

ANGLE of ATTACK

Operating and Installation Manual

AOA Sport and Pro

US Patent 6,271,769 B1

for

EXPERIMENTAL

AIRCRAFT

Part # _____

Serial #: _____

Advanced Flight Systems, Inc.

www.Angle-of-Attack.com

AOA MANUAL REV4
17605

COPYRIGHT ©2000-2004

OPERATION

ADVANCED

INSTALLATION

REPAIRS & CLEANING

CALIBRATION

APPENDIX

Intentionally Blank

Warranty and Registration Card

LIMITED WARRANTY AGREEMENT

Advanced Flight Systems, Inc. warrants its AOA instrument and system components to be free from defects in materials and workmanship for a period of one year commencing on the date of the first flight of the instrument. Advanced Flight Systems, Inc. (AFS) will repair or replace the instrument or system components under the terms of this Warranty provided the item is returned to AFS prepaid.

1. This Warranty shall not apply to any unit or component that has been repaired or altered by any person other than AFS, or that has been subjected to misuse, abuse, accident, incorrect wiring, or improper or unprofessional installation by any person. **THIS WARRANTY DOES NOT COVER ANY REIMBURSEMENT FOR ANYONE'S TIME FOR INSTALLATION, REMOVAL, ASSEMBLY OR REPAIR.** AFS reserves the right to determine the reason or cause for warranty repair.
2. This Warranty does not extend to any aircraft, or any other device to which the AFS AOA system may be connected, attached, or used with in any way.
3. **THE REMEDIES AVAILABLE TO THE PURCHASER ARE LIMITED TO REPAIR, REPLACEMENT, OR REFUND OF THE PURCHASE PRICE OF THE PRODUCT, AT THE SOLE DISCRETION OF AFS. CONSEQUENTIAL DAMAGES, SUCH AS DAMAGE TO THE AIRCRAFT, ARE NOT COVERED, AND ARE EXCLUDED. DAMAGES FOR PHYSICAL INJURY TO PERSON OR PROPERTY ARE NOT COVERED, AND ARE EXCLUDED.**

4. AFS is not liable for expenses incurred by the customer or installer due to AFS updates, modifications, improvements, upgrades, changes, notices or alterations to the product.
5. The pilot must understand the operation of this product before flying the aircraft. Do not allow anyone to operate the aircraft that does not understand the operation of the AOA system. Keep the operating manual in the aircraft at all times.
6. No one is authorized to assume any other or additional liability for AFS in connection with the sale of AFS products.
7. IF YOU DO NOT AGREE TO ACCEPT THE TERMS OF THIS WARRANTY, YOU MAY RETURN THE PRODUCT FOR A FULL REFUND. IF YOU DO NOT AGREE TO ACCEPT THE TERMS OF THIS WARRANTY, DO NOT INSTALL THE PRODUCT.
8. This warranty is made only to the original purchaser and is not transferable. THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES OR OBLIGATIONS, EXPRESS OR IMPLIED, ORAL OR WRITTEN. AFS EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THE PURCHASER AGREES THAT IN NO EVENT SHALL AFS BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING DAMAGES TO THE ENGINE OR AIRCRAFT, LOST PROFITS, LOSS OF USE, OR OTHER ECONOMIC LOSS. EXCEPT AS EXPRESSLY PROVIDED HEREIN, AFS DISCLAIMS ALL OTHER LIABILITY TO THE PURCHASER OR ANY OTHER PERSON IN CONNECTION WITH THE USE OR PERFORMANCE OF AFS's PRODUCTS, INCLUDING BUT NOT LIMITED TO STRICT PRODUCTS LIABILITY IN TORT.

Registration Card

To receive important notification of Service Bulletins,
AOA Manual updates and service difficulty reports,
please fill out the following and mail to:

Advanced Flight Systems Inc.
16285 SW 85th Ave, Suite #401
Tigard OR 97224 USA

Owner's Name: _____

Address: _____

City: _____

State: _____ *Postal Code ZIP:* _____

Country: _____

Home telephone: _____

Business Telephone: _____

E-mail: _____

Aircraft Model and N#: _____

P/N of CPU: _____ *Serial Number of CPU:* _____

Installer: _____

Intentionally Blank

Table of Contents

I. OPERATOR AND INSTALLER REQUIREMENTS	1
FREE TECHNICAL CONSULTATION	6
II. HOW IT WORKS	7
THEORY OF OPERATION	7
AOA DISPLAYS	10
MODES OF OPERATION	11
AIRCRAFT DATA BASE CONFIGURATIONS	13
III. WHAT TO DO FIRST	20
INVENTORY OF PARTS	20
IV. CAUTIONS	22
V. PANEL OR GLARE SHIELD INSTALLATIONS	24
PANEL MOUNTS	24
SPORT GLARE SHIELD MOUNTS	25
PRO GLARE SHIELD TRIM KIT	26
VI. AOA CPU TRAY INSTALLATION	28
VII. WING PRESSURE PORTS INSTALLATION	30
VIII. PITOT STATIC TEE INSTALLATION	36
IX. FLAP AND GEAR SWITCH INSTALLATION	38
X. WIRING INSTALLATION	40
XI. POST INSTALLATION TEST	46
XII. CALIBRATING PROCEDURES	48
XIII. SPORT CALIBRATION	50
XIV. PRO CALIBRATION	58

XV. ADVANCED APPLICATIONS	66
GEAR WARNING	66
ADJUSTING PRESSURE AMPLIFIER GAIN	67
SPORT GAIN ADJUSTMENTS	68
PRO GAIN ADJUSTMENTS	69
SLUING ANGLE ADVISORY AND PERFORMANCE DATA	70
OPEN COLLECTOR WIRING OPTIONS	72
BACKUP POWER WIRING OPTIONS	72
XVI. WARRANTY REPAIRS AND CLEANING	74
MAINTENANCE SERVICE	74
CLEANING THE SPORT DISPLAY	74
CLEANING THE PRO DISPLAY	75
APPENDIX	78
A. AOA REVIEW	78
B. ELECTRICAL CONNECTIONS	94
SPORT PIN OUT	94
PRO PIN OUT	95
PICTORIAL SCHEMATIC SPORT	96
PICTORIAL SCHEMATIC PRO	97
C. PANEL CUTOUT	98
PANEL CUTOUT SPORT	98
PANEL CUTOUT PRO	99
D. SPECIFICATIONS	100
E. ERROR MESSAGES	102
F. CHECKLISTS	104
G. INVENTORY	106

H. TROUBLE SHOOTING	108
I. PORT LOCATIONS/FLAP SWITCH CLOSURES	110
J. REVISIONS	114

Intentionally Blank

I. Operator and Installer Requirements

The AOA Instrument will never be used as a primary instrument and must be placarded as such. Installation of the AOA on experimental aircraft is considered a minor alteration and as such does not require anything other than a logbook entry. Installation on production or certified aircraft requires FAA approval (Form 337) which may be difficult or impossible to receive. This experimental instrument is not FAA certified or approved. Improper installation or usage on aircraft may cause death or injury.

Prior to flying AOA instrumentation, the pilot must obtain flight instruction from a qualified instructor. An emphasis item in AOA training is that wings contaminated with insects, dust, frost or ice stall at higher airspeeds and reach their critical AOA at lower angles. This is especially true of highly laminar airfoils that are generally more sensitive to light contaminants and environmental conditions than non-critical and turbulent boundary flow airfoils. Another emphasis item is that tractor powered aircraft will reach critical AOAs power off at a lower AOA and higher IAS than power on due to propeller effects.

