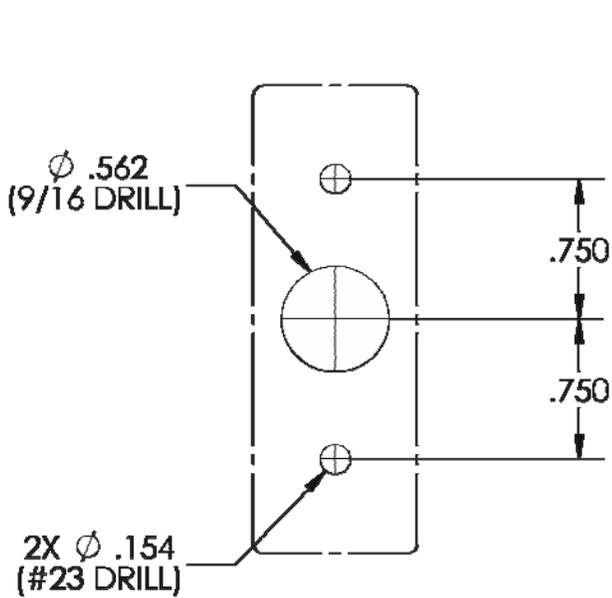
Legacy AOA Display Dimensions



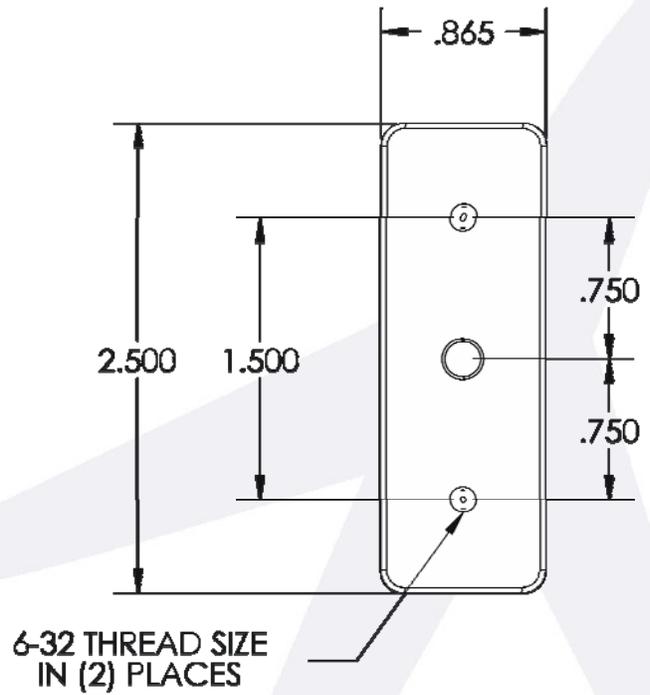
**FLUSH PANEL MOUNTING
(SHOWN WITH BRACKETS INSTALLED)**



Legacy Overall Case Size

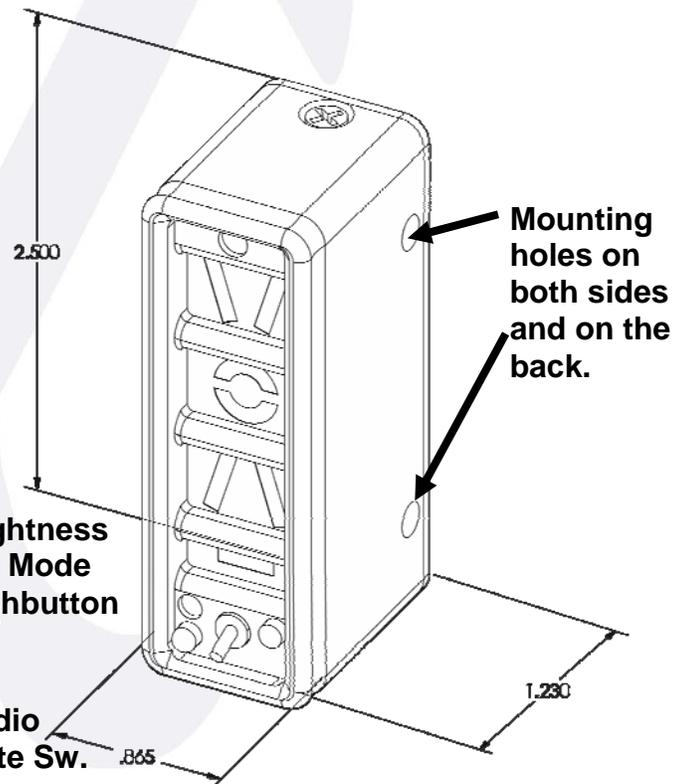
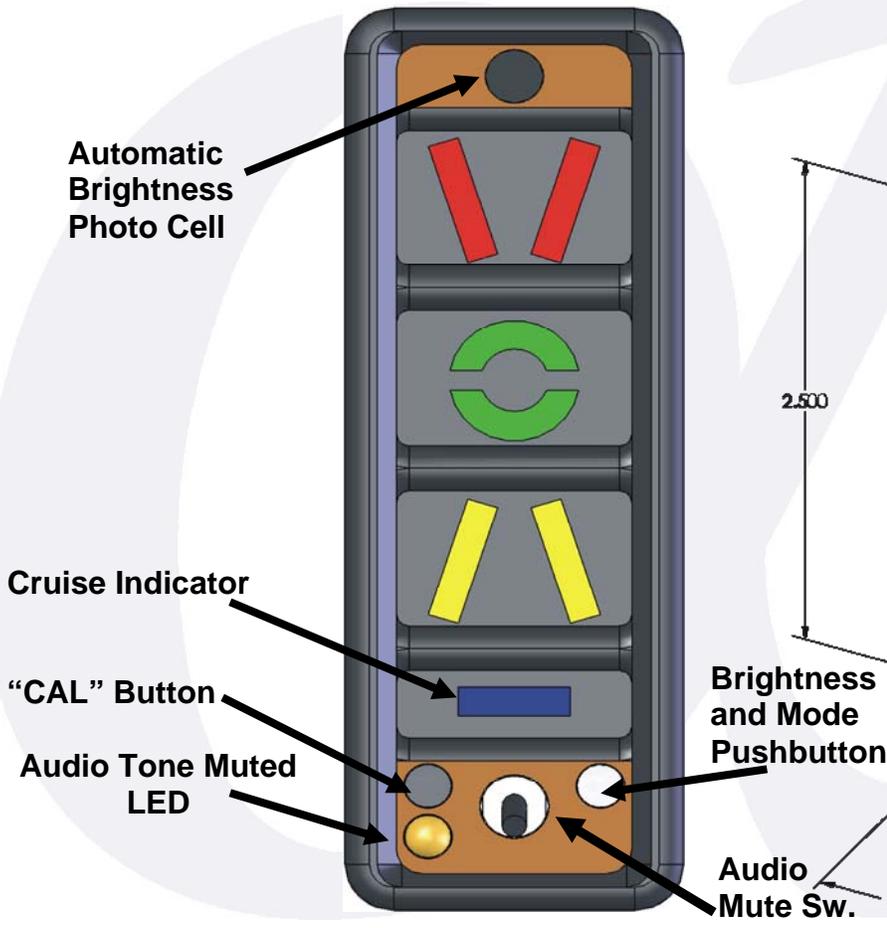


DRILL DIMENSIONS / TEMPLATE



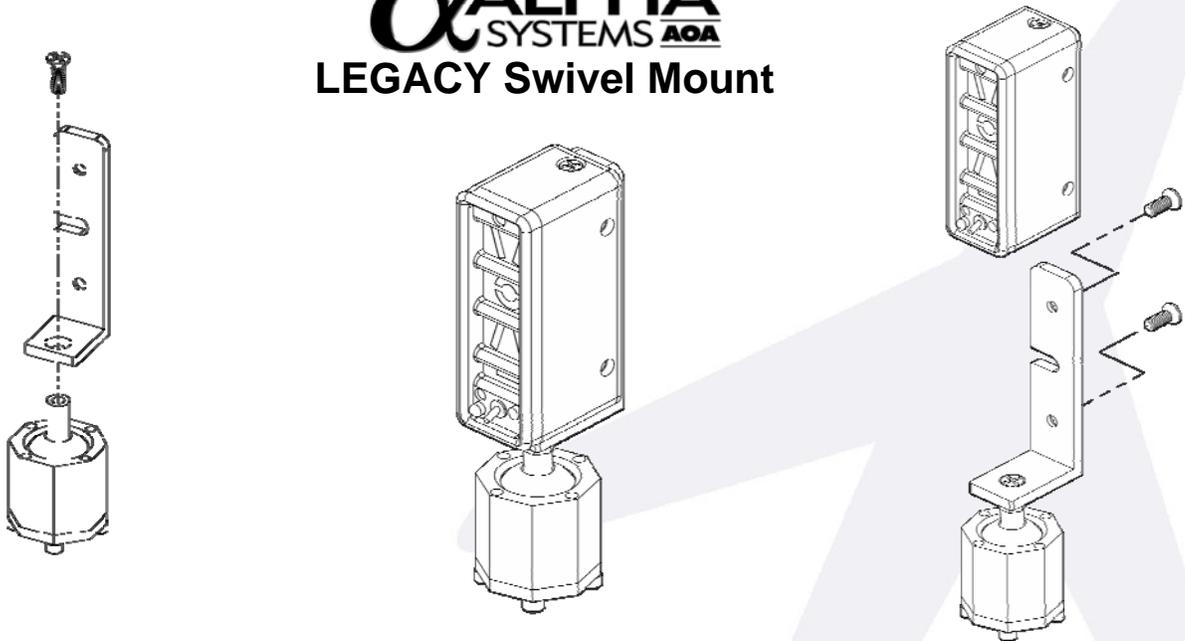
BACK MOUNTING

LEGACY AOA DISPLAY

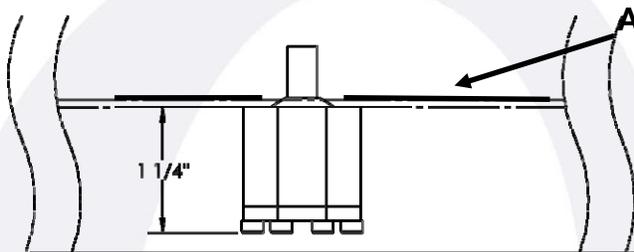




LEGACY Swivel Mount

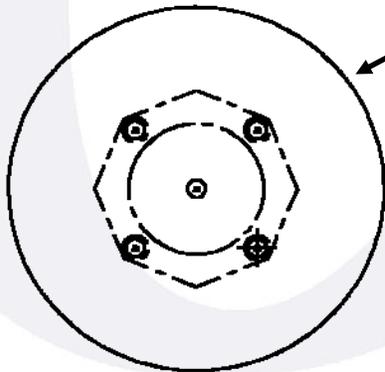


The “**LEGACY**” AOA, chevron styled display can be mounted in the pilot’s peripheral vision, vertically by purchasing the optional mounting kits. These mounting kits allow for accurate positioning in a vertical orientation, on or above the aircrafts glare shield and mounts simply with 4 screws.

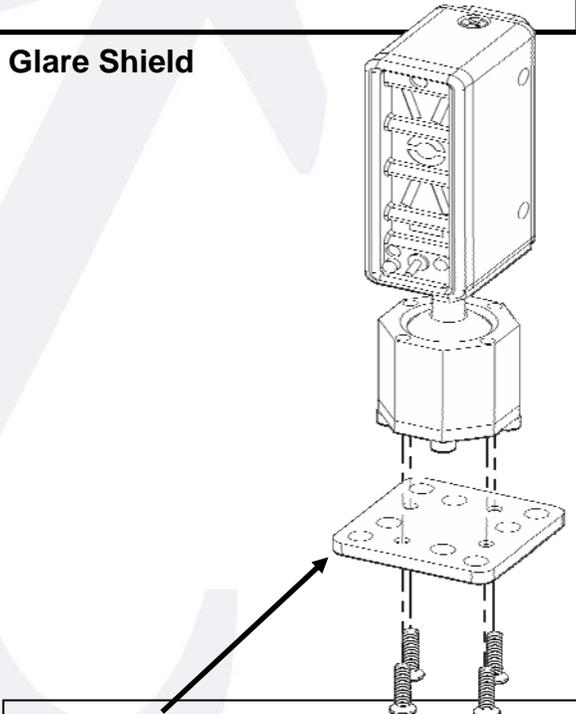


Aircraft Glare Shield

Swivel mount requires 1- $\frac{1}{4}$ ” clearance below glare shield.

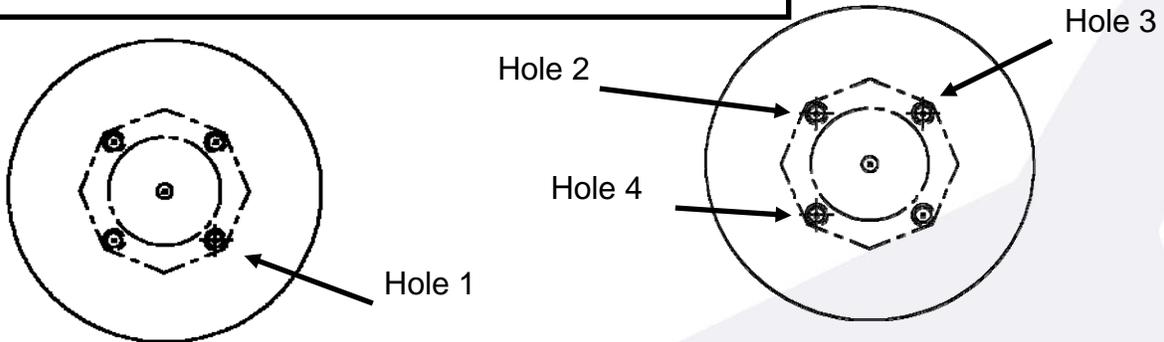


Drill guide disk with 5 holes, included with Ultra swivel mount kit.



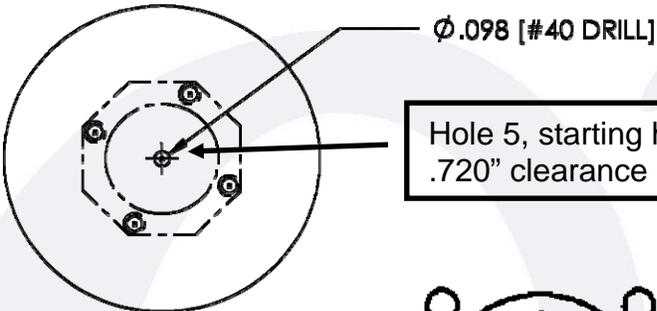
Surface mount swivel can be mounted on top of the glare shield or display inverted and mounted on a windshield frame.

The swivel mount drill guide disk is included with the mounting kit. It's used to aid in the drilling of the mounting holes for surface placement.



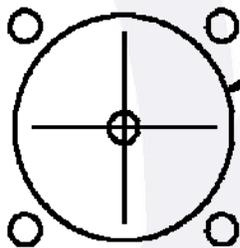
Step 1
Orient drill guide in location where swivel will mount, Using a #40 drill, drill hole, Cleco through hole, spin disk in final location.

Step 2
When disk is in the final position, drill hole 2, Cleco, drill hole 3, Cleco, drill holes 4 and 5.



Hole 5, starting hole for .720" clearance drill.

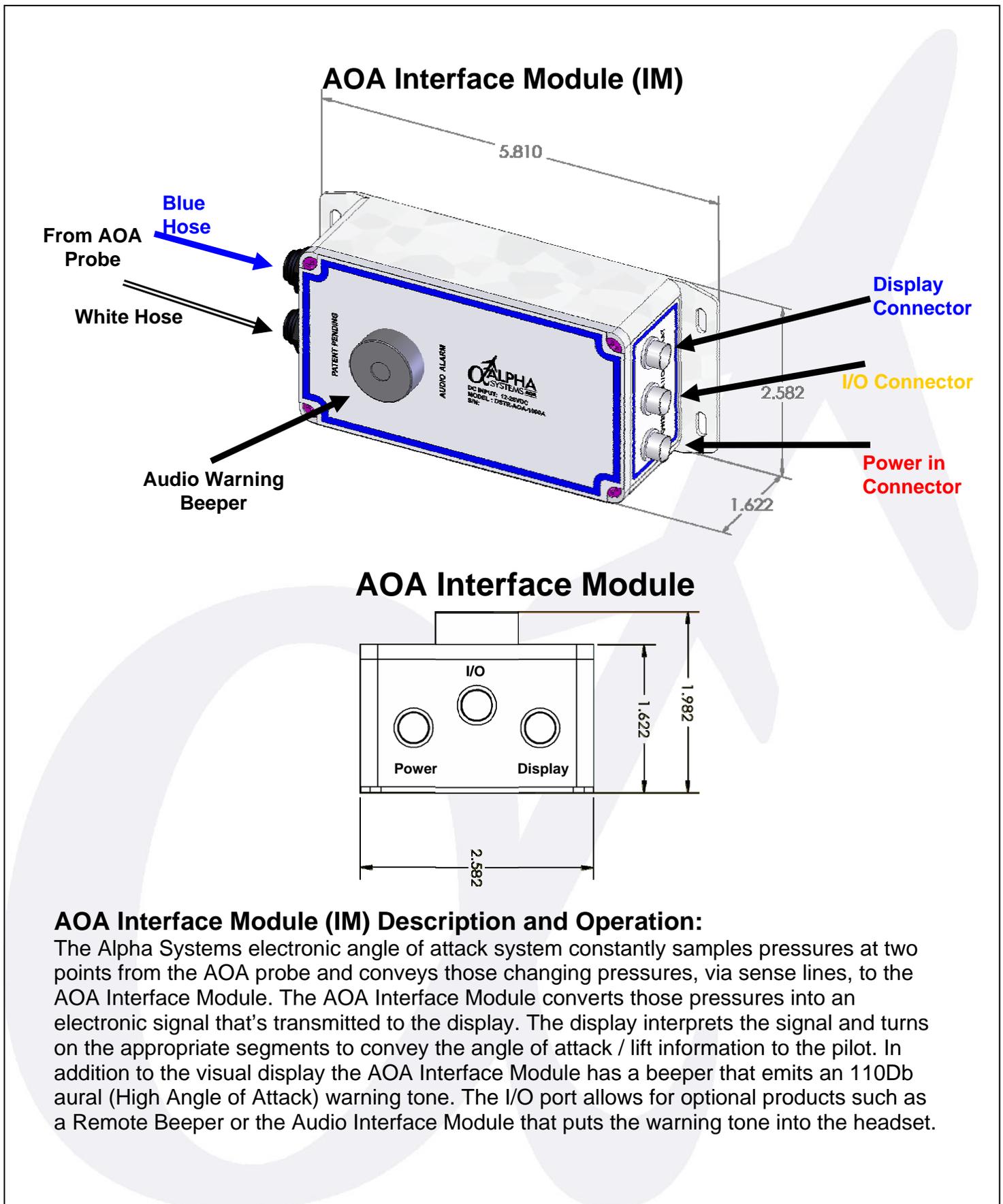
4 Mounting holes and center clearance pattern on dash.