Calibration of the instrument is critical for proper operation. A zero "g" and a descending power on slow flight maneuver must be flown in smooth air during the one time calibration process in both the cruise and landing flaps configuration. In addition, the pilots performing the calibration must determine for those in-between flap settings whether the cruise flaps or the landing flaps database should be used to compute AOA. This requires making the proper flap switch adjustments to insure the



OPERATION

high angle warning provides the desired margin prior to reaching the critical AOA. Guidance for aircraft flap switch setup, port locations and other frequently asked questions may be obtained by referring to Appendix I or via the internet at www.angle-of-attack.com frequently asked questions.

Some AOAs may be shipped with aircraft calibration data pre-installed. If you choose to use this data, you must verify the validity of the data or calibrate the AOA to meet your specifications. Checklists are included or available from our web site.

You assume all liability for the appropriate application, construction, calibration, maintenance and installation. Application, construction, calibration or installation errors may cause death or injury. Please read the instructions! For example, details such as the void above the lower pressure tap are important for proper operation. Do not fill the void with sealant or epoxies.

The instructions that follow, are of an advisory nature, may not apply to the particular installation, and may contain errors. Advanced Flight Systems Inc. makes no warranty, other than that in the Warranty Agreement, with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Advanced Flight Systems Inc. shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

This document contains proprietary information that is protected by copyright ©, patent and a patent pending.

All rights are reserved. No part of this document may be reproduced, or translated to another language without written consent of Advanced Flight Systems Inc. The information contained herein is subject to change without notice.

All operators using this AOA must read the manual in its entirety. Each installation is different and the installer and owner are solely responsible to insure that the usage is appropriate and safe.

You must include in your preflight checklist:

Wing Pressure Ports..... CHECKED
Pitot/Static Ports..... CHECKED
Air/Water Separator DRAINED

You must add to your Aircraft Operating Handbook the pilot operating instructions for verifying that the AOA system is working properly. You must include in your before take off checklist the Angle-of-Attack Push to Test check that is detailed within the Pilot Operating Handbook and faithfully execute the check prior to each flight:

Angle of Attack TEST/CHECKED

At each annual condition inspection, the results of the AOA Instrument inspection, verification and test must be recorded on an annual condition inspection checklist.

When using the AOA Instrument, cross checking to the airspeed indicator for reasonableness checks are required

OPERATOR AND INSTALLER REQUIREMENTS

and your airspeed indicator always takes priority in the event of disputes. The AOA Display must be placard with “NOT TO BE USED AS A PRIMARY INSTRUMENT.”

An up to date AOA Operator’s and, Installation Manual must be available to the pilot at all times. The entire manual is downloadable free from our web site at www.angle-of-attack.com and also available in print for a small fee upon request. Please keep your AOA manual up to date with new inserts as required.

The pressure ports must be placarded with



and the area around the ports must never be power washed. Care must be taken not to plug the ports with wax or polishing compounds.

The AOA drain must be placarded with:

**DRAIN PRIOR
TO FLIGHT**

Any errors during tests, inspections or checks shall be noted in the aircraft log book, the pitot/static tubes capped to prevent pitot/static errors and the instrument disconnected and placarded as inoperative in accordance with MEL's and FAR's.

The AOA Instrument or its parts are not to be resold without prior approval of Advanced Flight Systems Inc.

Stall warning devices and AOA devices are different in design. This AOA instrument does not meet the FAA TSO requirements for stall warning devices.

A failure of the Pitot/Static pneumatic system such as taking off with a covered pitot tube will cause the AOA to give false and unreliable information.

This system, like other electrical systems, requires a minimum voltage, fuse protection and an air-conditioned environment to function properly. The electrical and temperature specifications are listed in Appendix D. A separate circuit breaker that can be pulled to disable the AOA in flight is mandatory and must be in reach of the pilot in command.

Should any of the above be impractical or impossible to implement, the AOA Instrument must be returned in a new condition for a refund within 60 days.

Free Technical Consultation

If you need technical advise E-mail AFS@angle-of-attack.com. It is advisable to have this manual on hand for reference.

Your AOA Instrument has a part number affixed to the AOA CPU and the same number should be entered on the first page of your owner's handbook and the warranty registration card. This number will be helpful to determine how your instrument was configured. This number should also be available prior to calling.

Please fill out the warranty registration card and keep your address updated to insure you receive Service Bulletins and Service Difficulty Reports. The latest Service Bulletins and Service Difficulty Reports are always available on our web site at www.angle-of-attack.com.

II. How it Works

You have acquired a powerful instrument that is experimental by nature and will require initial calibration and/or verification by you for your aircraft.

Please review Appendix A and take the quiz coming back to this point in the manual when finished. If you are a Navy or Marine carrier pilot, the material in Appendix A may look familiar.

◇ Review of Appendix A completed

Theory of Operation

The AOA Instrument is based upon sound aerodynamic principle. The term "angle of attack" is the angle between the relative wind and the chord of the airfoil. The new term you may not be familiar with is "angle from zero lift" which is the angle measured from the reference angle when aligned with the relative wind creates no lift. Angle of attack and angle from zero lift are identical to each other for symmetrical airfoils. For non-symmetrical airfoils, the difference between angle of attack and angle from zero lift is a fixed constant. When the term angle of attack or AOA is used for non-symmetrical airfoils, the term angle from zero lift should be substituted in order to be technically correct. Your AOA Instrument technically measures angles from zero lift. When the PRO display indicates 0 units AOA, the aircraft properly calibrated is creating no lift.

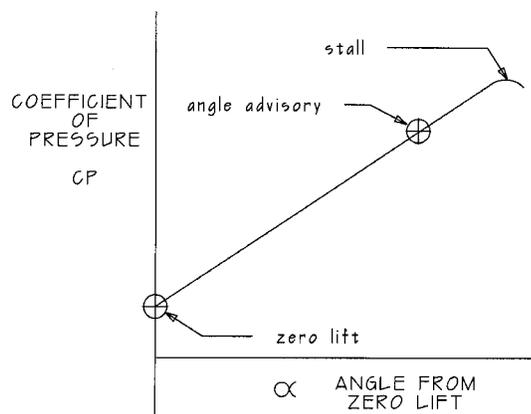
The Angle of Attack Instrument (AOA Instrument) utilizes pressures from two pressure ports located on your aircraft's upper and lower airfoil or probe, and pressures

HOW IT WORKS

from your aircraft's pitot and static ports. The result of dividing the airfoil or probe differential pressure P_w by the pitot static differential pressure P_p is a coefficient of pressure (CP). There is a unique variation of CP with angle of attack. This variation is very linear over most of the airfoil's AOA.

The process of calibrating the full range AOA Instrument to a specific airfoil requires as few as two coefficients of pressure that are permanently recorded into the angle of attack instrument's memory. The CPs include a zero lift CP and an angle advisory CP. These two CPs are then used to define the slope and intercept of the straight-line relationship between the coefficient of pressure and the angle from zero lift. This is easily accomplished in one short flight. Once the system is calibrated with these two CPs, all other coefficients of pressure can be equated to a specific angle from zero lift.

The coefficient of pressure at zero lift (OL) is determined by performing an in flight 0 "g" maneuver. The



coefficient of pressure at angle advisory (AA) is

determined by flying at the AOA or airspeed at 1 "g" where it is desirable to have the high AOA warnings activate ("angle angle push") usually at 1.15 times the stalling speed.

The upper and lower airfoil pressure ports may be simply small holes in the upper and lower surfaces of the wing connected to tubes routed to the AOA CPU eliminating the requirement for a probe altogether or may be from an alpha probe. The pressure ports for the pitot and static pressures may be from the pitot/static tube or individual pitot and static ports. Pick the pitot/static pressures by teeing into the pitot static systems just behind the airspeed indicator.

The angle of attack is displayed on an AOA instrument. When the AOA reaches high angles of attack, the AOA Instrument issues electrical, verbal and visual warnings.

FAR 23.207 requires stall warnings to begin at a speed exceeding the stalling speed by a margin of not less than 5 knots but not more than the greater of 10 knots or 15% of the stalling speed. Since the AOA Instrument is not an airspeed indicator, the term "stall warning" as defined by the FAA and FAR's does not apply to this AOA Instrument. We shall use the term "angle advisory". During the calibration process, AOA is used to determine where the angle advisory will activate.

The AOA Instrument will provide AOA information to the aircraft pilot and warnings when the AOA is at high angles and when the airfoil is operating at the optimum AOA for an approach and operating at some other performance related AOA such as the maximum endurance or best glide angle. It should be noted that ice,

HOW IT WORKS

frost, dust and insects adhering to the wing will increase the stalling speed and decrease the critical AOA.



AOA Displays

The AOA Sport Instrument's display is a three color light emitting diode (LED) eight ladder display which shall be located on the instrument panel or the glare shield.



The AOA Pro Instrument's display is a four-color liquid crystal display that shall be located on the instrument panel or the glare shield.

Modes of Operation

There are three modes of operation:

1. the Flight mode when the AOA Instrument is indicating AOA information and warnings and the display is moving up and down as AOA is increasing and decreasing;
2. the Test mode when the AOA Instrument is going through its self test;
3. and the Calibration mode as indicated on the Sport display by pattern of flashing LEDs or on the Pro when a 0 or 1 is followed by alpha characters.

When in the calibration mode, there are five (5) pages to choose from for the Sport and seven (7) for the Pro as follows:

1. The Hangar Calibration (HC) page is used to establish voltage offsets for the wing and the pitot/static differential pressure transducers at zero differential pressure. Each pressure sensor is unique.
2. The Zero "g" or Zero Lift page (0L) is used to establish the coefficient of pressure at an AOA where the aircraft is creating no lift.
3. The Angle Advisory page (AA) is used to establish the coefficient of pressure at an AOA where high angle warnings should activate.
4. (Pro Only) The Approach page (AP) is used to establish the coefficient of pressure at an AOA where the aircraft is at an optimum approach AOA.

HOW IT WORKS

5. (Pro Only) The Performance page (PF) is used to establish the coefficient of pressure at an AOA where the aircraft is at some optimum performance AOA typically the best L/D AOA or maximum endurance AOA.
6. (Pro Standard and Sport Optional) The landing gear warning page (LE) is used to establish the minimum airspeed where, if the gear is not down, a “Landing Gear” warning is enunciated.
7. The Save page (SA) is used to write all the data saved above in RAM to permanent memory (EEPROM).

Aircraft Data Base Configurations

The AOA Instrument senses when the aircraft is in one of two configurations using a simple micro switch connected to the flap movement mechanism:

1. The cruise or clean configuration when the flaps are up.
2. The landing configuration when the flaps are not in the up position or in the down position for landing setting.

For in-between flap configuration settings, the flap switch is configured so that the AOA CPU uses the most conservative database for computing AOA.

OPERATION

HOW IT WORKS



AOA Sport and Pro CPU (Computer or Brain Box))

The angle of attack central processing unit is enclosed in an aluminum tray. Although both the Sport and Pro are housed in identically shaped trays, there are major differences in the electronics. The 25 pin Dsub is for wiring the CPU to the display, the power supply, the push to test (PTT), dimmer and flap position switch. The four barbs will be connected to 1/8" OD color-coded pressure tubing.

The PCB (printed circuit board) is populated with a microprocessor, an EEPROM memory chip, a chip used for the audio play back of warning and error messages and a fuse. There is no battery in the CPU since the EEPROM memory chip does not require a battery to remember data.

HOW IT WORKS

OPERATION

HOW IT WORKS



AOA Sport LED Display

The display is a custom three color LED ladder. Eight LED segments are individually controlled by the microprocessor. A momentary push button switch controls the brightness. These bulbs have a typical life of about 100,000 hours. The display is also available in a glare shield mount.

The two bottom LEDs are green, the three above are yellow and the top three LEDs are red.

The bezel is black Delrin and was precision milled.



AOA Pro LCD Display

The angle of attack liquid crystal display is a custom four color display and back lit with 100,000 hour white LEDs. The power for the back light comes from the AOA CPU PCB. Fifty-two light bar segments are individually controlled by the microprocessor (direct drive) providing the maximum contrast possible. Due to polarizing, the display reads best when viewed straight on and from above.

The back of the LCD includes the surface mounted electronics. Inside the display is a light board to further increase the contrast.

The bezel is black anodized and was precision milled from solid aluminum.

HOW IT WORKS



Switches and Push Buttons

For aircraft equipped with flaps, slats, and/or retractable gear, microswitches sense whether the aircraft is in the landing or the cruise configuration.

A red push to test (PTT) button and a black instrument dimmer button is supplied. When both buttons are pushed and released at the same time, you enter the calibration mode.

OPERATION

Intentionally Blank

- ◇ Inventory complete (either "A" or "B" or "AB" kit)

The AOA CPU (angle of attack central processing unit) was thoroughly electrically checked for proper operation using a test box. The AOA LED or LCD display was also tested prior to shipment. If you encounter any quality control problems, please return the part for repair or replacement.

- ◇ The wiring harness was inspected but not electrically tested prior to shipment. Referring to appendix B, ring out the wiring harness now! This will confirm that the connections are good and correct and may save you lots of grief later should there be a problem.
- ◇ For some aircraft like the RV4, 6, 7, 8, and 10 the ports must be located in the wing at the proper location. For the Lancair Legacy the wing parts are preinstalled. In the above cases, the port location is critical and the CPU was shipped pre calibrated. See appendix I for the exact port locations. With properly located ports and a pre calibrated CPU, you need only verify that the AOA indications are correct (see the "Verification" yellow checklist).

IV. Cautions

- Calibration of the AOA Instrument requires a zero G maneuver in the cruise and landing configuration. Remove any loose items from the aircraft cabin or baggage compartment and check the engine compartment and remove any loose bolts etc. that are not properly secured and may move during this maneuver.
- Calibration of the AOA Instrument requires a descending slow flight maneuver in the cruise and landing configuration. On humid days and at low power settings carburetors and even throttle bodies will ice up causing engine stoppage. Use carburetor heat and clear the engine frequently as required in your pilots' aircraft operating manual.
- The AOA Instrument flap, gear, PTT, and dimmer Dsub pins and switches shall not have a power supply connected to them. Simply switching these pins to a ground will provide the signal that is required. Voltages applied to these pins may damage the AOA CPU.
- The accuracy, fidelity and reliability of the AOA Instrument are dependent upon several factors. The location of the pressure ports relative to the wing, accuracy of the pitot static system, and the quality of the job done in calibrating the AOA Instrument are of most significance.
- The AOA Instrument shall never be used as a primary instrument during any flight maneuver. It may be

used as a backup to primary instruments such as the airspeed indicator.