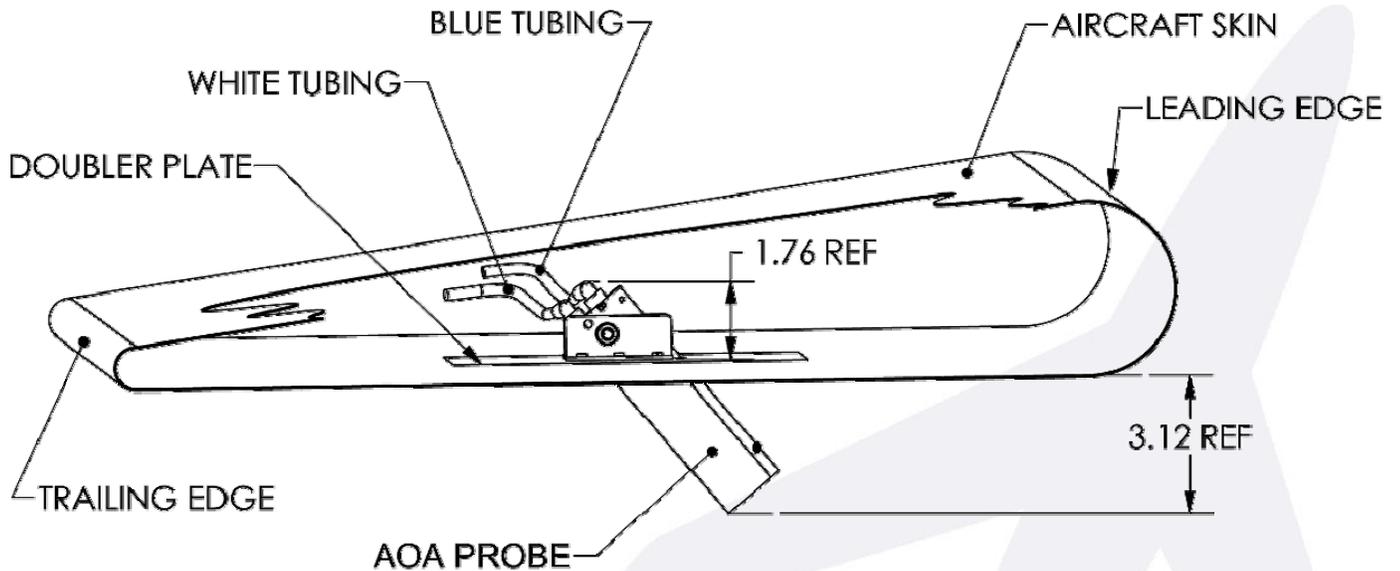


Ø.720 [23/32"]

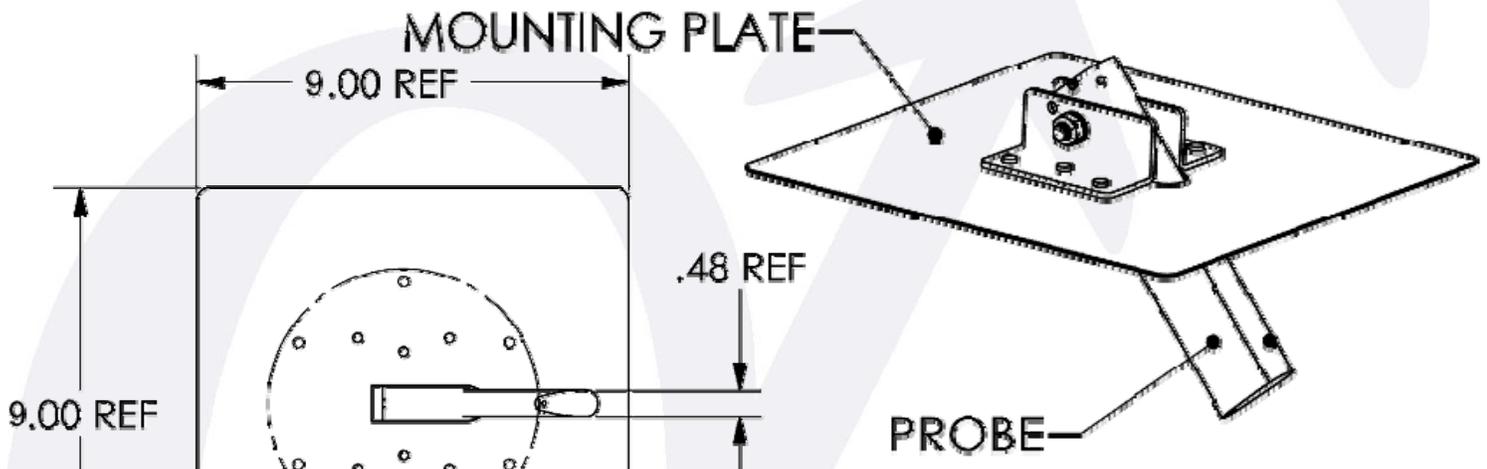
Step 3
Using Hole 5, drill for clearance swivel base of .720".

Once the 4 outer holes are located and drilled, re-drill with a # 32 (.116") clearance for the 4-40 mounting screws.





The AOA probe must be mounted solidly to the aircraft , in clean air flow (undisturbed air), a minimum of 2 feet outside the prop arc, typically mounted 6" back from leading edge, 6" up from trailing edge, at any attitude, slip or skid **NOTHING** disrupting the direct air into the AOA probe.



NOTES:

- 1.) Probe and 2 fittings = .23 LBS.
- 2.) 9"X9" plate + hardware = .40 LBS (Less when cut to fit existing opening)
- 3.) Add .25 LBS with optional probe heat
- 4.) Weight of sense line is .02 Lbs / Ft.

For most aircraft, the AOA probe mounting plate **WILL** be cut to the shape of an existing inspection opening as outlined in this manual. After the mounting plate and probe are attached to the aircraft, it also may become necessary to remove material on the mounting plate to allow the AOA probe to be adjustable past the 50 degree angle to allow for full scale electronic calibration (if additional angle increase required).

2.1 Preparation: This chapter will guide you through the planning phase of the installation process. To prepare for the installation it is recommended that you read this manual in its entirety and complete this chapter prior to performing any work.

2.2 Establish the Desired Location of the Angle of Attack display:

The angle of attack system is intended to provide supplemental information therefore it **can not** be used as a replacement for any required instruments. There is some good guidance in AC43.13-2B Chapter 11 and FAR §23.1321 that refer to the location and installation of the instruments. Basically the instruments should be arranged in the standard “T” configuration with the angle of attack indicator **preferably** as high and left of the attitude indicator as possible. The location should also allow routing of the electrical wiring so it will not interfere with any moving controls, cables or come in contact with any line containing flammable fluids or gases. Since the display is electronic there are a number of other considerations that should be looked at, for example the intent of FAR 23.1311 is to cover installation of “CRT” or “LCD” displays that replace conventional analog instruments. Since the AOA system does not replace any required instruments and does not involve a “CRT or “LCD” display the regulation may not apply. Taking a conservative approach and showing compliance with this FAR can be done as follows:

- 23.1311 Electronic display instrument system
 - (a)(1) Arrangement and visibility; this requirement will have been met by complying with FAR 21.1321.
 - (a)(2) Be easily legible under all lighting conditions; this requirement has been met by design. The display is designed to be seen in direct sunlight and has a built in dimming device for lower levels of light.
 - (a)(3-7),(b)&(c) Does not apply since the system is a stand alone system and does not interface or replace any existing instruments or displays and is not considered essential for flight.

Listed below are four different scenarios, find and complete the one that pertains to your installation and use the following formula when calculating the additional load:

(Indicator Weight) X (Aircraft “G” Limit) X 1.5 (Safety Margin) = Additional Load

Example:

.5lbs X 6.6 X 1.5 = 4.95lbs.

- **IF** you are planning to install the indicator in an **existing hole** on the instrument panel then a determination is needed to insure that the fasteners/shock mounts will accept the additional load of the indicator. This is an easy one, the indicator only weighs .5lbs (or less, depending on the model) so the addition of the indicator should not normally exceed the limits of the mounting hardware. This is a preferred method of installing the indicator and in most cases will require no additional alterations, hence a minor alteration. Please refer to AC43.13-2B Chapter 1 and Chapter 2 paragraph 203(a-e) for guidance.

- **IF** you are planning to install the indicator in a ***panel that is shock mounted and has no existing mounting hole present*** you will need to make two determinations. First, will the shock mounts accept the additional load of the indicator and secondly, will the panel be strong enough with an additional instrument hole in it. The indicator only weighs .5lbs (or less, depending on the model) so the addition of the indicator should not normally exceed the limits of the shock mounts. The panel strength should not be an issue if you keep the hole spacing the same as the original panel layout. This is also a preferred method of installing the indicator and in most cases will require no additional support structure, hence a minor alteration. Please refer to AC43.13-2B Chapter 1 and Chapter 2 paragraph 203(a-e) for guidance.
- **IF** you are planning to install the indicator on a ***glare shield*** you will need to make a determination that the structure is strong enough to support the weight of the indicator. This is also a preferred method of installing the indicator and in most cases will require no additional support structure, hence a minor alteration. Please refer to AC43.13-2B Chapter 1 and Chapter 2 paragraph 205(a-c) for guidance.
- **IF** you are planning to install the indicator in a panel ***where no mounting hole is present and the panel is not shock mounted*** several determinations will be required. First is the panel **non-structural**? If so, you will need to determine that the mounting hardware will accept the additional load of the indicator and will the panel be strong enough with an additional instrument hole in it. The indicator only weighs .5lbs (or less, depending on the model) so the additional load of the indicator should not normally exceed the limits of the mounting hardware. The panel strength should not be an issue if you keep the hole spacing the same as the original panel layout. This method of installing the indicator will, in most cases, not require additional support structure, hence a minor alteration. If the panel you intend to install the indicator in is a **structural** panel, than this would be considered a **major alteration** and engineering data **may** be required and should be obtained prior to any work being performed. Please refer to AC43.13-2B Chapter 1 and Chapter 2 paragraph 203(a-e) for guidance.

2.3 Establish the Desired Location for the AOA Interface Module:

The AOA Interface Module (IM) is used to convert pressures, measured at two points on the probe, to an electronic signal that is then delivered to the indicator which displays angle of attack information to the pilot. The AOA Interface Module (IM) may be physically installed just about anywhere observing the following limitations:

- On a structure that will support the additional load of the module.
- The sense lines shall not interfere with any moving controls or cables.
- The electrical wiring shall not interfere with any moving controls or cables and shall not come in contact with any line containing flammable fluids or gases.
- The AOA IM must be bonded to the airframe (grounded for shielding).
- Mounted within six feet of the indicator. *
- Mounted within six feet of the power source or the optional on/off switch. *

**Note: If a longer cable is required it may be possible to have a longer custom cable assembly fabricated, contact Alpha Systems for more information.*

Use the following formula when calculating the additional load:

$$(\text{Module Weight}) \times (\text{Aircraft "G" Limit}) \times 1.5 (\text{Safety Margin}) = \text{Additional Load}$$

Example:

$$.8\text{lbs} \quad \times \quad 6.6 \quad \times \quad 1.5 \quad = \quad 7.92\text{lbs.}$$

If the AOA Interface Module can be installed without adding additional support structure than it would normally be a minor alteration. Please refer to AC43.13-2B Chapter 1 and Chapter 2 paragraphs 201, 202, 204-206 for guidance.

2.4 Establish the Desired Location on a Wing for the AOA Probe with the Following Limitations:

- Minimum of **24"** outboard of the propeller arc.
- Minimum of **12"** inboard of the wing tip.
- At least **6"** outboard of any struts or landing gear.
- Between **10% to 90%** of the mean aerodynamic cord (**MAC**).
- Must **not** be mounted on a wing incorporating a remote compass system if probe heat is to be installed.

Due to the number of aircraft, wing designs, inspection locations, braces, struts and so on, the object of the best location is "**clean air flow / undisturbed air**" at the location of the probe for all AOA angles, slips or attitudes, would not affect the measurement of air present at the AOA probe.

Listed below are three different scenarios, find and complete the one that pertains to your installation and use the following formulas when calculating the additional load and drag:

$$(\text{Probe + Hardware Weight}) \times (\text{Aircraft "G" Limit}) \times 1.5 (\text{Safety Margin}) = \text{Additional Load}$$

Examples:

$$.6\text{lbs} \quad \times \quad 6.6 \quad \times \quad 1.5 \quad = \quad 5.94\text{lbs.}$$

$$(\text{Drag Coefficient}) \times (\text{Frontal Area of the Probe}) \times V_{NE}^2 = \text{Drag in LBS at } V_{NE}$$

$$.000327 \quad \times \quad .064 \quad \times \quad 200^2 = \quad .83712$$

➤ **IF a non-structural inspection panel** is available determine that the existing structure will support the additional load and drag of the probe and mounting hardware. Please refer to AC43.13-2B Chapter 1 & Chapter 3 for guidance. This is the preferred method of installing the probe and in most cases will require no additional support structure, hence a minor alteration. However, if you have a very fast and/or a thin skinned aircraft the addition of supporting structure may be required, if so that would be considered a major alteration.

➤ **IF a structural panel is available** and used to support the probe this would be considered a major alteration. Engineering data **may** be required and should be obtained prior to any work being performed. Please refer to AC43-13-1B Chapter 4, AC43.13-2B Chapter 1 & Chapter 3 for guidance.

➤ **IF no inspection panel is available** to support the probe, an inspection hole along with a doubler and/or supporting structure may be installed in the wings skin. This would also be considered a major alteration and engineering data **may** be required and should be obtained prior to any work being performed. Please refer to the airframe manufactures maintenance manual, AC43.13-1B Chapter 4, AC43.13-2B Chapter 1 & Chapter 3 for guidance.

2.5 Establish a Plan to Route the Sense Lines Through the Aircraft Structure with the Following Limitations:

- Do not remove hose end caps until final connector installation.
- Minimum bend radius of 4" for the lines must be observed.
- Attach lines at regular intervals by means of suitable clamps.
- Do not clamp lines at the end fittings.
- Use AN931 Grommets (preferred) or bulkhead fittings where they pass thru bulkheads.
- Engineering data may be required **if** entering a pressure vessel.
- Keep well clear of any moving controls or cables.

Refer to the airframe manufactures maintenance manual and AC43.13-1B chapter 12 section 4 for instructions on replacing/installing new pitot static lines.

2.6 Establish a Plan for the Electrical Power: The electronic A.O.A. system requires less than ¼ amp. (250 mA) of electrical power within its acceptable voltage range of 10-28VDC. Our recommendations would be to have the A.O.A. draw power from the avionics bus through an on/off switch in series with the positive lead for the control module (this would offer some protection from surges during starts and the on/off switch would enhance operational flexibility). Based on the very low power requirements this system may be installed as a minor alteration. However, since it is an electronic display there are a number of other considerations that should be looked at first before that determination is made. We will take you step by step through the applicable regulations and explain the pertinent parts.

- 23.1331 Instrument using a power source
 - (a) Power Indicator; this requirement has been met by design; loss of power is indicated by all lights off (i.e. no deceptive indications).
 - (b)(1&2) Installation and power supplies; these requirements have been met by design; the system does not interface with any other instruments or displays and the control module is shielded and utilizes MIL spec shielded wire as an added safe guard to prevent any interference.
 - (c) Two independent power sources; this requirement may be met on aircraft equipped with two different power sources connected to the same electrical bus that the A.O.A. system receives power. For example, an aircraft with the following equipment connected to the electrical bus that supplies the A.O.A. system would satisfy this requirement:
 - an engine driven generator/alternator **and**
 - a storage battery **and**
 - a means to indicate the batteries proper state of charge and is monitored and displayed to the pilot.

- 23.1351 Electrical, general
 - (a)((1&2) Electrical loads; if the electrical system was adequate prior to the installation the additional load of the A.O.A. system would be considered negligible and thus would not have any appreciable effect. The key here is the electrical system must be considered adequate before adding any additional loads.
 - (b) Function of each electrical system; if the electrical system is not altered to affect methods of operation and is free from hazards this part would be complied with.
- 23.1357 Circuit protective devices
 - (a) Protective device; a circuit protection device must be installed for this installation. We recommend that you use the same type and manufacturer that is already installed (1 amp).
 - (b) Essential circuit; the A.O.A. system power can not be connected to a circuit that protects essential equipment. We recommend that an additional circuit protection device be installed and labeled in the same manner as the original aircraft manufacturer.
 - (c)(1&2) Re-settable circuit protective device; requires a manual reset and will only reset once the overload is eliminated regardless of position of the operating control, again if you use the same as the original manufacturer this regulation will be satisfied.
 - (d) Is not applicable.
 - (e)(1&2) Fuse replacement; if you use a fuse for a circuit protection device that is intended to be replaced in flight you must carry spare fuses that are readily accessible to each required pilot.
- 23.1365 Wire analysis
 - (a.) Capacity; the power cable incorporates #22 shielded MIL Spec. wire and is sized correctly for the length supplied. If the optional switch is installed, wire size is determined by the wire length (considering its routing from the circuit breaker/fuse through the switch to the AOA interface module and to an adequate ground) and the load of .25 amps. Determine the size of wire required from AC43.13-1B Chapter 11 Section 5 (for 14VDC in free air #22 wire will be adequate for runs up to 29 feet & for 24VDC in free air #22 wire will be adequate for runs up to 60').
 - (b.) Flame and toxic fume resistant; the wire supplied with the AOA interface module is MIL Spec. shielded wire and meets these requirements. If additional wire is used, use Mil Spec. wire to comply with this requirement.
 - (c.) Not applicable.
 - (d.) Identification; this is complied with by design; the cables supplied with the system are identified with a heat shrink label. If additional wiring is needed; colors, numbering or labeling can be used to ID the wire, it can be as easy as using a permanent marker to ID the wire.
 - (e.) Installation and routing. Electrical cable/wire must be installed such that the risk of mechanical damage and/or damage caused by fluids, vapors, or sources of heat, is minimized.

- 23.1367 Switching (if the optional on/off switch is installed), each switch must be
 - (a) Able to carry its rated current.
 - (b) Constructed with enough distance or insulating material between current carrying parts and the housing so that vibration will not cause shorting.
 - (c) Accessible to appropriate flight crewmembers.
 - (d) Labeled as to operation and the circuit controlled.

We recommend that you use a Mil. Spec. switch with silver contacts rated for twice the required amperage (i.e. Honeywell 1TW1-2, MS27716-22-1 SPST switch).

If the regulations are complied with as described above, the AOA system can be connected to the aircraft electrical system as a minor alteration. For additional information please refer to AC43.13-1B Chapter 11, which has a wealth of information on wire, switches, loads, etc., also AC43.13-2B Chapter 2 paragraph 207 is useful.

2.7 Optional Probe Heat Installation:

The optional probe heat requires 7.2 amps of electrical power at 14 or 24VDC. For this reason, installation of probe heat may be considered a major alteration, due to the current draw requirement. We will take you step by step through the applicable regulations and explain the pertinent parts.

- 23.1351 Electrical load analysis
 - (a) ((1&2) Electrical loads; the electrical system must be adequate for the intended use. What this means is that the additional load of the probe heat would not degrade the ability of the electrical system to furnish the required power at the proper voltage to each load circuit essential for safe operation, considering an electrical load analysis or by electrical measurements that account for the electrical loads applied to the electrical system in probable combinations and for probable durations. The key here is the electrical system must be considered adequate before adding any additional loads and have additional capacity to handle the load of the probe heat without degrading the system. The old rule of thumb was electrical load analysis would require the load imposed by installed equipment not to exceed 80% of your generator/alternators capacity. Understanding the term “*probable combinations and for probable durations*” gives the installer a little more latitude in the electrical load analysis.
 - (b) Function of each electrical system; if the electrical system is not altered to affect methods of operation and is free from hazards this part would be complied with.

- 23.1357 Circuit protective devices
 - (a) Protective device; a circuit protection device must be installed for this installation. We recommend that you use the same type and manufacturer that is already installed (10amp).
 - (b) Essential circuit; the probe heat can not be connected to a circuit that protects essential equipment. We recommend that an additional circuit protection device be installed and labeled in the same manner as the original aircraft manufacturer.
 - (c)(1&2) Re-settable circuit protective device; requires a manual reset and will only reset once the overload is eliminated regardless of position of the operating control, again if you use the same as the original manufacturer this regulation will be satisfied.
 - (d) Is not applicable.
 - (e)(1&2) Fuse replacement; if you use a fuse for a circuit protection device that is intended to be replaced in flight you must carry spare fuses that are readily accessible to each required pilot.

- 23.1365 Wire analysis
 - (a.) Capacity; is determined by the wire length (considering its routing from the circuit breaker/fuse through the switch to the probe heater and to an adequate ground) and the load of 7.2 amps. Determine the size of wire required from AC43.13-1B Chapter 11 Section 5, (14VDC in free air #14 wire will be adequate for runs up to 20' & for 24VDC in free air #16 wire will be adequate for runs up to 25'). As an added precaution to prevent interference with other aircraft systems use MIL Spec. shielded wire.
 - (b.) Flame and toxic fume resistant; use a MIL Spec. wire and you will have met these requirements.
 - (c.) Not applicable.
 - (d.) Identification; colors, numbering or labeling can be used to ID the wire, it can be as easy as using a permanent marker to ID the wire.
 - (e.) Installation and routing. Electrical cable/wire must be installed such that the risk of mechanical damage and/or damage caused by fluids, vapors, or sources of heat, is minimized. Route as far away as possible from any instrument, system or wiring that may be effected (i.e. compass/flux gate, antenna or antenna coax).

- 23.1367 Switching; each switch must be
 - (a) Able to carry its rated current.
 - (b) Constructed with enough distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting.
 - (c) Accessible to appropriate flight crewmembers.
 - (d) Labeled as to operation and the circuit controlled.

We recommend that you use a Mil. Spec. DC switch with silver contacts rated for twice the required amperage (i.e. Eaton 8500K9, MS24523-22 SPST switch).

AC43.13-1B Chapter 11 has a wealth of information on wire, switches, loads, etc. also AC43.13-2B Chapter 2 paragraph 207 is useful.

2.8 Review your Plans and Determine that it Meets the Requirements of the Following Regulations:

§23.1301: (a) Is it of a kind and design appropriate to its intended function?

If you intended to add an angle of attack system and can do it as described above then the answer is yes.

(b) Can it be labeled as to its identification, function?

The indicator meets this identification requirement for the indicator.

However, if you install the optional on/off switch or probe heat then you are required to label the switch(s) and circuit breaker(s) as to their function.

(c) Can it be installed according to limitations specified?

You must meet **all** specified requirements to answer this yes.

If you answered any of the above questions with a **“NO”** then revise your plan until you can answer all the questions with a **“YES”**.

§23.1309: (a)(1) When performing its intended function will it adversely affect the response, operation or accuracy of any:

(i) Equipment essential to safe operations?

If the A.O.A. system is installed correctly it should not affect any other equipment as it is a stand alone system which does not interface with any other equipment, one exception is the optional probe heat which must be looked at very closely.

(ii) Other equipment unless there is a means to inform the pilot of the

affect? Same as above, additionally do not utilize a circuit breaker shared with any other piece of equipment for the A.O.A. system or the probe heat in an effort to avoid this situation.

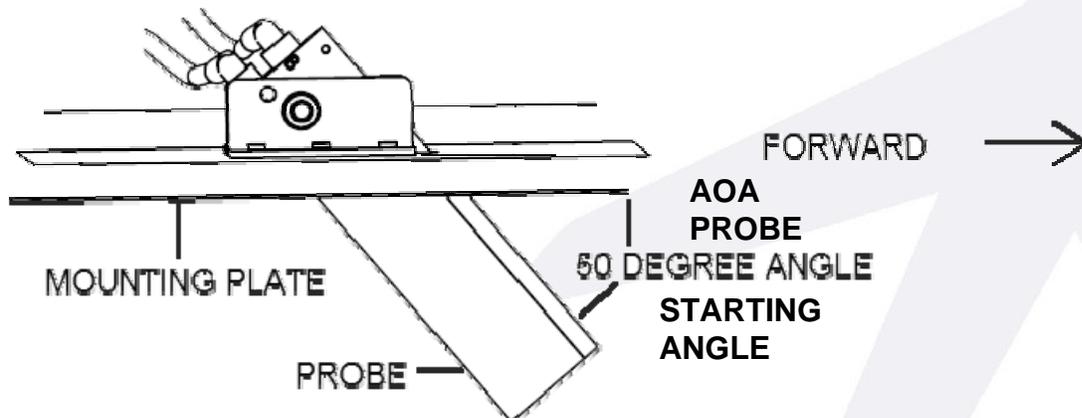
Refer to AC23.1309-1D section 9, it will help you answer the questions and the flow chart makes it easy to determine if the installation will meet the requirements of §23.1309(a).

If you answered either of these two questions with a **“YES”** then revise your plan until you can answer them both with a **“NO”**.

If you made it through all this successfully, you are doing great, and are now ready to install the Alpha Systems AOA, “Legacy” Angle of Attack System in your aircraft.

3.1 Preparing to Install the Probe:

- In chapter two the location for the probe was established. If it was determined that additional structure or modification to the wing will be required, perform that work now in accordance with the established plan and or any required engineering data.
- If not already done so, remove the inspection panel at the location where the probe will be mounted. Modify the probe mounting plate to fit the hole (the panel removed may be used as a template). Ensure that the slot in the mounting plate is aligned so that the rounded end of the slot faces forward.



- On a non-structural panel the screw spacing should be no less than 1 screw every 2 to 3 inches along the outside circumference of the mounting plate. If the existing layout is greater add nut plates as required to accomplish the proper screw spacing (on a structural panel the screw spacing would be much closer).
- Drill holes in the probe mounting plate to match the layout in the wing.
- Install the mounting plate on the wing and check for proper fit. When satisfied remove the panel and prepare the panel for paint.
- Finish panel as desired and set aside to cure.

3.2 Install the AOA Sense Lines:

- Gain access to the aircraft so that the AOA sense lines can be installed and routed through the aircraft from the probe location to the AOA Interface Module location in accordance with the plan established in chapter two.
- Route the AOA sense lines and observe the following requirements:
 - Minimum bend radius of 4".
 - Attach lines at regular intervals by means of suitable clamps.
 - Do not clamp lines at the end fittings.
 - Use AN931 Grommets (preferred) or bulkhead fittings where they pass thru bulkheads.
 - Do not remove the caps installed on either ends of the sense lines and leave sufficient length so they may be cut to length later in the installation process.
 - Keep the lines well clear of any moving controls or cables.

3.3 Install the Wiring, Switch & Circuit Breaker for the A.O.A System:

NOTE: *It may be advantageous to perform the steps found in **section 3.4** at the same time the following work is performed if the optional probe heat is to be installed.*

In chapter two a plan was established so that the requirements for supplying power to the A.O.A. system were satisfied, in accordance with that plan:

- Ensure that the aircraft electrical system is **NOT** powered and the aircraft battery is disconnected.
- Install the circuit breaker. Mount in a manner accessible to a crewmember during flight for circuit breaker resetting.
- Identify and label the circuit breaker.
- Optional, install the “**on/off**” switch so it is accessible to appropriate crewmembers.
- If installed, label the switch as to its operation.
- Route the cable/wire from the circuit breaker to the “on/off” switch, if installed, then to the control module location, observing the following:
 - Keep wires well clear of any moving controls or cables.
 - Physically separate electrical wire from lines or equipment containing oil, fuel, hydraulic fluid, alcohol or oxygen.
 - Route wires above flammable fluid lines and securely clamp to structure, ***in no case may a wire be clamped to line containing flammable fluids.***
- **Connect the White wire (NO Stripe) to power (+).**
- **Connect the White wire WITH Blue Stripe to an adequate ground (-).**
- If additional wire was used ensure the wire is identified / labeled.
- Attach the shielding together at a break in the wire (i.e. at the switch) and ensure it is insulated so as to prevent contact with any other conductor.
- Do not connect the shield to ground as it is grounded at the connector, doing so would cause a ground loop.
- Recheck for proper polarity, **(+)** White wire, **(-)** White with **Blue Stripe** (Ground).

3.4 Install the Wiring, Switch and Circuit Breaker for the Probe Heat:

Note: *This section may be skipped if the optional AOA probe heat is not to be installed.*

In chapter two a plan was established so that the requirements for installing the probe heat were satisfied, in accordance with that plan:

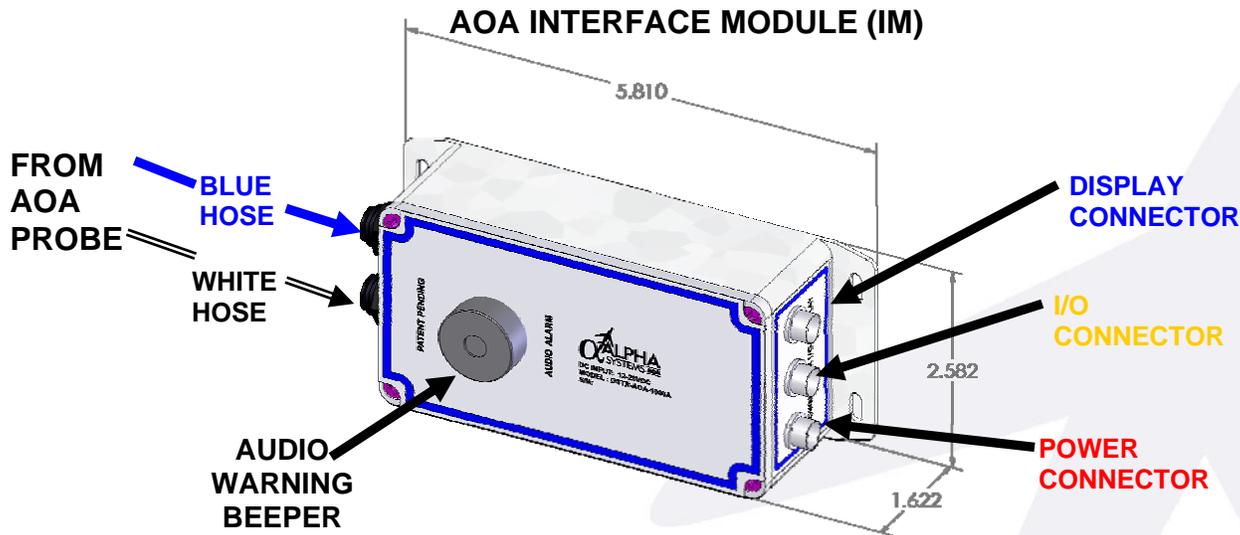
- If not already done so, ensure that the aircraft electrical system is **NOT** powered and the aircraft battery is disconnected.
- Install the circuit breaker. Mount in a manner accessible to a crewmember during flight for circuit breaker resetting.
- Identify and label the circuit breaker.
- Install the switch so it is accessible to appropriate crewmembers.
- Label the switch as to its operation.
- Label the wire so it may be identified once installed.
- Install the wire from the circuit breaker through the switch to the probe location and to a suitable ground observing the following:
 - Physically separate electrical wire from any lines or equipment containing oil, fuel, hydraulic fluid, alcohol or oxygen.
 - Route wires above any flammable fluid lines and securely clamp to structure, ***in no case may a wire be clamped to line containing flammable fluids.***
 - Route as far away as possible from any instrument, system or wiring that may be effected (i.e. compass/flux gate, antenna or antenna coax).
 - Leave sufficient wire at the probe location so it may be cut to length and connected to the probe later in the installation process.
- Attach the shielding to a suitable ground on one end of the wire only, this will prevent a ground loop. Attach the shielding together at a break in the main conductor (i.e. at the switch connections) and ensure it is insulated so as to prevent contact with any other conductor.

3.5 Install the Legacy, AOA Indicator:

- In chapter two the location for the AOA indicator was established. If it was determined that additional structure or modification to the instrument panel will be required, perform that work now in accordance with the established plan and or any required engineering data.
- Install the AOA indicator and check for fit and clearances.
 - The Legacy display may be mounted using any two of the six threaded (6x32) mounting holes. If utilizing side holes the screw can not be any longer than 1/4" plus the mounting panel thickness. If utilizing the rear holes the screws can be no longer than 1/4" plus the mounting panel thickness. The angles provided with the mounting kit are provided to aid in mounting the indicator in the instrument panel and their use is not mandatory.
 - The Legacy display was designed to be mounted in a Vertical orientation.
 - The Legacy display can be mounted above the glare shield with one of two different optional mounts. **1.) Solid dash mount bracket, 2.) Vertical flush mount swivel kit.** These kits allow the AOA "Legacy" display to be mounted and positioned so that the display is up as high in the cockpit as possible, allowing viewing of the aircrafts' AOA without looking down to the instrument panel.
- **Route the cable from the AOA indicator to the AOA IM location, observing the following:**
 - Keep wires well clear of any moving controls or cables.
 - Physically separate electrical wire from lines or equipment containing oil, fuel, hydraulic fluid, alcohol or oxygen.
 - Mount electrical wire bundles above flammable fluid lines and securely clamp to structure, ***in no case may a wire be clamped to line containing flammable fluids.***

3.6 Install the AOA Interface Module (IM):

- In chapter two, the location for the AOA Interface Module (**IM**) was established. If it was determined that additional structure or modification will be required, perform that work now in accordance with the established plan and or any required engineering data.
- Attach the AOA Interface Module (**IM**) to the airframe utilizing the attached mounting base plate. The AOA **IM** must be grounded for shielding. If the module is not grounded by the mounting hardware install a grounding strap from one of the mounting screws to a suitable ground.
- Cut the AOA sense lines (at a 90° angle, **NO burs**) to length and insert the lines firmly in the connectors, observe the color coding, **BLUE / FRONT TO BLUE LINE AND WHITE / BOTTOM TO WHITE LINE.** When correctly installed the line will be inserted approximately 3/8" into the connector. **Push hose in connector until it stops.**
- Ensure the line is installed correctly by giving the tubing a light pull, if the tubing does not back out it is a good connection.
- If you ever need to disconnect the lines; **depress the black collar** (the furthest outboard portion of the connector) on the fitting and pull the line out. **See help sheet included with manual.**



- Connect the display cable connector (6 Pin) to the AOA Interface Module (**IM**) connector, they are both color coded **BLUE**. This may be accomplished by holding the cable connector by its black strain relief and rotate it on the display connector until the alignment keyways mate up then push towards the control module and the retaining collar will snap into place tightly against the AOA **IM**. **Verify connector is seated completely by pulling lightly on wire and connector stays on AOA Interface Module.**
- Connect the power cable connector (4 PIN) to the AOA **IM** connector; the connector label and the power cable are both color coded **RED**. This may be accomplished by holding the cable connector by its black strain relief and rotate it on the case power connector until the alignment keyways mate up, then push towards the AOA **IM** and the retaining collar will snap into place tightly against the AOA **IM**. **Verify connector is seated completely by pulling lightly on wire and connector stays on AOA IM.**
- To remove either of the electrical connectors grip the collar and pull away from the AOA **IM**, slide the connector off.

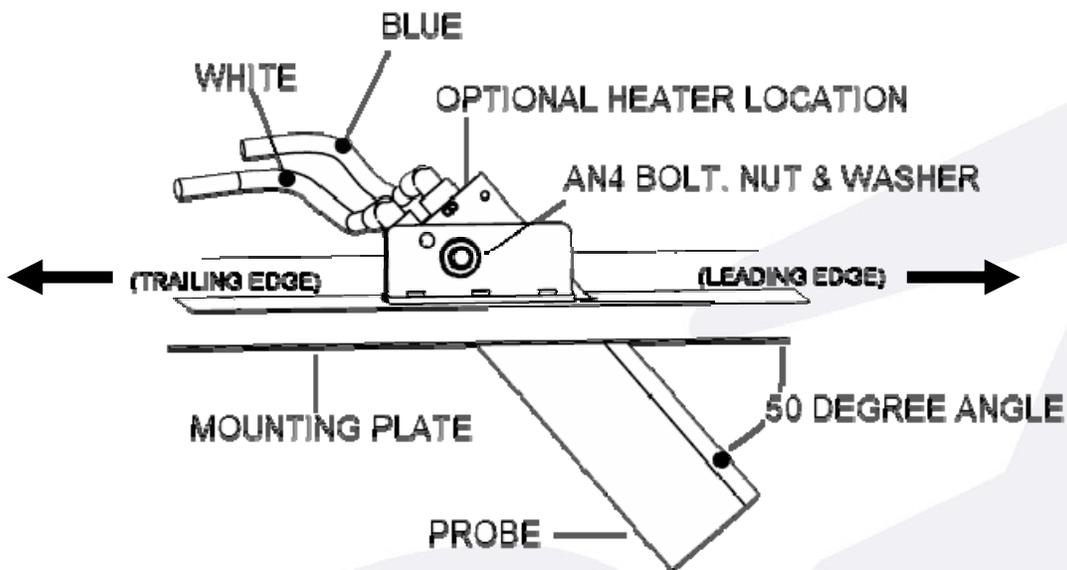
Note: The center connector labeled "I/O", color coded Yellow, is for future use and should have the protective cover installed.