- The critical AOA verbal warning will occur at a lower AOA and higher airspeeds when the airfoil is contaminated. Power off flight in tractor driven aircraft may result in a lower critical AOA and a higher stalling IAS than with power on due to propeller effects.
- If the AOA CPU is removed for repair or service, prior to flight cap the red and clear tubes to insure that the pitot/static system continues to work properly.
- The AOA requires pitot/static system inputs to operate. The installation of a separate pitot/static system would provide more redundancy and is recommended.
- The gear warning system does not arm and cannot issue warnings until the IAS exceeds the landing gear warning speed (usually after takeoff). Setting the landing gear warning speed too high could result in the system never arming during a slow flight around the pattern. Setting the landing gear warning speed too low could eliminate warnings altogether.
- The pressure tubes must not be crimped. The minimum bend radius is 3/4". Be careful when removing and reinstalling adjacent equipment that could crimp the tubes.

V. Panel or Glare Shield Installations

- ◇ A. See Appendix C. The AOA display will normally be mounted on the instrument panel or on the glare shield. Note that there are two styles of Sport instrument bezels panel and glare shield. A trim kit is available for the Pro if it is mounted other than on a panel. A metal template is available for all panel mounted displays to insure clean and accurate panel cutouts.
- ◇ B. The AOA Sport display bezel is milled from Delrin and care is required to prevent stripping the threads. The proper method to torque the mounting screws is to bottom them out then rotate one-eighth additional turn.

Panel mounts

- ◇ C. Locate the template on the front of the instrument panel and positioning it straight up and down. Securely attach the template to the panel using packers tape or drill a small hole through the center of the bezel and bolt into place on the instrument panel.

Using a 1/8" drill bit and the top and bottom template guide holes, spot face the panel just enough to leave centering marks. Remove the template.

- ◇ D. Using a 1/16 drill bit and using the centering marks, drill through the panel. Using a #32 drill bit (1/8" bit is OK), open up the holes to accept a 4-40

screw. Reinstall the template on the instrument panel using the instrument mounting holes, 4-40 screws and nuts.

- ◇ E. Using a 1/8" drill bit and the template as a guide, drill the inner four holes forming the edge radius for the panel cut out. Remove the template. For the Pro only, enlarge the four inner holes using a 3/16" drill bit. The Sport has 1/16 corner radius and the Pro has 3/32" radius corners.
- ◇ F. Hog out the area between the four holes using a dremel, file or both. Careful though not to square the corners.

For the Sport the arrow or triangle molded into the side of the gray electrical connector is closest to the bottom of the display and above the green LEDs. For the Pro the connector is located at the top of the display.

Sport Glare Shield mounts

- ◇ C. Note the holes in the side of the bezel. These holes are designed for glare shield mounting. Use these mounting holes in a variety of ways as follows:
- ◇ D. Tap the holes with a 4-40 tap. Drill matching holes through your glare shield. Use 4-40 screws (not supplied) to secure the bezel to the glare shield.

Pro Glare Shield Trim Kit

- ◇ A. Call about an optional trim kit for a glare shield mounting. The trim kits includes a cover for the back of the display and a trim and tang for the front of the display.

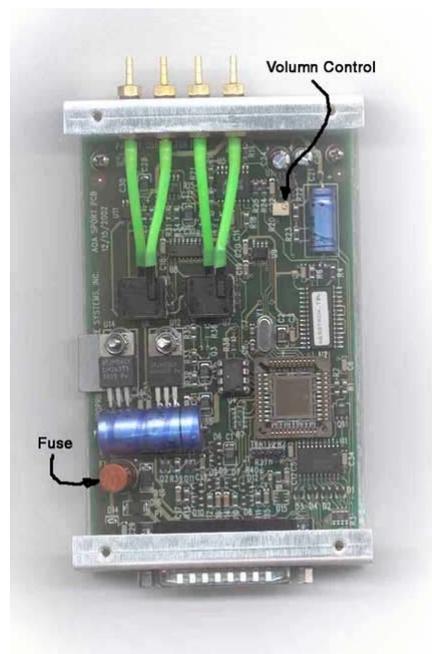
Intentionally Blank

INSTALLATION

VI. AOA CPU Tray Installation

- ◇ A. Remove AOA CPU tray cover by unscrewing the four machine screws on the top. Note that there is a 1-amp fast blow fuse (brown cylindrical) installed on this board. Make sure it is installed. This fuse protects the AOA CPU. The aircraft circuit breaker (not provided) protects the wiring to the AOA CPU.

- ◇ B. Note the potentiometer located on the AOA CPU PCB with the very small brass screw on top. This little pot will adjust the volume of the audio output. If the AOA CPU is located where access to the top is afforded, you may want to drill a 1/4" diameter hole centered over the screw located directly above the rheostat so that volume changes can be made without opening the tray. To increase volume, turn the screw up to eight (8) turns or more clockwise.



- ◇ C. The tray has been sized to fit forward of the pilots and passengers or instrument panel.
- ◇ D. The AOA CPU tray should be located in the cabin area of the aircraft accessible to electrical power, the AOA LED and the pressure tubes. Areas not acceptable would be the engine compartment, a wing compartment subject to extreme temperature variations and near strobes or other electrically noisy devices like hydraulic pumps. The Dsub connector on the bottom of the AOA CPU tray must be accessible. The tray may be mounted horizontally or vertically. It should not be mounted with the black label facing down. The tray has four threaded mounting holes (6-32 thread) which may help secure the tray into the position of your choice. The mounting screws must not penetrate the tray by more than 1/4 inch since longer penetrations may interfere with components inside the tray rendering the AOA instrument inoperative. Velcro mounting is also acceptable.

VII. Wing Pressure Ports Installation

Wing pressure ports are used to measure the local wing lift. These ports may be located on the upper and lower surface of your aircraft's wing.

Due to the numerous wing pressure port location options, consider the following. Upper pressure ports are subject to moisture contamination and should be provided with an air water separator. While parked on the ramp a method to prevent the ports from being contaminated by debris or insects is advisable.

The ports should be marked with a placard similar to the markings for static ports. The ports must be located outboard of propeller wash even with the aircraft in a slip. There is a different wing kit depending upon what type of



material the wing is constructed. For aluminum, fabric and wood skinned wings we supply a white Delrin air/water separator. For composite skinned wings we supply phenolic air/water separator parts.



Typical composite wing installation

The size of the wing pressure port holes may be small #60 bit (.040") to prevent insect contamination. The ports should be accessible either through

the wing tip or an access panel. Hose barbs compatible with 1/16" ID hose and a 10/32 thread are provided, as is the air/water separator. The ideal location for the pressure ports is where the local pressures vary linearly with AOA. A sure way to determine good wing pressure port locations is by noting what others have found to work. There are some places where pressure ports should not be located on the wing such as in line with the propeller wash, too close to the wing tip, and in areas difficult to access. Generally 15% to 40% chord and forward of the ailerons will work well. The upper and lower ports should be located at the same % chord but offset by 2" to 4" spanwise.

- ◇ A. Pick the pressure port locations. For the best wing port locations, check the Appendix I or better yet, our web site at www.angle-of-attack.com for the most recent information.