3.7 Install the AOA Probe and Mounting Plate:

- **(Optional)**, if installing a heated probe, it will come from the factory installed with high temperature fittings and colored (**Blue / White**) high temperature hoses with the heater in AOA probe.
- Install the probe in the modified mounting plate and secure it by inserting the AN4 bolt through the mounting plate and probe. Install the washer and nut, tighten it so the probe will not move in flight but will allow adjustments without loosening the nut.

- **Optional**, cut the electrical wires for the probe heat to length and connect them to the heater, **polarity is not an issue**, connect power to one lead and ground the other. Attach the shielding to a suitable ground on one end of the wire only; this will prevent a ground loop.

Cut the AOA sense lines (at a 90° angle, **verify NO burs**) to length so they may be easily attached to the probe but short enough so they will not kink when the mounting plate is secured to the wing. Allow enough hose to re-position AOA probe angle for final adjustments.



- Insert the lines firmly in the connectors, observe the 2 letters (**B & W**) on the side of the AOA probe, “**B**” (for **Blue, Front Hole**) **TO BLUE LINE** and “**W**” (for White, Bottom Hole) **TO WHITE LINE**. When correctly installed the line will be inserted approximately 3/8” into the connector. Push hose in firmly until a positive stop.
- Ensure the lines are installed correctly by giving the line a light pull and if the line does not back out it is a good connection. If you ever need to disconnect the lines depress the black collar (the furthest outboard portion of the connector) on the fitting and pull the line out.
- Slowly slide the probe and mounting plate into position ensuring that everything will fit properly and not kink or bind. When satisfied, secure the mounting plate to the wing and tighten all screws.
- Adjust the AOA probe to the **initial 50°** angle, tighten bolt and nut snugly so that the probe will stay in position and not move in flight. If needed, the probe can be repositioned with a firm pull or push on the ground to correct for mounting AOA probe value errors.
- **It may be necessary to remove material from the mounting plate that would prevent the probe to be installed at the proper angle. If the 50° (or less) angle of the AOA probe interferes with the plate or in the final calibration steps, the probe to be at a tighter angle, remove material as required.**

3.8 Inspect the AOA Installation, Perform Initial Ground Calibration:

- Inspect in the areas that were opened to install the A.O.A. sufficiently so you can determine that the installation was done correctly and no discrepancies are left unresolved.
- Connect the aircraft battery.
- Close any open circuit breakers for the A.O.A. system and probe heat.
- Power up the aircraft electrical system and turn on the A.O.A. system, then the probe heat, (if installed). Disregard any A.O.A. indications at this time.
- **The Legacy display will be flashing ALL AOA segments; this indicates ALL calibrations need to be made BEFORE it is functional.**
- Re-inspect the areas that were opened to install the A.O.A. system, paying particular attention to the electrical part of the installation, determine that there are no unresolved issues with the electrical part of the installation.
- If probe heat was installed check the operation of the probe heat with the switch in the “on” and “off” position. Ensure the compass or other systems are **NOT** affected by the probe heat. When finished place the probe heat off.

CAUTION BURN HAZARD:

When checking the AOA probe heater, DO NOT TOUCH THE AOA PROBE! Use a thermometer or place your hand above the probe to feel the radiated heat. Leaving the probe heat on for extended periods while on the ground, will shorten its service life.

(ON THE GROUND) ZERO CALIBRATION PROCEDURES

- Perform the “**(On the Ground) Zero Pressure Calibration**” (**Step 1**) procedure utilizing the flow chart found in figure 3.1 or the amplified procedures in section 3.9.

The next procedure is optional, and can be done as required.

- To perform the “**Brightness Calibration**” procedure utilizing the flow chart found in figure 3.2 or the amplified procedures in section 3.9.
- Power off the aircraft electrical system.
- Close the aircraft up by installing any access panels or equipment removed to install the AOA.
- **Once the system has had the Zero Pressure calibration set, is not necessary to re-enter the Zero Pressure calibration if power is removed. The system stores the value.**

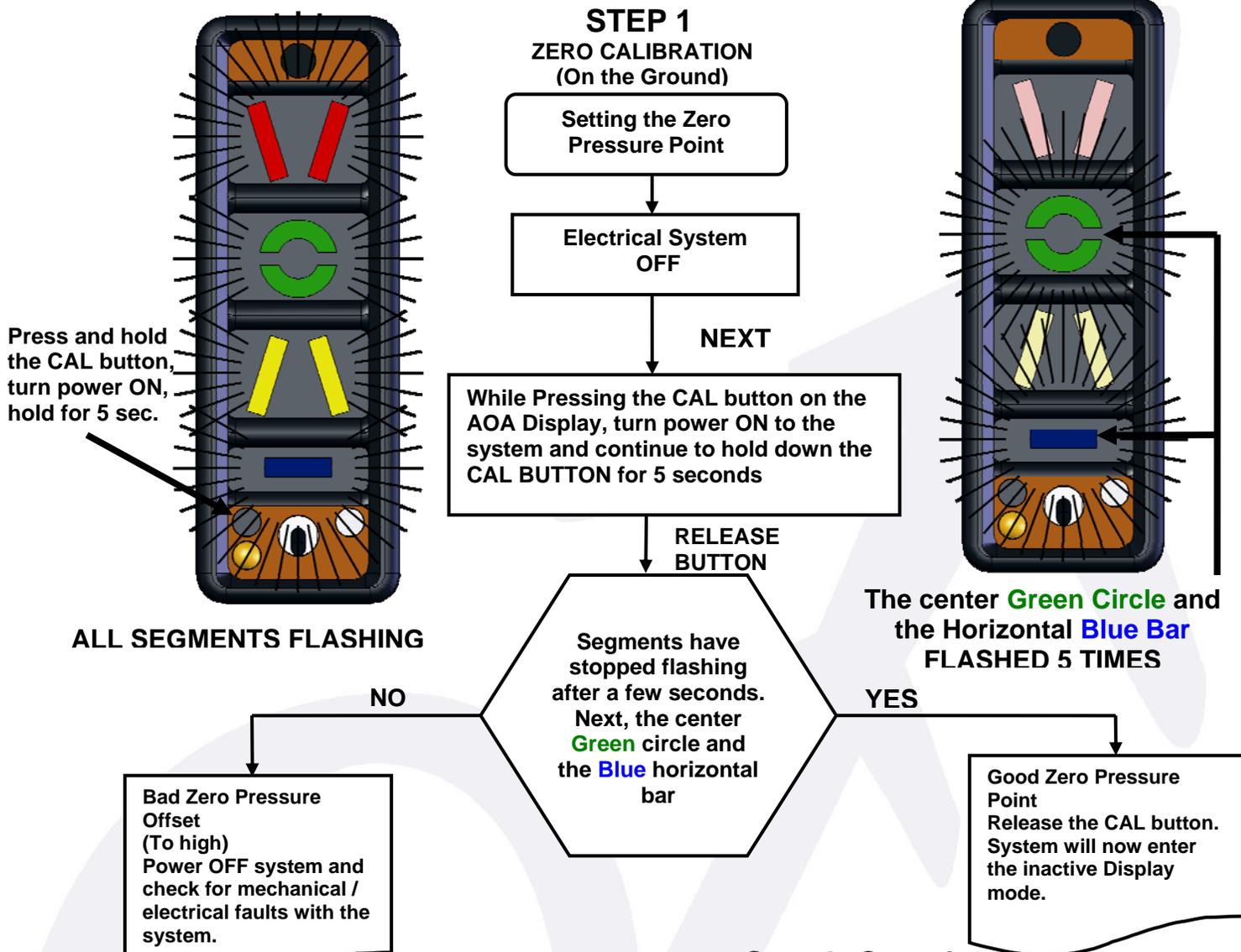


Figure 3.1

Causes:

- Air Hose is kinked
- Air Hose is obstructed by foreign matter
- Electrical failure with the system

To isolate failure:

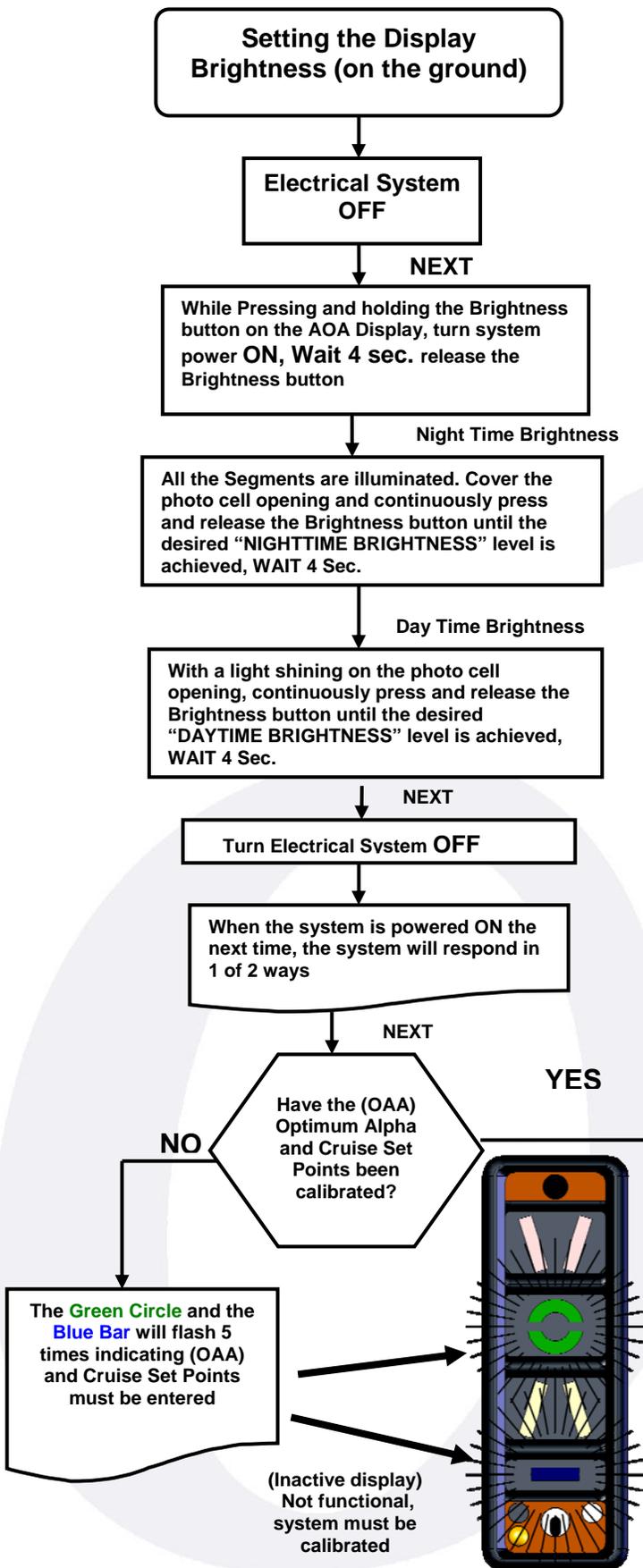
Disconnect the air hoses from the AOA Interface Module and repeat the procedure.
 If the condition is gone, the failure is mechanical.
 If the condition persists, the failure is probably electrical related.

Step 1: Complete

After the unit has accepted the ground calibration value, the center **Green circle** and the horizontal **Blue Bar** on the AOA Display will flash 5 times to indicate that the **OAA** and **Cruise** set points need to be calibrated. The AOA Display is set to **INACTIVE** until In-Flight Calibration Mode, Step 2 is entered.

Step 1: (On the Ground) Zero Calibration Overview

After installation and electrical connections are completed, electrical and pressure zero set points need calibration. When the unit is first turned on, **all segments** will flash, indicating the unit must have the **Zero** calibration procedure completed. The ground calibration set point can be reset at any time after the initial calibration. However, **ALL** in-flight set points **must** be reset and identified.



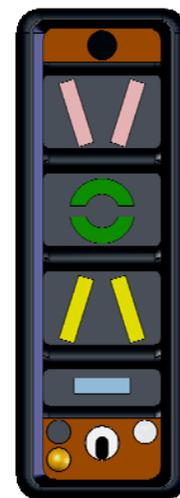
The brightness levels on the display **CAN** be set on the ground and all of the LED's forced **ON** by following this procedure. Both the "day time" and "night time" brightness levels can be adjusted and set.

Both levels can be changed, in the cockpit, in flight, at any time. There are 16 brightness levels, cycling through to the maximum, then starts over from the lowest light setting.



Cover Photo Cell here to simulate "DARK" setting or shine light to simulate "DAYTIME" setting.

Quickly press and release brightness button until desired brightness is reached.



(COMPLETELY FUNCTIONAL) Set points have been entered and when in-flight, will display the AOA, (amount of lift) calibrated to the aircraft.

Figure 3.2

3.9 Amplified (On the Ground) Calibration Procedures:

When powering the system on for the first time, **ALL** segments on the AOA DISPLAY **should** continuously flash on and off simultaneously, indicating a non-calibrated system.

Step 1 (On the Ground) Calibrating the Zero Pressure Point

This must be done in a zero pressure condition, preferably in a calm environment such as a hanger or no wind environment.

While pressing the **CAL** button on the AOA DISPLAY, apply power to the system.

Continue pressing the **CAL** button for about 5 seconds after power has been applied.

All the segments stop flashing after a few seconds (**see note below**), this indicates the Zero Pressure value at the sensor is good and will be stored to system EEPROM and used as the system zero pressure point.

Release the **CAL** button, the Legacy AOA DISPLAY will flash the **Green “Doughnut”** and the **Blue Bar** 5 times, indicating both in-flight (OAA and Cruise); set points **MUST** be entered and then stored.

The operator MUST calibrate the system to the aircraft’s lift performance.

Refer to the next sections.

Otherwise:

If all segments on the AOA DISPLAY continue to flash, the Zero Pressure value at the sensor is too high and indicates something is wrong electrically or mechanically with the system, or something in the environment is affecting the system.

The system will flag the bad Zero pressure value and continue to flash all segments, even if the system is powered off and on, until an acceptable zero offset has been detected by repeating the above procedure.

To isolate the failure between mechanical or electrical, the air hoses should be disconnected from the AOA Interface Module and the above operation repeated.

If the condition persists, then the failure is electrical and the AOA Interface Module should be returned for an authorized repair.

If the setting is successful, then the failure is mechanical such as a blockage in the air hoses, etc. Once the mechanical failure is fixed, the above operation should be repeated.

Note: This is a power on procedure.

Because there is a power ON settling time for the electronics, **ALL DISPLAY SEGMENTS** on the AOA DISPLAY may flash several times before the system electronics stabilize and then stop flashing for an acceptable / valid zero pressure point that can be stored.

Setting Brightness Level of the Display Segments (On the Ground)

This step will allow the “Night Time and Day Time” brightness levels be set on the ground. Both the day time and night time levels can be changed at any time while in flight. This procedure makes it possible to “preset” the brightness before the in-flight calibration steps are completed.

Press and hold the **Brightness** button on the AOA DISPLAY. Turn power “**ON**”. Continue to hold the **Brightness** button depressed for about 6 seconds, release **Brightness** button.

The system will enter the diagnostic segment illumination routine, where all segments are illuminated one by one upwards, then, one by one downwards, ending with **ALL** segments being illuminated.

The system is now in the “Brightness Calibration Mode”.

Night Time Brightness Set Point:

Cover the photo diode on the AOA DISPLAY with your thumb or a piece of black electrical tape. Quickly press and release the **Brightness** button on the AOA DISPLAY cycling through the **16** brightness steps until the display is at a minimum or lowest level. This sets the “Night Time” brightness initial setting. **Wait 5 seconds for the unit to store the setting**, uncover the photo cell.

Day Time Brightness Set Point:

With a light applied directly to the photo diode on the AOA DISPLAY, quickly press and release the **Brightness** button on the AOA Display, cycling through the **16** brightness steps, until the display is at the maximum brightness (you’ll know when it’s max because going past it will cause the brightness of the display segments to return to the minimum level).

Wait 5 seconds for the unit to store the setting. Remove the light from the Display.

The Legacy display brightness will switch to a lower brightness unless the low light setting was set to maximum brightness or the cockpit is in daylight.

Remove power, wait a few seconds, and then **re-apply power**.

The system should enter its diagnostic display segment illumination routine in which all segments are illuminated one by one upwards, then, one by one downwards, then enter the **active** or **in-active** display mode, dependent on whether the system has been calibrated or not.

**You know the old saying, it’s not finished until the paper work is done.
Please refer to chapter four and document your work.**

4.1 Background Information:

The Alpha Systems Angle of Attack System (AOA) may be installed on many aircraft models numerous ways. For this reason we can not point you to a boiler plate logbook entry or sign off that will be good for all aircraft. We will help you through the documentation process by explaining pertinent topics and direct you in the proper direction by employing those topics in sample logbook entries.

4.2 Major vs. Minor Alteration:

In subject 1.3 we discussed the difference between a major and minor alteration, again **“a minor change is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics or other characteristics affecting the airworthiness of the product”**. In Chapter 2 some scenarios were listed that may in our judgment make the installation a major alteration; **however this determination is the responsibility of the person performing the installation**. If a determination was made that:

- The alteration was a **minor** alteration, the aircraft can be returned to service by an appropriately rated mechanic or by an individual that holds a repairman's certificate for that specific aircraft by documenting the alteration in the aircraft records.
- The alteration was a **major** alteration, the FAA must be informed. The form used to report the alteration and the FAA's response shall be determined by what part of the FAR's the aircraft was certified under. For example:
 - If a certified mechanic with “Inspection Authorization” (IA) **makes** a major alteration to a type certificated aircraft using **approved data** (STC's, AD's, etc.) he/she must simply report that alteration to the FAA on a form 337 by mailing it to them at Oklahoma City within 48 hours of returning the aircraft to service, no response is required by the FAA.
 - If a certified mechanic with “Inspection Authorization” (IA) **intends** to make a major alteration to a type certificated aircraft using **acceptable data** (i.e. AC43.13-1B, AC43.13-2B, etc.) he/she must submit a FAA form 337 to the local FSDO describing the work to be completed referencing that acceptable data **prior to commencing the work**. The FAA's response will normally be to approve the acceptable data by signing block 3 on the 337 form and returning it to the mechanic, this is referred to as a “Field Approval”. Once the alteration is completed and the aircraft is returned to service the mechanic must mail the completed 337 form to the FAA at Oklahoma City within 48 hours of returning the aircraft to service.
 - If a certified mechanic or a person holding a repairman's certificate for a specific experimental aircraft make or intend to make a major alteration to that aircraft they must report that alteration to the cognizant **FSDO** and **receive a written response prior to further flight**. There is no specific form that must be used to report the alteration; however the FAA will use the data you submit to determine if your alteration would require your aircraft to be returned to Phase 1 for further flight testing. So it would be to your benefit to report the alternation using references of acceptable data so your aircraft will not be returned to Phase 1 unnecessarily.

4.3 Logbook Entries:

The pertinent parts of FAR § 43.9 (in italics) that describes the requirements for content, form, and disposition of alteration records that pertain to the A.O.A. installation are listed below. I will attempt to explain the intent of the FAR as it applies to this installation.

*(a) Each person who maintains, performs preventive maintenance or **alters an aircraft** shall make an entry in the maintenance record of that equipment containing the following information:*

*(1) A description (or reference to data acceptable to the Administrator) of work performed. **(The FAA would like a description of the work completed and under what authority was this alteration done. Your description of the work along with references to acceptable data satisfies this requirement. Acceptable data, listed in chapter two of this manual, may be used to support the description of the alteration).***

*(2) The date of completion of the work performed. **(Self explanatory).***

*(3) The name of the person performing the work if other than the person specified in paragraph (a)(4) of this section. **(If work was performed on an airframe by anyone who does not hold an airframe mechanic/repairmen certificate, which is allowed under the authority of FAR § 43.3(d), their name should be included in the logbook entry).***

(4) If the work performed on the aircraft has been performed satisfactorily, the signature, certificate number, and kind of certificate held by the person approving the work. The signature constitutes the approval for return to service only for the work performed.

(The FAA wants to know who is responsible for returning the aircraft to service. This could vary from a private pilot performing preventive maintenance in accordance with § 43.3(g) to an A&P mechanic with IA returning a certified aircraft to service after a major alteration. Please refer to subject 4.2 for a more in depth explanation of who can return your aircraft to service after the installation of the A.O.A. system).

(d) In addition to this entry, major alterations shall be entered on a form, and the form disposed of, in the manner prescribed in appendix B, by the person performing the work.

(This is the requirement to notify the FAA described the 4.2 of this manual).

Please read on, it gets better, it has too. Let me explain by using examples of logbook entries.

For the first example, an A&P mechanic installs the angle of attack system in a customer's Flight Master 128, a certified aircraft. She has made a determination that the installation is a minor alteration. In this case only a logbook entry is required to return the aircraft to service. She could make the following basic entry fulfilling the requirements of § 43.9:

July 22, 2010, installed an Alpha Systems Angle of Attack System, part number DSTR-AOA-9000K, in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX.

Stacy R. Aviator
A&P 546324567

However, Stacy is a very conscientious mechanic and wants to make an entry that not only meets the FAR requirements but also documents the alteration in enough detail so that if a question arises in the future it can be remedied by simply reading the entry. She decides to make the following entry:

July 22, 2010

Aircraft Total Time: 358.2

To facilitate installing an Alpha Systems Angle of Attack System, part number DSTR-AOA-9000K, the following work was performed:

- Removed an existing inspection panel on the left wing 24" inboard of the wing tip at station 121. The probe mounting plate was trimmed to fit the opening and attached with a quantity of 8 AN526C832R8 screws. Successfully performed a structural analysis and static test in accordance with AC43.13-2B Chapter 1. Removed the mounting plate, prepped, primed and painted the mounting plate.
- Routed two sense lines from the left glare shield to the location of the probe in the left wing in accordance with AC43.13-1B Chapter 12 Section 4 Paragraph 61(a&b).
- Installed the probe, part number AOA-4027, to the probe mounting plate and connected the sense lines. Installed the probe assembly to the opening on the left wing at station 121 and attached with a quantity of 8 AN526C832R8 screws.
- Installed an Alpha Systems Angle of Attack Indicator, part number DSTR-AOA-9000, serial number AOAI0630-03, above the airspeed indicator on top of the glare shield in accordance with AC43.13-2B Chapter 1 and Chapter 2 paragraph 205(a-c).
- Installed an Alpha Systems Angle of Attack, AOA Interface Module, part number DSTR-AOA-1700, serial number AOAI0630-03, behind the instrument panel on the avionics shelf at station 119, in accordance with AC43.13-1B Chapter 11, AC43.13-2B Chapter 1 and Chapter 2 paragraphs 201, 202, 204 & 207.
- Inspected the Alpha Systems A.O.A. installation and performed the initial system power up, the (on the ground) zero pressure set point calibration and (on the ground) brightness calibration procedures.

Additionally all work described above was done in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX and in accordance with § 21.93(a) & 43.13(b). This airframe alteration is considered a minor alteration and is at least equal to its original condition.

- The "In-Flight" calibration procedures need to be performed in accordance with Chapter 5 of the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX and the satisfactory results recorded in the permanent aircraft records.

Stacy R. Aviator
A&P 546324567

NOTE:

If this was an experimental aircraft and the owner held a repairman certificate, for that specific aircraft, he/she could also return the aircraft to service.

After the “In-flight” calibration of the angle of attack (AOA) system, the aircraft owner made the following entry:

July 23, 2010

Aircraft Total Time: 359.3

A series of flights were made to successfully complete the in-flight calibration procedure. The probe angle after calibration is 52 degrees. The probe mounting bolt was tightened, the set screw was installed and the mounting plate was reinstalled. Performed in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX. Chapter 5.

Joe B. Aviator (no relation to Stacy)
Commercial Pilot Certificate # 546324567

In this next example an aircraft owner is very handy but does not hold a mechanic or repairmen certificate but would like to do the installation. He may, under FAR § 43.3(d) the installation may be performed under the supervision of a certificated mechanic. Stacy has developed a good reputation for doing a nice job on the installation of the A.O.A. system and has agreed to supervise Paul. She adds Paul’s name as the person performing the work when she makes the logbook entry.

August 12, 2010

Aircraft Total Time: 1432.2

To facilitate installing an Alpha Systems Angle of Attack System, part number DSTR-AOA-9000K, the following work was performed:

- Removed an existing inspection panel on the left wing 32” inboard of the wing tip at station 136. The probe mounting plate was trimmed to fit the opening and attached with a quantity of 8 AN526C832R8 screws. Successfully preformed a structural analysis and static test. Removed the mounting plate, prepped, primed and painted the mounting plate.
- Routed two AOA sense lines from the left instrument panel to the location of the probe in the left wing.
- Installed the AOA probe, part number AOA-4027, to the probe mounting plate and connected the AOA sense lines. Installed the probe assembly to the opening on the left wing at station 136 and attached with a quantity of 8 AN526C832R8 screws.
- Installed an Alpha Systems Angle of Attack Indicator, part number DSTR-AOA-9000, serial number AOAI0630-03, left of the airspeed indicator in an existing hole.
- Installed an Alpha Systems Angle of Attack AOA Interface Module, part number DSTR-AOA-1700, serial number AOAI0630-03, on the base of the glove box at station 124.
- Inspected the Alpha Systems A.O.A. installation and performed the initial system power up, (on the ground) zero pressure set point calibration and (on the ground) brightness calibration procedures.

Additionally all work described above was done in accordance with AC43.13-1B Chapter 11 & 12 section 4 Paragraph 61(a&b), AC43.13-2B Chapter 1 & 2 paragraphs 201, 202, 203(a-e) & 207 and in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX by Paul R. Pilot under my supervision.

In accordance with FAR § § 21.93(a) & 43.13(b) this airframe alteration is considered a minor alteration and is at least equal to its original condition.

The in-flight calibration procedure needs to be performed in accordance with Chapter 5 of the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX and the satisfactory results recorded in the permanent aircraft records.

Stacy R. Aviator
A&P 546324567

On the above entry, notice that the references to acceptable data were listed at the end of the entry rather than with the individual steps, either way is acceptable.

Paul is a student pilot so he had his flight instructor make the calibration flight and the following logbook entry:

August 16, 2010

Aircraft Total Time: 1432.8

The A.O.A. in-flight calibration procedures were successfully performed in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX. Chapter 5.

Justin C. Lindberg
Commercial Pilot Certificate # 546324567

Justin is not a mechanic or the aircraft owner so Stacy performed the work listed in her entry below:

August 16, 2010

Aircraft Total Time: 1432.8

The probe mounting bolt was tightened, the set screw was installed and the mounting plate was reinstalled. Performed in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, Rev XX. Chapter 5.

Stacy R. Aviator
A&P 546324567

(As a side note Paul and Stacy are now dating.)

Stacy's name is getting around and she is doing quite a few of the A.O.A. installations. She is approached by a customer that has a Flight Master 240, a Twin, and he would like the Alpha Systems A.O.A. system with the probe heat option. After reviewing Chapter 2 she determines that the only thing that would qualify as a major alteration is the addition of the probe heat because of the electrical load. She explains this to the aircraft owner and offers two options. The first is to fill out a FAA form 337 for the entire A.O.A. installation and submit it to the FAA for a field approval or do the installation now as a minor alteration without the probe heat and submit the paper work for the addition of the probe heat and install it at a later date. The owner decides to have the A.O.A. system installed now since he will be back later this fall for the annual anyway. Stacy did the installation and made a similar logbook entry as before and she followed AC43-210 and submitted a 337 form along with Instructions for Continued Airworthiness (ICA) to the FAA for a field approval of the probe heat, below is the narrative from box 8 of the 337 form.

Flight Master 240 Serial number: 123, Registration: N14U, August 18, 2010

Paragraph 1.) The objective of this alteration is to install the probe heat option to a previously installed Alpha Systems angle of attack system.

Paragraph 2.) Install probe heater in accordance with the Alpha Systems Installation and Operations Manual, IOM-Legacy, REV XX. and AC43.13-1B Chapter 11 and AC43.13-2B Chapter 2 paragraph 207.

----- END -----

As you can see she kept it short and sweet. **Before requesting a field approval ensure your request meets the criteria for a major alteration, fill out the paper work completely, use appropriate acceptable data and keep it simple.** The FAA does not want to spend time reviewing requests for field approvals when the alteration can be done as a minor alteration.

Here is another example from box 8 of FAA 337 form. Stacy submitted this prior to doing the work on Joe's A.O.A. installation. The work was done the morning of July 22 and she made an appropriate logbook entry prior to beginning the work on the A.O.A. installation.

Flight Master 128 Serial number: 321, Registration: N4JA, July 12, 2010

Paragraph 1.) The objective of this alteration is to install an inspection panel, identical to other inspection panels found along station 121 in lower skin of the left wing, 24" inboard of the wing tip equally distant between two ribs at station 121.

Paragraph 2.) Cut a 4" x 6" oval hole in the area described in paragraph 1. Install a doubler assembly, Flight Master part number DBLR-240LW. Fabricate an inspection cover from .032" 2024-T3 aluminum prep and paint. Secure the inspection cover with Qty. 8 AN526C832R8 screws. Work was performed in accordance with the AC43.13-1B Chapter 4 Section 4.

----- END -----

For more information please refer to AC43-210 which describes the field approval process and AC43.9-1F, instructions for completing the 337 form.

4.4 Documentation Review:

If the installation is determined to be a **minor** alteration; then the aircraft can be returned to service with a logbook entry by a certificated mechanic or a person that holds a repairman's certificate for that specific aircraft.

If the installation is determined to be a **major** alteration; then the aircraft can be returned to service with a logbook entry by a person that holds a repairman's certificate for that specific aircraft, certificated mechanic or a certificated mechanic with inspectors authorization, (depending on the aircraft) **AND** the FAA has been informed of the major alteration and a written response is received authorizing flight after the alteration or a Field Approval is granted.

The calibration flight(s) may be conducted under §91.407 by at least a private pilot that is rated to fly the aircraft. §91.407(b) regarding carrying persons other than crew members, only applies if the alteration has appreciably changed its flight characteristics or substantially affected its operation in flight, which should not be the case with this alteration. The adjustment and tightening of the probe may be accomplished by a mechanic, a person that holds a repairman's certificate for that specific aircraft or the aircraft owner if they hold at least a private a private pilot certificate under part §43.3(g) and Appendix "A" to Part §43 item (c)(26). These events need to be documented by the person performing the procedure(s); it can be done in one entry if performed by the same person.

The logbook examples demonstrate various ways to document work. The more detailed entries require additional time and effort but may be invaluable down the road if questions arise. **In addition many people judge the quality of the work performed by the logbook entry.** One word of caution is that when doing your installation and paper work include only references that were actually complied with. Including references that were not actually complied with, just to make the entry look better, could be considered fraud.

Notes: In an effort to make the documentation process easier, the entry can be made on any computer and printed (**do not use water based ink**) on plain paper and attached to the log book using a glue stick.

Stacy and Paul are engaged now but are a little embarrassed by all the attention they've been getting, so if you meet either one of them please don't bring up their blossoming romance.

When the aircraft is returned to service the in-flight calibration flight is next.

5.1 Background Information:

Angle of Attack (AOA) is the difference between the airfoil's cord line (a line from the leading edge to the trailing edge of the wing) and the relative wind (the inverse of the aircraft flight path).

Coefficient of Lift (C_L) is a relative measure of an airfoil's lifting capabilities. High lift airfoils found on typical general aviation aircraft have a curved or cambered upper surface and a flat lower surface. Airfoils found on high performance aircraft will typically have a thinner symmetrical airfoil. The C_L in both airfoils will increase with angle of attack until the stalling angle (C_{Lmax}) is reached at which point the C_L drops off rapidly. A plot of C_L vs. angle of attack will typically show C_L increases in a straight line for both airfoils to C_{Lmax} . A key difference between the two airfoils would be the high performance airfoil will generally stall at a much lower angle of attack than the high lift airfoil.

AOA Probe Angle and In-Flight Calibration Correlation

The Alpha Systems instrument derives **AOA / LIFT** measurement from the aircraft by the means of an AOA probe that's mounted solidly to the aircraft. The AOA value consists of the AOA of the wing (**when in flight**) combined with the angle of the AOA probe at differential pressures derived throughout the entire flight envelope of the aircraft in which it's installed.

The electronics must see data within a given range to allow for a linear and full scale reading. Due to the number of aircraft and other variables; stall angles, wing designs, coefficient of lift values, mounting locations, and so on, the probe angle will be initially set at an angle of 50 degrees to the cord of the wing. In most aircraft, starting angle would be derived from the bottom of the wing skin. During the calibration flight, the electronic display will give direct feedback (when in calibration mode and in flight), if the pressure values received from the AOA probe are outside the range to give a proper full scale display indication, the system will flash combinations of segments indicating which direction to change the probe.

DISPLAY EXAMPLES:

If the data is too **LOW**, (when in the **OAA** calibration mode) the display will flash the **RED CHEVRON** together with the entire **GREEN CIRCLE**, indicating the AOA probe angle must be increased, or pulled downward a minimum of 10 degrees, the computer rejects the attempted calibration value, keeping the unit inactive until a valid calibration set point has been entered.

If the data is too **HIGH**, (when in the **OAA** calibration mode) the display will flash the **GREEN CIRCLE** along with the **YELLOW CHEVRON** indicating the AOA probe angle must be decreased, or pushed upward a minimum of 10 degrees, the computer rejects the attempted calibration value, keeping the unit inactive until a valid calibration set point has been entered.

Once the computer accepts the AOA data representing a valid set point for **OAA**, the display will correspond by illuminating the entire **GREEN CIRCLE, (GREEN DOUGHNUT)** to the aircrafts' flight dynamic, repeatably. The pilot must then, change to the "**CRUISE**" calibration set point mode, fly at a cruise setting, straight and level, holding altitude, push the "**CAL**" button, the display will illuminate the **BLUE horizontal bar** indicating large amount of Lift, or Cruise flight. The final step of the calibration procedure is to store the 2 valid values (**OAA, CRUISE set points**) by depressing and holding the **Brightness / Mode button** for 5 seconds. Once the computer stores the 2 set point values, the unit will enter the segment illumination routine, by counting up, then down, then indicate the aircrafts' current **AOA** value, FULLY FUNCTIONAL.

The Alpha Systems AOA, Angle of Attack System has 2 In-Flight Calibrated Set Points.

1.) **Optimum Alpha Angle, (OAA).** Alpha Systems AOA defines **(OAA)** as the aircraft's ability to be flown, in slow flight, by the pilot and identify empirically the combination of the following: **A.)** at safe altitude, slow flight with a reduced power setting (such as down wind or pattern power setting) **B:)** continue to pitch back to a point where the aircraft is no longer able to climb (0 vertical speed, 5 to 10 FPM climb max), **NOT** in a descent, **Zero sink**, able to hold altitude with, **C.) FULL** aileron and rudder control which identifies the aircrafts **minimum** complete controllable set point **(OAA)** and the display indicating the **GREEN DOUGHNUT**.

2.) **Cruise Set Point.** Once the **OAA** set point is flown, identified and stored in the system, **(Step 2)**, The In-flight **Cruise** set point mode must be entered, (by pressing and holding the **Brightness** button **(>6 sec.)**). The pilot adds power, fly's straight and level, holding altitude, at a Cruise setting for the aircraft, when reached, pushes the **CAL** button storing the value by an indication of the **BLUE BAR** being illuminated.

This set point allows the system to create a linear AOA range from **Cruise** to **OAA**, and from **OAA** up to **Stall**. Once the calibration mode is exited from, **which stores both set points**, allowing the system to become functional for the range identified by the pilot for the aerodynamics unique to the aircraft flown.