WING PRESSURE PORTS INSTALLATION

- ◇ B. Install the supplied air water separator. The drain should be at the bottom and the hose barb installed with gasket on the side near the top of the air water separator. It is not necessary to over tighten the barb fitting. Torque the barbs to a maximum of seven (7) inch pounds. Seal all surfaces and do a pressure check. For metal installations, ProSeal may be used as a sealant.
- ◇ C. Install a hose barb and gasket over the lower wing pressure port. A strip of phenolic or Delrin tapped with a 10/32 thread and bonded, screwed and or riveted to the bottom skin is adequate. Seal all mating surfaces and pressure check. A 3/8" diameter cavity just below the barb that acts to break capillary action is required for proper operation.
- ◇ D. Route a blue (sky) colored tube from the upper wing pressure barb to the AOA CPU barb marked upper wing. Route a green tube (grass) from the lower wing pressure barb to the AOA CPU barb marked lower wing. Don't confuse the two colors which may be difficult to tell apart if you are color blind or working in a poorly lit environment.

WING PRESSURE PORTS INSTALLATION

Aluminum Wing Installation

ADA Pressure Ports	May 1, 1999
Aluminum Wing	ADA_460b_rev2.dwg JBF
Proprietary Software Systems, Inc.	

Offset the upper and lower pressure ports by 2" to 4" span wise
 aileron area of wing span wise is optimum span location
 Keep the upper and lower pressure ports at the same $\frac{1}{2}$ chord
 Avoid locating the ports near round head rivets

Clean all mating surfaces prior to installation
 Use sealant between pressure blocks and wing
 Pressure ports drilled with #60 bit (.040 dia.) after block placement
 Pressure test all systems for leaks prior to flight
 Use acceptable methods, techniques and practices in accordance with DOT FAA circular AC 43.13-1B

Chord - Distance from the leading edge to the trailing edge of the airfoil including the aileron

INSTALLATION

WING PRESSURE PORTS INSTALLATION

Composite Wing Installation

ADA Pressure Ports	March, 1999
ADA_460 rev1.dwg rev 1	JBF
Proprietary Software Systems, Inc.	

Sand OD of 3/4" phenolic to slide fit within 1" OD tube
 Sand OD of AL donut to slide within 1" OD phenolic tube
 Install air water separator first
 Use 40 grit sand paper to roughen bonding surfaces
 Seal the inside surface of the tubes using epoxy the tubes may be porous

Call for port placements for various aircraft
 Keep the upper and lower pressure ports at the same % chord
 Keep the upper and lower pressure ports 2" to 4" of each other span wise
 Clean all mating surfaces prior to bonding

Remove wing core at ports
 Pressure ports drilled with #60 bit (.040 dia.) min.
 Pressure test all systems for leaks prior to flight
 Use acceptable methods, techniques and practices in accordance with DOT FAA circular AC 43.13-1A

← % CHORD →

3/4" OD Phenolic tube
 1" OD phenolic tube
 AL donut
 Drain valve

Axis of tube normal to lower wing surface

Composite Upper Pressure Port and Air/Water Separator

Composite Lower Pressure Port
 lower port air/water separator

← Same % Chord as upper port →

Chord - Distance from the leading edge to the trailing edge of the airfoil

Intentionally Blank

INSTALLATION

VIII. Pitot Static Tee Installation

- ◇ A. If you opt to tee into the existing pitot system, a nylon 1/4" OD tee is provided with a hose barb adapter. Cut into the pitot tubing and slip the "B" nuts over the tubing. Push the white nylon inserts into the end of the tubes. Attach to the tee and torque the nuts in accordance with the manufacturer's instructions below. The nylon works with either 1/4 inch OD nylon or AL tubing. If you prefer AL fittings rather than nylon, return the nylon tees for aluminum AN-4 replacements. If using some other sized aircraft tubing, you will have to provide your own tees that adapt to the 10/32 hose barbs provided.
- ◇ B. If you opt to tee into the static system a nylon 1/4" OD tee with inserts is provided with a hose barb adapter. Cut into the existing static system and install the tee just like you did in the previous instructions.
- ◇ C. High quality transparent colored pressure tubing is provided. Use the clear tubing to connect the static system to the AOA CPU barb marked static. Use the red tubing to connect the pitot system tee to the AOA CPU barb marked pitot.



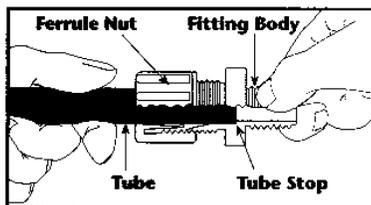
- ◇ D. The hose barbs with gaskets should be tightened to a maximum of 7 inch pounds. Do not over tighten! Perform a pitot and static pressure test required by FAR's to insure there are no leaks in the pitot/static system.

INSTALLATION INSTRUCTIONS FOR JACO TUBE FITTINGS

1. Cut the tubing end squarely and remove the internal and external burrs.
2. Insert the tubing through the back of the nut all the way through the nut assembly to the tube stop in the fitting body (see illustration). If the tubing does not enter the nut easily, loosen the nut one turn and then insert the tubing all the way to the tube stop in the fitting body.
3. Turn the nut hand tight.
4. Wrench tighten the nut $1\frac{1}{2}$ - 2 turns.
5. All nuts must be retightened when the system reaches projected operating temperature.

NOTE: Squeaking sound when tightening nut is normal. For pipe threaded connections, Teflon Tape* must be used.

*Dupont's Reg. T.M. Patent 1983



CAUTION: To insure proper assembly, tubing **MUST** be fully inserted into the fitting body to the tube stop.

INSTALLATION

IX. Flap and Gear Switch Installation

The AOA Instrument needs to know if you are in the cruise or landing configuration. If you don't have flaps, slats or a retractable landing gear, then you are always in the landing configuration and no switch installation is required. If you have a fixed gear, the gear switch is not required.

For flap/slat settings in-between cruise and landing configurations, the AOA Instrument's flap switch must be set up so that the AOA CPU is using the most conservative database to compute AOA. This is usually the flap down database. When the ports are located outboard of the flaps, the flap down switch should electrically ground the AOA "FLAP" wire by 1/3 flaps and remain grounded through full flaps.



In some installations like RVs it may be easiest to activate the arm of the microswitch as the flaps move into the up position. In this case the AOA "FLAP" wire would be connected to the microswitch NC (normally closed) lug.

The flap switch usually is most easily installed on the flap drive mechanism rather than on the flap itself and would be less exposed to the elements.

- ◇ A. See www.angle-of-attack.com/FAQ for the most recent aircraft specific flap switch closure points. Switch closure prior to 1/3 flaps on the web site

means the contacts in the switch must close somewhere between 0 and 1/3 flaps as the flaps are extended. The arm of the microswitch could be set to close at the flaps up position and be open at all other flap settings and still meet the above requirement electrically with the "Flap" wire hooked to the NC (normally closed) lug.

- ◇ B. Install the flap switch to close as instructed. The switch is most easily installed on the flap drive mechanism rather than on the flap itself. There are two holes through the switch to ease installation. An angle bracket may be custom built to hold the switch in proper position. There are many flap installation pictures on our web site.
- ◇ C. Optionally install a gear down switch to indicate when the gear is down. If one lug of an existing landing gear down and locked switch is directly connected to a ground, this switch may serve both the gear light and AOA gear warning systems. Remember, the wire labeled "GEAR" must not be connected to a power supply and must be pulled to an electrical ground when the gear is down.
- ◇ D. If the AOA aural message "FLAPS" is heard when the flaps are moving down you got it wired right. If the "FLAPS" occurs as the flaps are moving up, you got it wrong. Move the "FLAPS" wire to the other lug.

X. Wiring Installation

A standard cable is provided and pre-wired at the 25 pin Dsub end. The other end of the harness is wild. Note Appendix B that describes the Dsub25 pin connects to be used in the following instructions. Ring out the wiring harness now.

The harness is wired for a 560-ohm audio output that allows you to match the output impedance of the AOA to standard aircraft headphone, audio panel and intercom audio devices.

Direct wiring to non amplified standard 26-ohm cockpit loud speaker will require the 26-ohm audio output and a ground (audio low). This will require the addition of a two conductor shielded cable not supplied.

- ◇ A. Measure the wiring distance from the AOA Display to the AOA CPU. This is most easily done using a string taping it to existing wiring bundles over the desired routing. Cut the excess cable from the AOA display cable. The runs to the other switches, power and ground should also be measured at this time and the wires marked and cut to length.
- ◇ B. Strip the shield of the wire labeled "AUDIO" back two inches and shrink-wrap. Connect the center conductor to either the tip of the audio headphone jack, the audio input of the intercom or a spare audio selector channel designed for aviation audio inputs.

Direct wiring to non-amplified standard 26-ohm cockpit speakers require the 26-ohm audio output and a two conductor shielded cable not supplied.

- ◇ C. Connect the wire labeled "Ground" to an aircraft ground.
- ◇ D. Install a new CB of 5 to 1 amps and mark the CB as "AOA". A separate CB is required because the AOA Instrument could be disabled by pulling the CB without disabling any other aircraft systems. Pull the circuit breaker and connect the wire labeled "Vin" to the circuit breaker.
- ◇ E. Connect a grounding wire for the flap switch from the lug marked common (COM) to a ground. The normally open (NO) lug of the switch shall be connected to the appropriate pin of the Dsub labeled "flap" assuming the lever arm of the switch is activated as the flaps move down. If the lever arm of the microswitch was activated as the flaps reach full up, connect the wire labeled "flap" to the normally closed (NC) lug. This switch must be dedicated to the AOA CPU flap sensing and not used for other indicators.

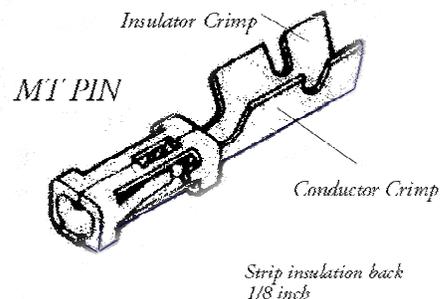


WIRING INSTALLATION

WIRING INSTALLATION

In electrical terms, generally the AOA needs to see a ground via the "flaps" wire when the flaps are not up. See the FAQ section of our web site.

- ◇ F. Install the PTT and Dimmer wiring. One lug of the PTT (red) and Dimmer (black) switch is connected to an aircraft ground. The other lug is connected to the wire coded "PTT" and "Dimmer" respectively.
- ◇ G. Install the landing gear wiring, connecting the common lug of the position switch to any aircraft ground and the NO (normally open) lug to the wire coded "gear". Assuming the existing gear switch makes the ground connection, it is easy to tee into the wire running from the gear down indicator light to the gear position switch. Isolation diodes are included in the CPU so additional diodes are not required.
- ◇ H. (Pro Only) For the Pro display install the six MT connector pins to the display end of the AOA LCD shielded cable. This is done by stripping back the cable wrap and shield one and one half inch (1 1/2"). Use shrink-wrap to insulate the trimmed end of the shielding. Strip back the insulation by 1/8" of each of the six wires. Note that the MT contacts have a strain relief that must be crimped to the insulation and the



electrical crimp that should be crimped onto the conductor requiring a two-crimp process. The MT contacts should be loaded into a MAC Tools (Snap on part #TCT1028) or equivalent size E crimper with the crimp end of the contact flush with the face of the crimper. Insert the insulation 1/16" into the contact and lightly crimp the strain relief portion of the contact to the insulation of the wire. Move the MAC tool 1/16" deeper over the contact and crimp using maximum pressure for a good crimp on the conductor.

Load the six contacts into the MT housing being careful to rotate the contact prior to insertion so that the retainer tab of each contact catches the long slot on the numbered side of the housing. The orange wire should be in slot one, then blue, green, red, white and black in slot six of the housing.

Route the LCD cable to the AOA LCD. There are two possible ways to connect the MT connector to the header but only one works. Slip the MT housing over the AOA LCD header with the connector legend visible (facing away from the display).

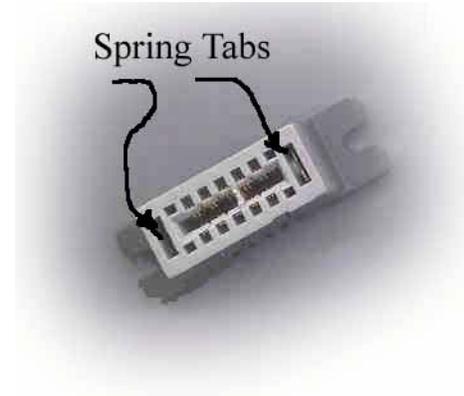
- ◇ I. (Sport only) For the Sport the AOA LED display is connected to the AOA CPU using a 10-conductor ribbon cable supplied. The wiring distance from the AOA display must be determined. Cut the excess ribbon cable using scissors to make it the proper length. Note that the ribbon cable is color-coded. The colored edge of the ribbon cable is conductor #1. Slip the ribbon

WIRING INSTALLATION

cable through the edge card connector so that the #1 conductor is under the triangle or arrow molded into the connector. It makes no difference if the cable is routed through the connector from the left or right side. Just insure that the red conductor is under the triangle or arrow molded into the side of the connector. Align the ribbon cable square to the edge card connector, protect the face of the display with some tape, and squeeze the connector onto the ribbon cable using a pair of pliers. Use a knife to trim the excess cable.

Note: *If the strain relief has been accidentally seated prior to inserting the ribbon cable, disassemble the display as shown in the chapter on how to clean the display. Locate the two slits on the front of the connector.*

Using a thin blade in the slits spring the metal tabs outward and pull on the strain relief.



Intentionally Blank

INSTALLATION

XI. Post Installation Test

- ◇ A. Position the flaps to up. Power up the AOA by pushing in the AOA circuit breaker and watch the AOA display and listen to the audio.
- ◇ B. After a short delay, restart the testing sequence by a push and release of the red PTT button to confirm the red button works. The AOA display should be blank for several seconds. All the light bars of the AOA display should light for several seconds. The audio should enunciate "Angle Angle Push", "Flaps", "AOA PASS" or other aural warnings.
- ◇ C. Change the flap setting from up to down. The aural warning "FLAPS" should sound and possibly other aural warnings or error messages. If the "FLAPS" sounds only as the flaps move from down to up, the wire labeled "flap" must be moved to the other open lug on the flap switch. For the Pro, as flaps go down the green donut in the center of the display must light.
- ◇ D. Push and release the black Dimmer button to dim the display and to confirm the button works. Verify the display dims. Since the Sport display is normally blank while in the flight mode and on the ground, push and release the Red PTT button to force the Sport through a self test so you can see if the display has dimmed. After completion of the test, push the dimmer button again and the display should be bright. Note that you cannot dim the display during the self test or while in the

calibration mode. The dimmer function only works while in the flight mode.