The AOA system is calibrated **IN-FLIGHT** and uses a highly identifiable reference point " α " (**FULL GREEN Circle / Doughnut**) to indicate this angle **(OAA)**. Once the pilot has completed the calibration procedure, setting both **OAA** and **Cruise**, the AOA system can be used to identify angles of attack related to aircraft performance, such as **approach, OAA, cruise, maximum range, Vso, stall**, and **best glide** to name a few. Once identified by the corresponding segments, these AOA angles may be used repeatably and accurately at any weight or density altitude, **every time**.

5.2 Setup and In-Flight Calibration:

The calibration flight(s) may be conducted under §91.407 by at least a private pilot that is rated to fly the aircraft. The adjustment and tightening of the probe may be accomplished by a mechanic, a person that holds a repairman's certificate for that specific aircraft or the aircraft owner if he/she holds at least a private pilot certificate under part §43.3(g) and Appendix "A" to Part §43 item (c)(26).

This procedure may be done as a single pilot operation however it does require your attention to be diverted away from flying the airplane. In the interest of safety may we recommend that you solicit the aid of someone that can perform the calibration procedure while you fly the airplane or vice versa.

Use the following outline as a guide to complete the in flight calibration:

- Review the aircraft records; ensure that the return to service entry has been made.
- Plan a flight to an area where slow flight can be performed without any undue hazards (reference § 91.303 & § 91.305).
- Review stall recovery and minimum controllable flight procedures for your aircraft.
- Acquaint yourself with the AOA indicator and its controls (Figure 6.1).
- Preflight and operate the aircraft as you would normally.
- When in an area where slow flight can be performed and the air is smooth. Perform clearing turns to ensure the area is clear.

ANYTIME THE AIRCRAFT IS STALLED; PERFORM THE STALL RECOVERY PROCEDURE FOR YOUR AIRCRAFT.

- Follow the aircraft procedures and slow the aircraft, in the clean configuration, to minimum controllable flight.
 - Maintain coordination.
 - Maintain altitude with the pitch (use pitch trim to relieve back pressure).
 - Use power as needed to maintain flight just above a stall (stall warning continuously activated and occasionally feeling stall buffets).
- Perform the in-flight calibration procedure found in figures 5.1a and 5.1b or from the amplified procedures found in section 5.4 for the Optimum Alpha Angle (**OAA**) and the **Cruise** set points.
- Recover from slow flight.
- Accelerate to normal cruise in level flight, we recommend a power setting for long range cruise.
- Return to the airport and shut down the aircraft.

Note:

If the AOA display indicates a "Bad Set Point", return to the airport and have the necessary angle adjustments made to the AOA probe. When the AOA probe angle adjustments have been made, perform the **entire in-flight calibration procedure** outlined in this section until you are successful.

CAUTION:

DO NOT ALLOW ANY AOA PROBE ANGLE ADJUSTMENTS TO BE MADE WITH THE ENGINE RUNNING.

5.3 Completing the Calibration:

- Exit the Calibration Mode (**Stores the 2 values OAA, Cruise**).
- Confirm the angle of the AOA probe and write it down.
- Remove the probe assembly from the aircraft.
- Tighten the AOA probe mounting bolt to 60 ± 10 inch pounds.
- Add set screw to probe mounting plate and tighten to 30 inch pounds.
- Reinstall probe assembly.
- Ensure the AOA probe has not and will not move, **caution: do not over stress the structure**.
- Re-check the probe angle to ensure it has not moved.
- Refer to chapter four and make the necessary logbook entry(s).
- Verify in-flight set points **OAA** and **Cruise** compare to previous segment indications.

Satisfactorily completing chapters 1-5 finishes the installation process.

You should be proud, installing the system as outlined; required well thought-out decisions and hard work, **Congratulations!!!**

Please refer to chapter 6, Operations, for Operating Information.

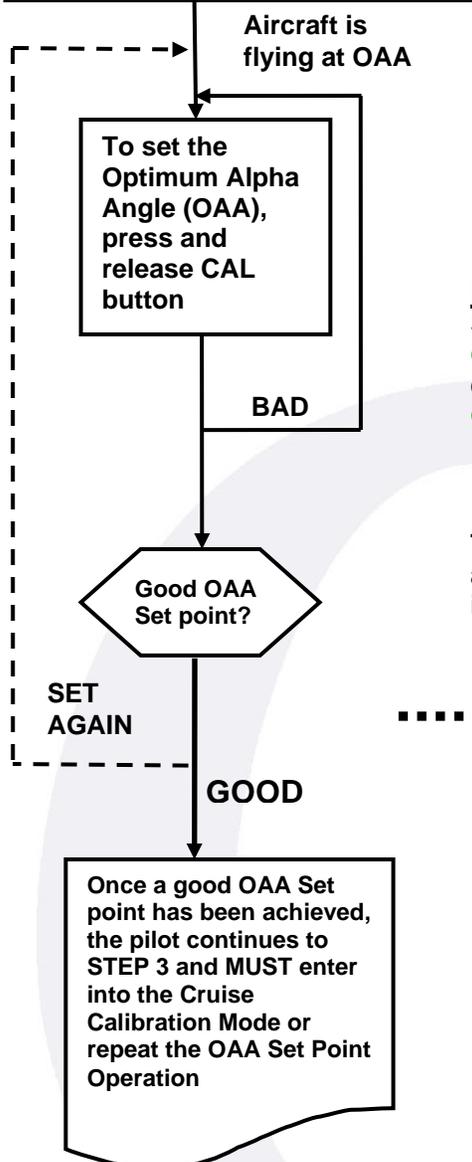
STEP 2
(OPTIMUM ALPHA ANGLE SET TPOINT)

Setting the Alpha Systems (OAA) Set Point

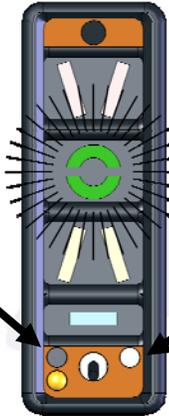
Press and hold the Brightness button (>6 sec.) until the **Green Circle** blinks 3 times, then twice every 6 sec. until valid value is entered and OAA calibration mode is exited. Optimum Alpha Angle (OAA) Set Point Calibration mode entered. Climb to altitude / pitch to OAA

In-Flight calibration requires the pilot to climb to a safe altitude for slow flight maneuvers. Aircraft will be put into the flight condition of Optimum Alpha Angle (OAA): Aircraft is at the **Optimum Alpha Angle (OAA)**:

- 1.) Aircraft is at a safe altitude for slow flight maneuvers.
- 2.) Minimum controllable flight, lower power setting, (such as a down wind or landing pattern power setting).
- 3.) Able to hold altitude, 0 Vertical Speed, **not descending, zero sink** (5 to 10 fpm climb OK if your aircraft loses flight control stability at 0 VS).
- 4.) Full aileron, elevator and rudder control, pilot to identify the set point by pitching back slowly to a pitch no longer able to climb but able to hold altitude with full control of the airplane.



Step 2
Quickly press and release to calibrate when flying aircraft at (OAA)



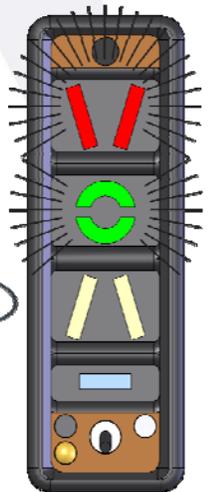
Step 1
Press and hold Brightness button (>6 sec.) until the Green circle blinks 3 times

Bad Set point: Too Low (out of range):

Set point too low – the **Red chevron** and the **Green Circle** flash ON and OFF 3 times, the display will remain inoperative; then just the **Green Circle** continues to blink every 6 seconds.

The probe must be repositioned so the angle between the wing and the probe is increased by 10 degrees (toward vertical)

Tip 10 degrees back

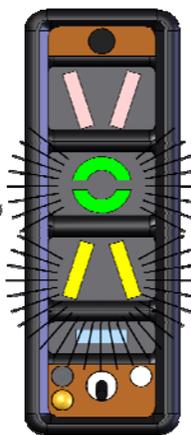


Bad Set point: Too High (out of range):

Set point too high – the **Green Circle** and the **Yellow Chevron** flash ON and OFF 3 times. The display will remain inoperative; then just the **Green Circle** continues to blink every 6 seconds.

The probe must be repositioned so the angle between the wing and the probe is decreased by 10 degrees (toward horizontal)

Tip 10 degrees forward



Note: 1.) When in the Optimum Alpha Angle (OAA) Calibration mode, if the **Brightness** button is depressed and held (>6 sec.) with no (OAA) value entered, the **Green Circle** will blink 3 times, then continue to flash twice every 6 seconds indicating (OAA) has **NOT** been set. The AOA system will remain at the Optimum Alpha Angle (OAA) Set Point Mode until a valid value has been entered.

Figure 5.1a

Step3
(CRUISE SET POINT)
IN-FLIGHT CALIBRATION

Setting the Alpha Systems
AOA Cruise Set point

Press and hold the
Brightness button (>6 sec.)
until the **Blue Horizontal Bar**
blinks 3 times.
(Cruise Set Point Calibration
mode entered)

Cruise flight
ACHIEVED

To set the Cruise Set
point, press and
release CAL
button

Good Set
Point?

SET
AGAIN ?

GOOD

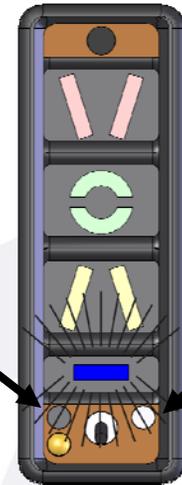
To EXIT calibration mode,
press and hold the
Brightness button (>6 sec.)
until the segments on the
AOA Display start to
illuminate one by one
upwards and then one by
one downwards
(This completes calibration)

Operational Mode
Pilot to identify other
aircraft In-flight
values

Figure 5.1b

The pilot must fly the aircraft at a "Cruise" In-flight condition, straight and level, holding altitude at Cruise power. This procedure sets the display to indicate "Cruise" AOA for the aircraft.

STEP 1
Press and Hold
Brightness /
Mode
Button (>6
sec.) until
the **Blue Bar**
blinks 3
times



STEP 2
Quickly
press and
release CAL
button when
flying at
"Cruise"

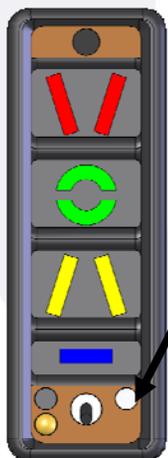
BAD Bad Set Point:
Set point too low – the **Blue Bar** will flash 3 times ON and OFF, Either the aircraft is not in Cruise or value out of range.

Good Set Point:
The display will change to represent the new **Cruise** set point, illuminating the **Blue Bar**. The operator can set it again or exit calibration Mode, storing the values, putting the system in functional mode.

Note: When in **Cruise** Calibration mode, if the Brightness button is pressed and held (>6 sec.) AND a good **Cruise** set point has **NOT** been entered; The **Blue Bar** will flash ON and OFF. The AOA system will remain at the **Cruise** Calibration mode. The system forces the operator to enter the valid value for Cruise. The operator must exit the calibration sequence to have the AOA system store the identified values for the systems to give the appropriate AOA.

NOTE:
The **Blue Horizontal Bar** will flash twice every 6 seconds until a valid cruise setting is entered and Cruise calibration mode is exited.

Note: this sub-step must be taken in order to complete the calibration process **storing** the values, and put the AOA system in an operational display mode when powered on.



TO RE-CALIBRATE ALL IN-FLIGHT SET POINTS (RE-ENTER STEP 2) (OAA), PRESS AND HOLD THE BRIGHTNESS BUTTON (>6sec.) UNTIL THE **GREEN DOUGHNUT** BLINKS ON AND OFF 3 TIMES. (GO TO STEP 2 FLOWCHART).

Written Calibration Overview

The calibration of the Alpha Systems AOA has **3 simple steps**:

- 1.) (On the ground) **Zero** offset calibration.
- 2.) (In-flight) Optimum Alpha Angle (**OAA**) calibration.
- 3.) (In-flight) **Cruise** calibration.

Included in this manual are detailed definitions for each step and associated flow charts to assist the pilot for easy step by step calibration.

It is recommended, to make calibration easier, that the pilot flies the aircraft, a second person follow the calibration procedure and enter the appropriate set points for the instrument. **At ALL times**, flying the aircraft in a safe manner controlled by the Pilot -in- Command at safe altitude to maneuver the aircraft in slow flight.

Step 1: Zero Calibration (On the Ground)

The first calibration step after installation and electrical connections are complete, is to calibrate the Zero pressure set point. When power is applied for the first time, if all SEGMENTS flash, the unit is indicating ground Zero calibration procedure must be completed.

To set the Ground Zero value, with power off, depress and hold the “**CAL**” button. **WHILE holding the “CAL” button depressed**, turn AOA power ON, The segments should stop flashing after a few seconds, release “**CAL**” button, the unit will flash the “**Green Doughnut**” and the “**Blue Bar**” 5 times, indicating the Zero calibration value is valid and stored and the In-Flight **OAA** and **Cruise** calibration must be completed.

The Zero calibration can be reset at any time after the initial calibration; however, **ALL** in-flight set points **must** be reset and identified.

Step 2 and Step 3: Calibration of Optimum Alpha Angle (OAA) and Cruise (In-Flight)

The Alpha Systems AOA has two “**Calibrated**” In-Flight set points, **OAA** and **Cruise**, identified by the pilot at safe altitude. These 2 set points will be calibrated in flight to the airplane by the pilot, correlating the appropriate COLORED SEGMENTS for each angle of attack dynamic.

The Brightness / “MODE” Button

The brightness button is used for 2 functions: **1)** Changing the brightness level of the segments by quickly pushing and releasing the button. **2)** As a **MODE** switch, (**by depressing and holding for longer than 6 sec.**) to enter into, change, and exit the calibration steps.

The CAL Button

The **CAL** button is located at the bottom left corner of the case and is a black round button, recessed below the display surface. The button can be lightly depressed with a Pen or a PDA pointer.

After ALL the Calibration Set Points are Entered and Stored

After the Alpha Systems AOA has been calibrated, the pilot is able to identify other in-flight reference points such as: Max Climb Angle, Stall, Best Glide, V_{so}, Best Climb, indicated by the colored segments corresponding to those in-flight values.

To Match Aircraft's AOA to a Flight Value:

i.e.) **Best Glide**, Determine aircraft's exact Best Glide airspeed number from the pilot operating handbook, identify aircraft's total weight, compensate for density altitude values, add or subtract to give the pilot an accurate airspeed number. Fly aircraft to the designated Best Glide airspeed.... When holding that calculated airspeed, The AOA (**corresponding illuminated colored segment**) will always be the same Best Glide AOA from then on, regardless of gross weight changes, density altitude, and attitude.

5.4 Amplified OAA Calibration Procedure (In-Flight):

- From the factory, the unit is **NOT CALIBRATED**. The installer / pilot **MUST** complete **BOTH** the (on the ground) **Zero pressure** and **BOTH in-flight** calibration procedures of **OAA** and **Cruise**.
- After installation is complete and when power is applied for the first time; **ALL SEGMENTS** on the AOA DISPLAY should continuously blink on and off, indicating a **non-calibrated** system. Go to **Step 1 (On the Ground) Zero pressure**.

Step 2) Calibrating the Optimum Alpha Angle (OAA) Set Point (In-Flight Calibration)

The system must be put into the Calibration mode of **Optimum Alpha Angle (OAA)**.

Calibration Mode can be entered on the ground or in the air.

To Enter the Set Point Calibration Mode (After Power is On):

(Press and hold the **Brightness** button for longer than 6 sec.) or when the **Green Doughnut** blinks ON /OFF 3 times.

Release the **Brightness** button.

The system has now entered the **Optimum Alpha Angle (OAA)** calibration mode, which will be identified by the **Green Doughnut** blinking twice every 6 sec.

Note: The **Green Doughnut** will blink twice, every 6 seconds, until a successful setting is entered and the **OAA** calibration mode is exited.

Fly Aircraft at a Safe Altitude and Identify:

- The aircraft is at the **Optimum Alpha Angle (OAA)** when the following :
 - 1.) Aircraft is at a safe altitude for slow flight maneuvers.
 - 2.) Minimum controllable flight, lower power setting, (such as a down wind or landing pattern power setting).
 - 3.) Able to hold altitude, **not descending, minimum climb ability, ZERO SINK, (5 to 10 FPM climb OK if aircraft loses flight control stability at 0 V.S.)**.
 - 4.) Full aileron, elevator and rudder control, pilot to identify the set point by pitching back slowly to a pitch no longer able to climb but able to hold altitude with full control of the airplane. **NOT IN A BUFFETING CONDITION.**

To Save the Optimum Alpha Angle (OAA) Set Point:

Quickly press and release the **CAL** button on the AOA DISPLAY.

Note: *This operation can be repeated as many times as desired as long as the system is in the Optimum Alpha Angle (OAA) Calibration Mode.*

If the Setting was Successful:

The AOA DISPLAY will save the new set point in the system and the unit will become active. This set point must be verified by the pilot to identify correlation for the Optimum Alpha Angle (**OAA**) of his or her airplane to the display indicating The **“Green Circle / Doughnut”** at that flight condition.

Continue on to Step 3

IF THE OAA SET POINT WAS NOT SUCCESSFUL

The AOA display returns to an inactive state, discards the attempted set point (**value out of range**) and will continue to blink the **“Green Doughnut”** twice every 6 seconds until a valid **OAA** set point has been entered and the **OAA** calibration mode is exited. The system will flash a combination of colored segments to give feedback to the pilot indicating the angle of the AOA probe is incorrect and must be moved, to allow the display to indicate a proper full scale AOA value.

IF

The (**Green Doughnut + Red Chevron**) flashes simultaneously 3 times at a rapid rate:

This indicates that the set point is too LOW.

The AOA probe angle must be changed to an **increased angle** to the wing. If the entered set point is unsuccessful after several attempts, the aircraft should be landed and the AOA probe angle repositioned so the angle between the wing and the probe is **increased** by 10 degrees (**away from wing**). The in-flight (**OAA**) calibration procedure should be retried.

(Return to Step 2)

Or The (**Green Doughnut + Yellow Chevron**) flash simultaneously 3 times at a rapid rate:

This indicates that the set point is too HIGH.

The probe angle must be changed to a **decreased angle** to the wing. If set point is unsuccessful after several attempts, the aircraft should be landed and the AOA probe angle repositioned so the angle between the wing and the probe is **decreased** by 10 degrees (**toward wing**). The in-flight (**OAA**) calibration should be retried.