- ◇ E. Perform a pitot/static test. Tape over the wing ports and perform a leak test at the CPU side of the green and blue tubing. Remove the tape. Apply pressure at the CPU side of the green and blue tubing and test for air exiting the ports.
- ◇ F. Revise your check lists in accordance with Appendix F.
- ◇ G. Revise your Pilot Operating Handbook to explain how to accomplish the preflight check prior to takeoff. See Appendix F.
- ◇ H. Revise your Annual Condition Checklist in accordance with Appendix F.
- ◇ I. If the AOA is already calibrated, use the yellow Verification Checklist to confirm the calibration data loaded in the AOA is within limits for your aircraft. Otherwise proceed to the calibration instructions.

XII. Calibrating Procedures

This section is an expanded partial checklist to help explain the colored one half page checklist that you will use in-flight to calibrate the AOA. You also received a video that demonstrates how to calibrate the AOA, which will be worth reviewing. Do not attempt to use this manual or video to calibrate the AOA, use the colored checklist! If you lost the colored checklist, another can be downloaded from our FTP web site at www.angle-of-attack.com.

It is recommended that you practice this procedure on the ground with a copilot to get familiar with the push buttons and the various pages within the calibration mode. For landing gear warning options, see the Chapter on advanced applications.

There are two types of memory in the AOA CPU. RAM memory is volatile and is lost when the AOA is not powered. Non-volatile memory is good for about 100 years with no power even though there is no battery in the AOA.

EEPROM non-volatile memory can only be modified while within the calibration mode. EEPROM non-volatile memory is read and loaded into RAM during power up and whenever the flap setting is changed from up to down or down to up. The CPU uses RAM and pressure inputs to compute AOA.

To get into the calibration mode both the red (PTT) and black (dimmer) buttons must be pushed and released at the same time. The database accessed will depend upon the position of the flaps when the buttons were pushed

and released. If you want to modify the flaps up cruise database, you must first configure to flaps to up, then you can enter the calibration mode by pushing both the black and red buttons.

Once in the calibration mode, you can move through the various pages by pushing the black button.

When the red record button is pushed and released, data read from the pressure taps are copied to volatile RAM memory. This data is copied to non-volatile memory (EEPROM) only from the calibration SA (save) page when the record button is pushed and released. If data recorded to RAM is bad, you can simply push the black dimmer/page button multiple times skipping through the various pages of the calibration mode and skipping over the SA page thus avoiding a write to EEPROM non-volatile memory. However the bad data is still in RAM. To reload RAM with non-volatile EEPROM data, cycle the flaps.

Use the colored one-half page calibration checklist when doing the calibration rather than the next sections. After calibration has been completed, use the yellow Verification Checklist to confirm the data is correct for your aircraft.

XIII. Sport Calibration

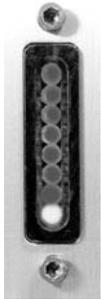
◇ A. To get into the calibrate mode, push and hold both the red push to test/record and black dimmer/page buttons for one second then release the buttons. The display will flash indicating you are in the first page (hangar calibrate) of the calibration mode. To return to the flight mode, push and hold both the red and black buttons and release.

The pressure transducers don't all put out zero volts at zero differential pressure. This is called the zero offset which is unique for each pressure transducer. This offset must be written to the permanent memory (EEPROM) of the AOA Instrument. The EEPROM used in the AOA Instrument does not require a battery and will remember what you wrote to it for at least 100 years. The best place for this first calibration step is in a hangar and out of the wind.

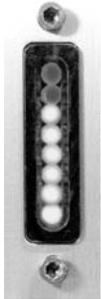


◇ B. Within a hangar or if outside pick a calm day, power up the AOA Instrument for five minutes. Then push both the red PTT/Record and black Dimmer/Page switches holding them for one second and then releasing. All the display LEDs are flashing indicating that you are in the first page of the calibration mode, the HANGAR CALIBRATION page.

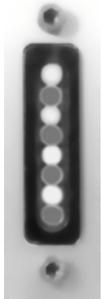
- ◇ C. Push the red PTT/Record button. The display should show a quick flashing sequence momentarily to indicate that the differential transducer offsets have been saved to RAM (random access memory) in the AOA CPU.



- ◇ D. The AOA now advances automatically to the ZERO LIFT page as indicated by the bottom green LED flashing and all other LEDs are off. This is the page where we input the zero "g" data while flying. Skip over this page to get to the ANGLE ADVISORY page. The ANGLE ADVISORY page is where we tell the AOA Sport to play the "Angle Angle Push" warning. Push the black dimmer/page switch to move to the SAVE page. If you opted for the gear warning, one additional push of the black button is required.



- ◇ E. The SAVE page is identified by every other LED flashing. Push and release the red PTT/Record switch to copy the volatile RAM data recorded earlier to permanent non-volatile memory storage. A short flashing sequence indicates that the data was recorded. We have now stored the zero offsets into non-volatile memory.



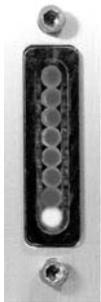
CALIBRATION

SPORT CALIBRATION

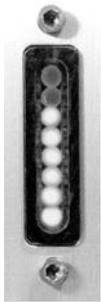
Turn off the power and let's get ready to go flying. Preparing for the flight calibration must be well planned in advance. Check the aircraft and remove any unsecured items. For pusher aircraft like Lakes, inspect the bottom engine cowl for bolts, nuts etc. laying on the bottom that will float into the propeller during the zero "g" maneuver. Your aircraft may have special requirements prior to doing a 0 "g" maneuver. Be prepared for false "angle angle push" warnings during flight since the AOA has not been calibrated. Consider pulling the AOA circuit breaker if this is a distraction.

- ◇ F. Put a tennis ball in your pocket or hang it from the overhead by a long string. This will come in handy later for the zero "g" maneuver.
- ◇ G. Let's go flying. With the flaps up, power up the AOA. Error 11, 12 and 13 are normal during the self-test in flight. Get into the calibration mode by pushing and releasing both buttons. Climb to about 3,000' AGL or higher into smooth air. Accelerate to the middle of your airspeed indicator's green arc in the cruise flaps up configuration.
- ◇ H. Place the tennis ball in the co-pilot's extended left hand or better yet hanging by a string from the overhead. Within gliding distance of the airport, do a practice zero "g" maneuver by smoothly pulling on the elevator control then pushing on the control. Keep the airspeed within the green arc of the airspeed indicator at all times. Do the zero "g" maneuver and just as the ball begins to float or the string goes limp, you are precisely at 0 "g". Don't plaster the ball on the ceiling. Try to maintain 0

"g" for about one to two seconds. During this maneuver the aircraft is creating no lift and is at zero degrees AOA.



- ◇ I. All the display LEDs are flashing indicating that you are in the first page of the calibration mode, the hangar calibration page. **Do not** press the red PTT/record switch since the data on this page was already set up during the hangar calibration. Advance to the zero lift page by pressing and releasing the black Dimmer/Page switch one time. You are now in the ZERO LIFT page as indicated by only the bottom green LED flashing.



- ◇ J. Push and hold the red PTT/Record switch. Do the zero "g" maneuver releasing the record button just as the ball begins to float or the string goes limp. The LEDs flash to indicate the data has been recorded into volatile RAM. The AOA automatically advances to the angle advisory page as indicated by the bottom six LEDs flashing as shown.
- ◇ K. The Pilots Operating handbook shall be used to compute the stall speed for the current conditions. The stall speed is multiplied by 1.15. This is a good speed to use for the descending slow flight maneuver where you would want to activate the "angle angle push" warning in the clean configuration. A power setting typical for approach and a descent in smooth air is desirable.