(Return to Step 2)

NOTES:

- 1.) If the **OAA** set point was **NOT** successful and the **Brightness** button is depressed and held for longer than 6 sec., the **Green Doughnut** will blink ON and OFF 3 times then continue to flash twice every 6 seconds indicating the system is at the **OAA** set point calibration mode until a valid **OAA** is entered.
- 2.) If both the **OAA** and the **Cruise** set points have been previously set and the **Brightness** button is depressed for (**>6 sec.**) (entering calibration mode), the operator can **EXIT** the calibration mode without changing the previously set **OAA** and **Cruise** values by simply depressing and holding the **Brightness** button again for (**>6 sec.**) returning the unit to functional mode.
- 3.) Once the **CAL** button has been pushed, (**when in the calibration mode**) the operator must complete the **ENTIRE in-flight** calibration process, (valid **OAA** and **Cruise** set points) and exiting to functional mode by depressing the **Brightness** button for (**>6 sec.**).
- 4.) It is **NOT** necessary to do the **Zero** calibration procedure once set. It can be re-entered for system re-cal at any time; however, **ALL in-flight** calibrations and identification of aerodynamic points to colored SEGMENT correlations must be flown and re-checked.

Step 3) Cruise Set Point Calibration (In-Flight Calibration)

The system must first have a **OAA** set point entered successfully, then be put into the **Cruise Set Point Mode (by depressing the Brightness button >6 seconds)** which will be identified by the **Blue Bar** blinking ON / OFF 3 times.

When at a normal cruise power, straight and level, holding altitude,

Press and hold the **Brightness button (>6 sec.)** until the **Blue Bar** blinks ON / OFF 3 times. Release the **Brightness button**.

(The system has exited **OAA** calibration and entered the **Cruise** calibration).

To enter a Cruise Set Point, Fly Aircraft at Safe Altitude:

- Increase power to a cruise power setting.
- Allow aircraft to level off, Cruise attitude.
- Aircraft flying straight and level, holding altitude.

Press and release the **CAL** button on the AOA DISPLAY.

IF the Setting is Successful:

The AOA DISPLAY will save the new **Cruise** set point and illuminate the **Blue Bar**.

Note: This operation can be repeated as many times as desired as long as the system is in Cruise calibration.

To Exit Calibration Mode:

When the pilot is confident of Both the **OAA** and **Cruise** set points are accurate and saved successfully, depressing the **Brightness** button and held (**>6 sec.**), the system will **EXIT** the calibration mode, storing the **OAA** and **Cruise** values, which is indicated by the AOA DISPLAY entering its self test segment illumination routine, all segments are illuminated one by one upwards, then, one by one downwards, to a fully functional Display Mode.

Both values, **OAA** and **Cruise** have been **stored**, representing the range from **OAA** to **Cruise**, and a range from **OAA** up to **Stall**.

Calibrations of OAA and Cruise Set Points are Complete!!!!**IF THE CRUISE SET POINT WAS NOT SUCCESSFUL:**

The AOA DISPLAY discards the attempted set point and the following event occurs:

**The Blue Bar flashes 3 times at a rapid rate.
This indicates that the set point is too low.**

If the setpoint was not successful and the **Brightness** button is depressed (**>6 sec.**), the **Blue Bar** will blink ON and OFF 3 times and continue to flash twice every 6 seconds. Indicating the system is still in the **Cruise** calibration mode.

NOTE:

Both **OAA** and **Cruise** set points **must** be entered and **must** be valid values **before** exiting from the calibration mode before the system can be used.

Helpful hints: AOA Display Segment Definitions (When in Calibration Mode)**- All Segments flash continuously**

- The system is not calibrated.
- The attempted zero pressure offset value at the sensor is too high, which indicates something is wrong electrically or mechanically with the system or something in the environment is affecting the system.

- The Green DOUGHNUT + Blue BAR flash simultaneously 5 times at a rapid rate

- The **(OAA)** Optimum Alpha Angle and **Cruise** set points need to be calibrated.

- The Green DOUGHNUT + RED CHEVRON flash simultaneously 3 times at a rapid rate

- The attempted **(OAA)** Optimum Alpha Angle set point is too low, reposition AOA probe away from the wing (larger angle). Re-enter OAA calibration mode.

- The Green DOUGHNUT + YELLOW CHEVRON flash simultaneously 3 times at a rapid rate

- The attempted **(OAA)** Optimum Alpha Angle set point is too high, reposition AOA Probe toward the wing (smaller angle). Re-enter OAA calibration mode.

- The Blue BAR flashes 3 times at a rapid rate

- The attempted **Cruise** set point is too low.

- The Green DOUGHNUT blinks on and off 3 times and continues to blink every 6 sec.

- Initial calibration, the system has entered the **(OAA)** Optimum Alpha Angle Set Point Calibration Mode and a valid OAA value needed to become functional.

-The Green Doughnut blinks on and off 3 times and is functional

- The Brightness / Mode button was pushed for longer than 6 seconds, entering into the **OAA** calibration mode. The previous calibration value is used for **OAA** and can be changed by pushing Cal button. To exit calibration mode, before pushing the CAL button, hold the Brightness / CAL button for **>6 sec.**, the unit exits calibration mode without changing the set points.

- The Blue BAR blinks on and off 3 times

- The system has entered the **Cruise** Set Point Calibration Mode.

Notes: 1.) If The power is turned **OFF** during the **OAA** or **Cruise** Set Point procedures, the pilot must enter the **Calibration mode** again and start over with **OAA** calibration than re-enter **Cruise** calibration value.

2.) It is not necessary to do the (on the ground) **Zero offset** calibration once a successful value was entered.

6.1 Background Information:

The Alpha Systems Angle of Attack system was primarily designed to improve operational safety of airplanes by increasing pilot awareness of available lift during operations at high angles of attack. Additional benefits may be reaped by identifying or maximizing aircraft performance based on a fixed angle of attack or a constant C_L , such as maximum range and best glide, stall.

AOA: Angle of Attack is the difference between the airfoils cord line (a line from the leading edge to the trailing edge of the wing) and the relative wind (the inverse of the aircraft flight path).

C_L : Coefficient of Lift is a relative measure of an airfoil's lifting capabilities.

C_{Lmax} : Coefficient of Lift Maximum is the angle of attack which if exceeded will cause the airfoil to stall.

C_D : Coefficient of Drag is a measure of total drag, induced and parasite drag.

C_L/C_D : Coefficient of Lift over Coefficient of Drag is a ratio between lift and drag.

C_L/C_D Maximum: is the maximum lift-to-drag ratio at which maximum range and maximum glide distance will be found for propeller airplanes.

6.2 System Description and Operation:

The Alpha Systems AOA "**Legacy**", electronic angle of attack system measures pressure at two points from an AOA probe mounted solidly to the wing in reference to the cord of the wing that conveys changing differential pressures, via AOA sense lines, to the AOA Interface Module. The AOA Interface Module converts the pressures into an electronic signal that is transmitted to the display. The display interrupts the signal and turns on the appropriate segments to convey the angle of attack or Lift information to the pilot. In addition to the visual display, the AOA interface module emits an 110Db aural, high Angle of Attack warning tone when the aircraft is approaching a high angle of attack. The AOA Interface Module (IM) also has an I/O connector that allows connection of the remote audio interface system that puts the warning tone in the pilot's headset.

The Alpha Systems AOA, angle of attack system draws a minimal current of less than approximately ¼ amp. (250mA) of electrical power. For the system to operate correctly, it must be supplied electrical power within a range of 10 to 28VDC, be calibrated correctly.

The AOA probe must be kept clear of any obstructions and be mounted securely, in clean air flow. The final AOA probe to wing angle will be determined by the amount the bottom of the wing varies from parallel to the cord of the wing. For most aircraft, the starting angle is 50 degrees from the leading edge of the AOA probe mounting plate. The AOA computer will adjust for differences within a limited electrical signal range. **AOA Probe angle readjustment may be needed to allow for full scale electronic calibration.**

Probe heat is an option and if installed requires approximately seven amps of electrical power at 12 or 28VDC to operate. To extend the life of the probe heat element it is recommended that the probe heat not be used for prolonged periods while on the ground.

6.3 The “Legacy” Display Overview:

The Legacy display has a chevron styled; LED driven, multi colored segments, **once calibrated**, illuminates segments corresponding to the angle of attack for the aircraft. The display will respond to the linear changes of the aircraft's AOA from Cruise, up to Stall and gives a repeatable, instantaneously changing segment representation of that range. The display will illuminate a series of transitional segments from, no segments to the **Blue Bar**, an indication of “Cruise” for the aircraft. The display also has a Brightness / Mode Pushbutton, “Cal” pushbutton, Audio MUTE toggle switch, Audio Muted amber LED, and an Automatic Photo Cell, which will change between 2 preset brightness levels depending on the ambient cockpit light level.

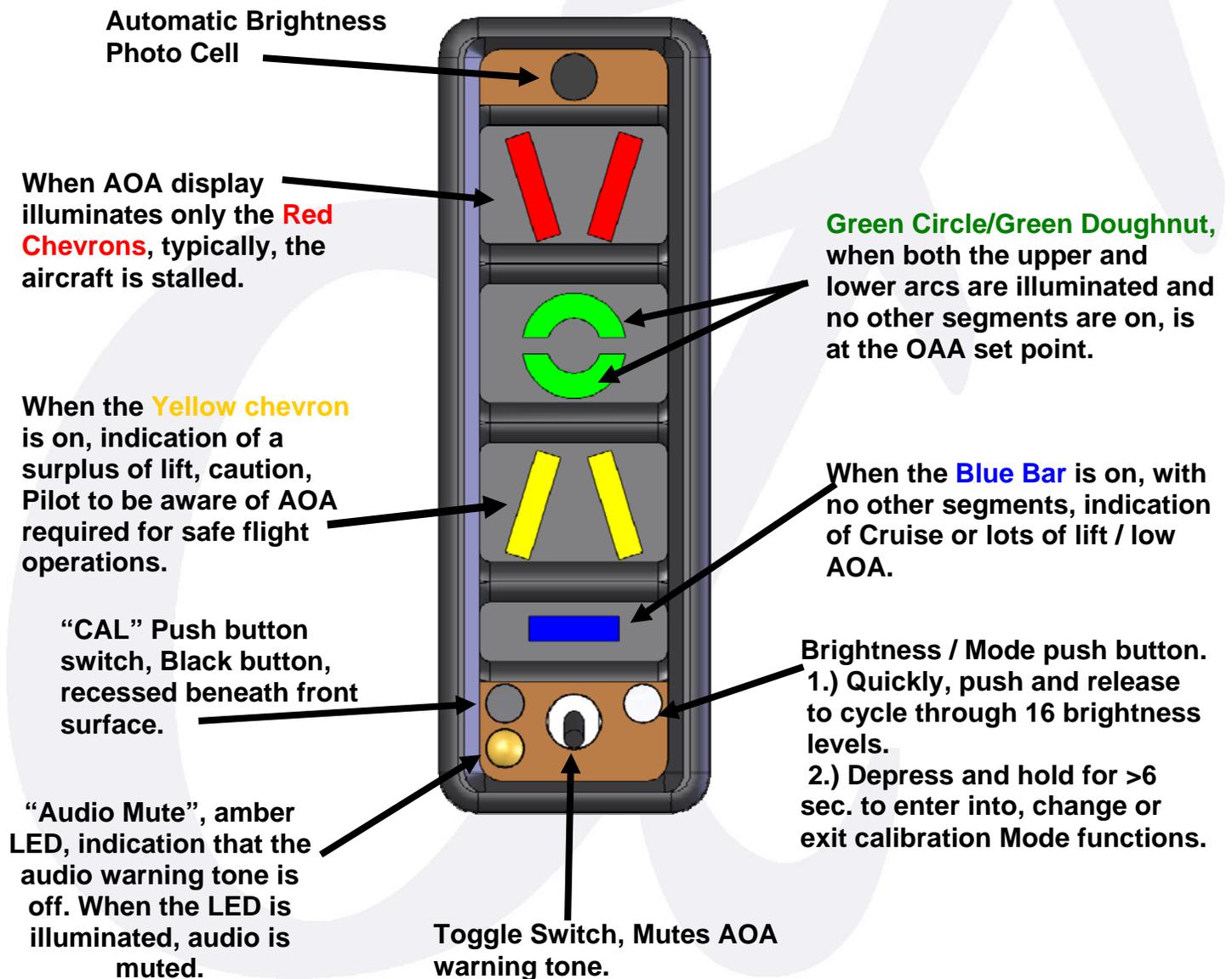
The following are the **Legacy's** 10 possible segment combinations. Every aircraft will correlate the lit segment or combination of segments to the specific aircraft's AOA dynamics once calibrated. The relationship of when and which combination is unique to the aircraft's AOA and can be accurately correlated **ONLY** when in-flight.

No Segments = Power **Off** or no lift, no pressure information in which the computer can display an output or on the ground with no movement.

- 1.) **Red Chevrons** = Extremely low or no lift / Critical Alpha, stall, loss of controllable lift, AOA extremely high, large correction required immediately, aircraft in uncontrollable descent. Perform stall recovery procedures.
- 2.) **Red Chevrons + top half of Green Circle (Top half of Doughnut)** = Possible stall, very high AOA, loss of control surface effectiveness, descending, major instant AOA correction required.
- 3.) **Top half of Green Circle (Top half of Doughnut) only** = Slight loss of lift, not able to hold altitude, descending, high AOA, possible slight loss of rudder, aileron, elevator control effectiveness, not enough lift to take off or even hold altitude.
- 4.) **Complete Green Circle (Green Doughnut)** = **OAA** (Optimum Alpha Angle), calibrated set point indicating minimum controllable with zero sink, full aileron, elevator, rudder control, slow flight, very minimal aircraft climb capability, just enough lift to hold altitude, complete aircraft flight dynamic effectiveness.
- 5.) **Bottom Half of Green Circle (Green Doughnut)** = Slightly lower AOA, max climb angle, highest AOA allowing somewhat of a slow climb, full control surface effectiveness. A small amount of additional available lift. Pilot prepare to correct or add additional lift if conditions / situation requires. Very little climb reserve.
- 6.) **Bottom Half of Green Circle (Green Doughnut) + Yellow Chevron** = Lower AOA, not much climb reserve, able to sustain a continued climb, complete and full directional control and stability.

- 7.) **Yellow Chevron** = Increase in climb rate possible, additional available lift, half way between **Cruise** and **OAA** set points. Complete aircraft control authority. Pilot to be aware of the amount of lift / AOA depending on the in-flight situation and the lift requirements. Able to make good climb rates, descent corrections with full control.
- 8.) **Yellow Chevron + Blue Bar** = Top end of the slow flight AOA indication, plenty of lift, significant increase in climb possible, just starting to loose lift, begin paying attention to AOA. Just under the maximum amount of lift or lowest AOA
- 9.) **Blue Bar** = Calibrated set point for **Cruise** of the aircraft, lowest AOA, **lots of lift**, indication capable of unlimited climb.

Alpha Systems, Legacy Display



Legacy Display and In-Flight Relationship

The Display, once calibrated, will give a linear transition of illuminated segments from the Cruise indication (**Blue Bar**) up through to the **Red Chevron** (Stall). As the pilot increases angle of attack, pulling back on the control stick / yoke, the pilot will see a direct response, transitioning into the **Red Chevron** on the Legacy display (loss of lift). “**Pulling into the Red**”, “**Pushing to the Blue**”

Optimum Alpha Angle (OAA)

The pilot will calibrate during an in-flight maneuver on a nice calm day, taking the aircraft to a safe altitude for slow flight maneuvers. **A.)** At minimum controllable flight, (slow flight) and at a lower power setting, (power at pattern RPM or manifold pressure). **B.)** Pilot able to hold altitude, **not in a decent**, ZERO SINK, as close to 0 vertical speed as possible. **C.) FULL** aileron, elevator and rudder authority, aircraft not exhibiting any buffet or loss of control surface stability. The pilot is to fly the aircraft at **OAA**, angle of attack, calibrating the display to correlate the **Green Doughnut** to indicate the aircrafts' AOA for minimum maneuvering (**OAA**).

Cruise Indication

After calibrating the aircrafts' lift representing the “**Cruise**” set point, the **Blue Bar**, when the aircraft is at **Cruise** (angle of attack, lots of lift).

Max Climb Angle

Is when only the **Bottom Green arc** of the doughnut is illuminated, indication of the aircraft's maximum angle of attack that allows a slow continued climb.

Stall Indication

After the calibration is complete, the pilot will identify which colored segment or combinations of segments identify the “Stall” angle of attack for his or her aircraft. The Stall is dependant on the coefficient of lift and the angle of attack for each airplane. Once identified, the illuminated segment will always indicate the aircrafts' Stall AOA. Typically, the Legacy will either just be transitioning into, or the **Red Chevron** illuminated.

Other Flight Reference Values: Other flight values such as **Stall, V_x, V_y**, can be identified after the pilot has completed the calibration of **OAA** and **Cruise** set points. The pilot then flies the aircraft at the exact airspeed value from the pilot operating handbook that references ie: (**V_x**), the corresponding illuminated segment that equal the associated angle of attack (**V_X**), from that day on, regardless of gross weight changes, density altitude, power, attitude the display will give repeated results.

Legacy Display Control Switch Features

Brightness / MODE Push Button Switch (Multiple Functions)

- A.)** The Brightness push button, when quickly depressed and released, repeatably, will step through 16 levels of display brightness. When the maximum brightness level is reached, the brightness returns to the minimum and steps up each time the button is depressed.
- B.)** The Brightness button is also used to enter, change from OAA to Cruise calibration and exit the Calibration mode, **when depressed and held for longer than 6 seconds (>6 sec.)**. It also switches between different calibration set points, (**OAA**), (**Cruise**), and stores the calibrated values of **OAA** and **Cruise** when exiting to **operational mode**.
- C) Before power is turned on**, if the Brightness button is depressed and held, then turning power “ON” forces the display to have all colored segments ON after a count up then down self test. This allows the pilot / installer to set the 2 brightness level presets, “day time” and “night time” while on the ground, with all segments illuminated. Turning power OFF, resets the unit and saves the last “night time” and “day time” brightness levels.

Audio “Mute” Toggle Switch

This switch, when in the UP position, Mutes the Audio warning tone. The audio warning tone comes **ON** when the angle of attack increases from the **Yellow Chevron** and when the illumination of the **lower Green arc** turns on. The tone is present for a short time, (3 quick beeps), as the angle of attack continues to increase. A beeper in the AOA Interface Module (IM) generates 110 Db tone with an output to the I/O connector that allows the audio interface module to send the signal for an optional connection to the pilots headset or to a remote beeper.

Audio Beeper

The black round beeper on the **IM** emits a tone of 110 Db and can be heard in most cockpits even with noise cancellation headsets on. The audio beeper can be muted by the Audio Mute toggle switch on the lower part of the display. Optional remote beeper or an audio interface to headset is available for noisier cockpits.

Auto Brightness Photo Cell

The photo cell is in the top, middle of the AOA display and automatically detects the ambient light changes which will switch from “**day time**” brightness preset to “**night time**” brightness presets.

Calibration Button (CAL)

The calibration button is the recessed black push button in the lower left corner of the display. This button is used to enter selected calibration set points (**Ground Zero, OAA & Cruise**) during the calibration procedures.

6.4 Demonstration of Optimum Alpha Angle (OAA), Clean and Dirty:

As noted earlier, this AOA system was primarily designed to improve operational safety of airplanes by increasing pilot awareness during operations at high angles of attack, (**slow flight, landings and take offs**).

The system is calibrated with the aircraft in the **clean configuration** which means that when the flaps are lowered the display will indicate a higher angle of attack (**lower segment**) before stalling. It is our contention that **any operation below the OAA “Green doughnut” at low altitude is unsafe and if encountered immediate corrective actions should be taken to reduce the angle of attack (increase lift) regardless of the aircraft configuration.**

To familiarize you with the **Legacy** indications during stalls use the following outline as a guide:

- Plan a flight to an area where stalls can be performed without any undue hazards (reference § 91.303 & § 91.305).
- Review stall recovery procedures for your aircraft.
- Acquaint yourself with the AOA indicator and its functions.
- Preflight and operate the aircraft as you would normally.
- When in an area and at a safe altitude that safe operation at slow flight can be performed and the air is smooth, perform clearing turns to ensure the area is clear.
- Follow the aircraft procedures and slow the aircraft, in the clean configuration (No Flaps):
 - Maintain coordination.
 - Maintain altitude.
 - Monitor the AOA indicator.
 - Slow to the stall.
 - Perform the stall recovery procedure for your aircraft.

OBSERVED INDICATIONS:

As the aircraft slows and the angle of attack increases note the following:

- The colored segments on the AOA indicator will transition from the **Blue Bar** (Cruise) up through to the **Red Chevron**.
- The High Angle of Attack **“TONE” or “WARNING”** will sound anytime the angle of attack is increased above the **Yellow Chevron**.
- The aircraft’s stall warning should activate prior to the **Green Doughnut**.
- When the airfoil stalls, the Legacy display will typically be transitioning from the **Upper Green arc of the Doughnut** to the **Red Chevron or in the Red Chevron**.

As the recovery progresses:

- The AOA indicator will transition from the **Red Chevron** through the **Green Doughnut** and continue through the **Yellow Chevron** until finally the **Blue Bar** (Cruise).
- The aircrafts stall warning will silence.

Follow the outline above again but perform the stall and recovery in the landing configuration (dirty) and observe the following:

- The segments on the Legacy indicator will transition starting with the **Blue Bar** through to the **Yellow Chevron, Green arcs**, up to the **Red Chevron**.
- The high angle of attack warning tone will sound anytime the angle of attack is increased beyond the **Yellow Chevron**.

- The aircrafts stall warning will activate approximately when the **Yellow Chevron** transitions to the **lower half of the Green Doughnut**.
- When the airfoil stalls, typically the display will be illuminating the **Red Chevron**, deeper into the **Red** then in the clean configuration.

As the recovery progresses:

- The AOA indicator will transition through the **Green Doughnut**, **Yellow Chevron** to finally the **Blue Bar** (cruise, lots of lift).
- The aircrafts stall warning will silence.
- The lower the segments, **from Red, Green arcs, Yellow Chevrons, to Blue Bar**, more lift, (lower angle of attack).

Practice these two stalls until you become familiar with the indications on the AOA and the relationship of your airspeed indicator. Since the airfoil on your aircraft will **ALWAYS** stall at the same angle of attack every time (**regardless of weight**) the AOA indications will be the same every time. To prove this try an accelerated stall in the clean configuration using the same outline as above. Notice that as the wing loading is increased in the turn, the aircraft stalls at a **higher indicated airspeed** but **at the same angle of attack**.

Do you remember, ever since you were a student pilot you heard that the aircraft can stall at any airspeed, attitude or power setting? **Now** you have an instrument that will indicate the angle of attack and an impending stall or stall **every time regardless of airspeed, attitude or gross weight**.

6.5 Demonstration of Takeoff and Climb using AOA:

The use of A.O.A. for takeoff and climb performance will greatly increase the pilot's awareness while operating at high angles of attack and yield safe and consistent results.

For example if you intend to perform a short field over an obstacle takeoff there are a number of factors you must consider to arrive at the proper indicated airspeed for the climb. Changing gross weight, pressure altitude, temperature will all have an affect on the indicated climb speed. On the other hand, once you establish the correct angle of attack for the climb, it will be the same regardless of the factors previously mentioned.

To determine the correct A.O.A. for a climb we need a base line to start from. For this example we will figure it out for V_x , (best angle of climb). Some aircraft may use two different speeds based on the aircraft configuration, let's use the one for clearing an obstacle on takeoff. Refer to the aircraft manual to determine the configuration and airspeed for V_x considering the following factors:

- Identify actual gross weight.
- Pressure altitude, at the demonstration altitude.
- Temperature, at the demonstration altitude.
- Correct CAS for installation errors to arrive at IAS.

As before to familiarize you with the AOA indications for V_x use the following outline as a guide:

- Plan a flight to an area where the desired maneuvers may be performed without any undue hazards.
- Acquaint yourself with the Legacy A.O.A. indicator.
- Preflight and operate the aircraft as you would normally.
- When in the area perform clearing turns to ensure the area is clear.
- Maintain coordination.
- Maintain altitude.

- Use power to slow and configure for V_x .
- Maintain the indicated airspeed for V_x .
- Observe the Legacy display A.O.A. indication and make a mental note.
- Return to normal flight.
- Write down the illuminated segments.

This A.O.A. indication will be accurate for future use at any gross weight or altitude, **every time**. Also this same method may be used to determine the A.O.A. for any climb. Now try it for V_y , best rate of climb, using the procedure described above.

Document the angles of attack by the illuminated corresponding segments in a permanent record for future use (for example: $V_x = \text{Yellow Chevron}$).

Now practice the use of the AOA for takeoff at airports that give you a comfortable margin. Then when you perfect the technique you can perform short field over an obstacle takeoffs safely. Use the following outline as a guide.

- Review your aircraft procedures for short field over an obstacle takeoff.
- Plan for a flight at an airport where normal takeoffs and landing may be performed.
- Preflight and operate the aircraft as you would normally.
- Perform the takeoff run as specified in the aircraft manual.
- At the specified takeoff speed rotate smoothly to the A.O.A. for V_x .

CAUTION

Do not over rotate or rotate too rapidly as either will cause catastrophic results.

- When well above the obstacle decrease the A.O.A. and clean up on schedule.
- Adjust the pitch to achieve the A.O.A. for V_y and continue the climb.

OBSERVED INDICATIONS:

As the aircraft accelerates down the runway the A.O.A. indicator will start to illuminate with the **Red Chevron**, then **top half of the Green Doughnut**, through to the combination of **lower half of the Green Doughnut**, then just the **Yellow Chevron**. When the pitch is rotated up, the A.O.A. indication will move towards V_x , adjust the pitch to maintain the V_x angle. To accelerate and clean up the pitch is lowered, thus lowering the A.O.A. and decreasing induced drag, increasing lift. This will allow the aircraft to accelerate so the flaps can be retracted, the changes in angle of attack can be observed.

6.6 Demonstration of Performance Based on a Constant AOA or C_L :

As mentioned earlier the AOA may be used for identifying aircraft performance based on a fixed angle of attack or a constant C_L . For this discussion C_L/C_D Maximum indication will be identified. This is the maximum lift-to-drag ratio at which maximum range and maximum glide distance will be found for propeller airplanes.

For those of you that really get into researching, find the data on the airfoil that is installed on your aircraft. Compare the C_L at various angles of attack to C_D for your aircraft at respective angles of attack. The angle of attack (AOA) that provides the maximum ratio between C_L and C_D is considered C_L/C_D Maximum.

OR

For the rest of us, the aircraft manufacturer has already figured this out. They show it as a calibrated airspeed that will result in an angle of attack that is C_L/C_D Maximum. They had to present the information in this fashion because they did not install an angle of attack indicator on the aircraft. So to find the angle of attack for best glide calculate an indicated airspeed considering:

- Actual gross weight.
- Pressure altitude, at the demonstration altitude.
- Temperature, at the demonstration altitude.
- Correct CAS for installation errors to arrive at IAS.

As before, to familiarize you with the Legacy A.O.A. indications for C_L/C_D Maximum use the following outline as a guide:

- Plan a flight to an area where the desired maneuvers may be performed without any undue hazards.
- Acquaint yourself with the Legacy display A.O.A. indicator.
- Preflight and operate the aircraft as you would normally.
- When in the area perform clearing turns to ensure the area is clear.
- Maintain coordination.
- Maintain altitude.
- Use power to slow and maintain best glide speed.
- Observe the Legacy display A.O.A. indication; this is C_L/C_D Maximum.

This A.O.A. indication will be correct for future use at any gross weight, altitude, **every time**. Document the angles of attack by the segments illuminated in a permanent record for future use (for example: Best Glide = **Bottom half of the Green Doughnut** being illuminated).

The methods used to arrive at this A.O.A. indication will be the same for all constant angle of attack or C_L maneuvers.

6.7 Demonstration of Approaches using AOA:

A long standing rule of thumb is to use an approach speed of 1.3 times the power off stall speed in the landing configuration. Another rule of thumb is in gusty winds add 5kts. for mom and if it's really gusty add 10kts. for mom and the kids. While flying the approach at higher speeds seems to be safer, having additional speed and kinetic energy on a short runway may not be in the best interest of mom and the kids. With the means to accurately know and control the angle of attack you can fly a more stable approach and land with less kinetic energy for any given situation than flying arbitrary approach speeds. Flying an approach and landing using an AOA indicator may be a safer procedure.

The AOA has been calibrated for an angle of attack just slightly less than C_{LMAX} however an acceptable margin above that angle to fly approach and landings has not been determined. As a starting point use the aircraft manual to determine the stall speed of the aircraft at the **actual gross weight** in the landing configuration. Take that calibrated airspeed and multiply it by 1.3, 1.2 and 1.1. Then refer to the airspeed correction chart to determine the correction, if any, to convert from calibrated airspeed to indicated airspeed for the three speeds. For example:

Calibrated Stall Speed X 1.3 = App. CAS ± the correction = App. IAS
 58Kts. CAS X 1.3 = 75.4kts. CAS + 2 kt correction = 77kts. IAS
 58Kts. CAS X 1.2 = 69.6kts. CAS + 3 kt correction = 73kts. IAS
 58Kts. CAS X 1.1 = 63.8kts. CAS + 4 kt correction = 68kts. IAS

For ease of discussion let's call these speeds and the resulting A.O.A. indication as 3, 2 and 1 respectively. Once the AOA angles have been identified they will be **accurate at any gross weight, every time.**

To establish angles of attack for approach using AOA indications use the following outline as a guide:

- Plan a flight to an area where stalls and slow flight can be performed without any undue hazards (reference § 91.303 & § 91.305).
- Review stall recovery procedures for your aircraft.
- Acquaint yourself with the Legacy display AOA indicator.
- Preflight and operate the aircraft as you would normally.
- When in an area where stalls and slow flight can be performed and the air is smooth, perform clearing turns to ensure the area is clear.

IF THE AIRCRAFT IS INADVERTENTLY STALLED PERFORM THE STALL RECOVERY PROCEDURE FOR YOUR AIRCRAFT.

- Follow the aircraft procedures, slow and configure to the landing configuration:
 - Maintain coordination.
 - Maintain altitude with the pitch (use pitch trim to relieve back pressure).
 - Use power as needed to maintain flight at the first of the calculated approach speeds, 3.
 - Write down the colored segments illuminated.
 - Use power as needed to slow to and maintain flight at the second of the calculated approach speeds, 2.
 - Write the new segments illuminated.
 - Use power as needed to slow to and maintain flight at the third of the calculated approach speeds, 1.
 - Write down the final colored segments illuminated.
 - Return to normal flight.

Document the angles of attack by the colored segments illuminated in a permanent record for future use (for example: 3 = 1.3 approach is **Lower Green arc and Yellow Chevron**).

To familiarize you with the aircraft while flying practice approaches using the A.O.A. indicator as a guide please use the following outline:

- Plan a flight to an area where stalls and slow flight can be performed without any undue hazards (reference § 91.303 & § 91.305).
- Review stall recovery procedures for your aircraft.
- Acquaint yourself with the Legacy display AOA indicator.
- Preflight and operate the aircraft as you would normally.
- When in an area where stalls and slow flight can be performed and the air is smooth, perform clearing turns to ensure the area is clear.
- Follow the aircraft procedures, slow and configure to the landing configuration:
 - Maintain coordination.
 - Set the power as you would to fly a normal approach.
 - Maintain altitude with the pitch until the A.O.A. approaches the 3 indication, lower and use pitch to maintain that AOA (use pitch trim to relieve back pressure).
 - Fly the aircraft in the descent (straight & turning), pay attention to the flight control effectiveness.

- While the aircraft is still at a safe altitude simulate a landing flare by reducing the power to idle and increasing the angle of attack to maintain altitude until the stall (note the relative time in seconds from the start of the simulated landing to the stall).
- Perform a stall recovery.
- Climb back to the initial altitude.

Repeat the steps above using A.O.A. indications 2 and 1. Gain experience by practicing these simulated approaches and landings using the A.O.A. indicator.

Some noticed observations:

- The control effectiveness decreased with higher angle of attack.
- The higher the angle of attack, the more attention has to be given to rudder inputs to compensate for adverse yaw.
- Approaches at the higher angles of attack left little time between starting the flare and stall.

Some techniques and things to consider when using an AOA to fly the approach:

- Coordinate the use of pitch and power to fly the approach and landing.
 - **Use PITCH primarily to control the A.O.A.**
 - **Use POWER primarily to control the descent rate.**
(Keep in mind how much power it took to just maintain altitude).
- A stable approach all the way to the runway is much safer than making radical changes to the A.O.A. or descent rate once an obstacle is cleared.
- **Set a safe standard for yourself using all your experience to set a maximum AOA for any approach and do not let pressures cause you to fly an approach at too high of AOA.**
- When flying in gusty conditions fly a lower A.O.A. so that when a wind gust changes your angle of attack it does not exceed **your maximum A.O.A.**
- Having a great new system to indicate angle of attack does **NOT** change the laws of physics, use it as a new tool to keep mom and the kids safe.
- If you are planning to use the AOA to land on a postage stamp, use your excellent judgment skills so you don't have to use your exceptional pilot skills just to survive.

We just barely scratched the surface of aerodynamics, if you are interested in learning more may we suggest obtaining a copy of “The Advanced Pilot’s Flight Manual” by William K. Kershner published by Aviation Supplies & Academics, Inc. (ASA).

Or the great basic book “Stick and Rudder”!!!!!!!

**FLY SAFE!
GOT LIFT?**

7.1 Continued Maintenance:

Maintenance and upkeep of the Alpha Systems AOA Legacy unit is very simple. All of the aluminum parts have been anodized for maximum protection. There are NO overhaul time requirements.

Probe Maintenance

During calibration, a mark was placed at the base of the probe next to the mounting plate. Make sure that the mark is still visible; the line identifies the position of the probe when calibrated and is a verification line for preflight. Confirm that the probe is tight; mounted securely and there are no visible cracks in the mounting plate or probe. The inspection plate screws must be secure and the mounting plate shows no sign of wear or cracking around the screw heads. If the probe plate is to be removed, assure hoses and fittings are tight and hoses are inserted completely into connectors and are not kinked. After re-installation assure probe angle is as originally mounted and re-check in-flight calibration set points and other in-flight dynamic values are at the same calibrated colored segment illumination reference points.

Display Maintenance

The Alpha Systems AOA display should be inspected to ensure the security of the display to the instrument panel or glare shield verifying mounting security. It should not be loose and all mounting screws tight. Each time the AOA is turned on, the unit illuminates each individual colored segment until all segments are on, and then turning each segment OFF. Verify each segment turns ON and OFF independently. Verify set points and the other aero-dynamic values are still identical to the calibrated illuminated color segments are as previously set.

AOA Interface Module (IM) Maintenance

Verify all electrical connectors are completely inserted and all connections are tight. Electrical wires and connections are secure and no cuts or wear is visible on the wire. The AOA Interface Module mounting screws are tight and no cracks or loose brackets are present. Hoses are inserted completely, not kinked and no wear or depressions.

Basically, if you believe that the lines may be blocked, cut or kinked, remove the lines from the AOA IM and blow air from the cockpit **out** towards the probe. This will remove the obstruction and test the lines integrity from the inside of the cockpit out to the AOA probe mount. Verify hoses are intact with no leaks and are not restricted or kinked in any way. If there is any doubt, **DO NOT** rely on the instrument and have the mechanic check on the installation or call the Alpha Systems company.

**Verify correlation of the illuminated colored segments to aircrafts AOA.
Recalibrate when ANY AOA probe angle changes or adjustments are
identified or completed.**

DO NOT BLOW INTO THE PROBE

If the calibration is in question, **recalibrate as per manual.**

The Legacy display will illuminate varied colored segments with repeated responses to the same aircraft AOA after calibration. Verify as to the calibration procedures contained herein this manual. If the responses are different or don't respond in a smooth transition from the **Cruise** setpoint to **OAA**, and from **OAA** to **Stall**, or from no colored segments on the ground, a linear transition through all of the segments illuminating one by one until the **Cruise** set point is reached, (**Blue Bar**), recalibrate. If the recalibrations are unsuccessful, have the mechanic inspect ALL installation mounts, tubes, fittings, verify AOA probe holes are clear and hoses are not cut.

**If reattempts at calibrations are unsuccessful; call Alpha Systems AOA / DepotStar, Inc. for customer service.
1-877-571-3770 or 763-506-9990**

We appreciate the opportunity to provide an instrument that will aid every pilot with additional information increasing pilot awareness of lift when in flight. Alpha Systems is committed to continue supporting the GA community with innovative solutions and improvements to our Angle of Attack Systems.

**Please tell all your friends and fellow pilots about
Alpha Systems AOA!**