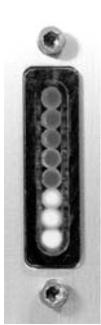
Note that you are already in the ANGLE ADVISORY page as indicated by the display.



- ◇ L. Push and hold the red PTT/Record switch. When on the desired speed release the switch to record the angle advisory data to volatile RAM. The LEDs flash to indicate the data has been recorded into RAM. The AOA automatically advances to the save page as indicated by every other LED flashing as shown unless you opted for the gear warning option.
- ◇ M. Push and release the red PTT/Record switch to copy the zero "g" and angle advisory RAM data recorded earlier to non-volatile permanent memory storage. A short flashing sequence indicates that the data was recorded.
- ◇ N. The AOA Instrument advanced automatically to the flight mode and should be displaying AOA as you fly along. Pull back and push forward on the controls and see if the display moves up and down. If so continue.
- ◇ O. Configure the aircraft in the landing configuration with flaps and gear down.
- ◇ P. Repeat the above starting at paragraph "G" above using flaps down instead of up.

To skip over a page, just push and release the black page button. If you feel the data just put into RAM is not good, from the save page, just push and release the black page button and all the RAM data entered since getting into the

calibration mode will not be saved to permanent non-volatile EEPROM memory.



- ◇ Q. If you opted for the gear warning, do the following. From the landing gear page of the calibration mode, push the red record button at the IAS where you want the "Landing Gear" aural warning to first sound if the gear was not down. From the save page, push the red record button. Reconfigure to the other flap setting, enter the calibration mode and skip over all pages until in the save page and push the red record button.

You have finished the basic calibration process. If done properly, there are no error messages as you change the flaps from cruise to landing and back.

- ◇ R. Head back to the airport in the landing configuration and shoot a visual approach. The Navy teaches pilots to use the elevator to control AOA keeping the middle yellow LED light lit and to control the rate of descent using the throttle. Your approach IAS is primary and should be at about 1.4Vs assuming you used 1.15Vs for your angle advisory calibration point. If you don't like where the approach speed ended up, recalibrate the angle advisory using a slower or faster speed. This will move the approach speed down or up by the same percentage.
- ◇ S. Cross check the AOA to the IAS. Insure that the angle advisory "angle angle push" is appropriate

SPORT CALIBRATION

relative to the indicated air speeds for the present conditions.

- ◇ T. Use the yellow verification checklist to insure your calibration data is within acceptable limits.

Intentionally Blank

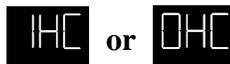
CALIBRATION

XIV. Pro Calibration

- ◇ A. Does the test sequence perform as per Chapter XI?

The pressure transducers don't all put out zero volts at zero differential pressure. This is called the zero offset which is unique for each pressure transducer. This offset must be written to the permanent memory (EEPROM) of the AOA Instrument. The EEPROM used in the AOA Instrument does not require a battery and will remember what you wrote to it for at least 100 years. The best place for this first calibration step is in a hangar and out of the wind.

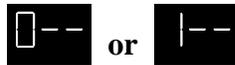
- ◇ B. Within a hangar or if outside pick a calm day, power up the AOA Instrument and surrounding instruments for several minutes. Then push and release the PTT and Dimmer switch simultaneously to get into the calibration mode. The digital display of the AOA LCD should show either



depending upon the position of the flaps/slats. A "IHC" indicates that the flaps/slats are in the landing configuration and in the hangar calibration page. A "OHC" means cruise configuration flaps/slats and in the hangar calibration page. Either flap configuration is OK since from this page the offset for both pressure transducers will be available to both databases.

In the calibration mode the red PTT button becomes the record button and the black Dimmer button becomes the Page button.

- ◇ C. Push the red record button. The display should show either



momentarily to indicate that the offsets have been saved to RAM (random access memory) in the AOA CPU. Note that RAM is not permanent memory. The display after a short delay should show either



to indicate that you have advanced to the next calibration page (zero lift page).

- ◇ D. Push and release the black page button several more times until on the save page as indicated by either a



on the AOA LCD.

- ◇ E. Push and release the red record button to save the offsets to the EEPROM (permanent 100-year memory). You can at any time write over the

permanent memory by repeating the above process with new data. However if the zero offsets are changed, obviously you must reprogram the flight calibration points as well. The AOA LCD will now show either a



to indicate that the EEPROM write was accomplished successfully and returns to the flight mode.

- ◇ F. Turn off the AOA Instrument and ready the aircraft for the flight calibration process.

Preparing for the flight calibration must be well planned in advance. Check the aircraft and remove any unsecured items. For pusher aircraft like Lakes, inspect the bottom engine cowl for bolts, nuts etc. laying on the bottom that will float into the propeller during the zero "g" maneuver. Your aircraft may have special requirements prior to doing a 0 "g" maneuver. Be prepared for "angle angle push" warnings during flight since the AOA has not been calibrated. Consider pulling the AOA circuit breaker if this is a distraction.

- ◇ G. Put a tennis ball in your pocket or hang it from the overhead by a long string. This will come in handy later for the zero "g" maneuver.
- ◇ H. Let's go flying. With the flaps up, power up the AOA on the ground. Confirm no Error 11 or 12. Get into the calibration mode by pushing and

releasing both buttons. You should see a "0HC" on the display. You already practiced the following on the ground first, right? T/O with flaps set for a normal T/O. If you change the flap setting, the AOA will not reflect this because you are in the calibration mode. The flap, PTT, gear and dimmer sensing works only when you are in the flight mode. Climb to about 3,000' AGL into smooth air with your co-pilot and a sick sack ready at hand. Accelerate to the middle of your airspeed indicator's green arc in the cruise configuration with the flaps up.

Place the tennis ball in the co-pilot's extended left hand or better yet hanging by a string from the overhead. Within gliding distance of the airport, do a practice zero "g" maneuver by smoothly pulling on the elevator control then pushing on the control. Keep the airspeed within the green arc of the airspeed indicator at all times. When the ball starts moving aft and floats just above the hand or the string goes slack, that is precisely 0 "g". Don't plaster the ball on the ceiling. Try to maintain 0 "g" for about 1/2 second. This is where the aircraft is creating no lift or zero units AOA.

- ◇ I. Have the copilot work the buttons. The donut should be off indicating you are in the cruise configuration with flaps up.
- ◇ J. Push and release the black page button until



shows in the AOA LCD indicating you are in the cruise configuration (0__) and on the zero lift calibration page (_0L).

- ◇ K. Push and hold the record button.
- ◇ L. Do the zero "g" maneuver releasing the record button just as the ball begins to float or the string goes limp. The AOA LCD displays



to indicate the coefficient of pressure has been calculated, the AOA set to zero and recorded into RAM.

The AOA CPU reads the wing and the pitot/static differential pressure transducers more than 16 times each and computes the coefficient of pressure. This took about 1/5 of a second.

The Pilots Operating Hand Book shall be used to compute the stall speed for the expected conditions. It should then be multiplied by 1.15. This is a good speed to fly at this point in the calibration process. If no stall data is available, then climb to a safe altitude, clear the area, slow the aircraft to where it feels like it is about to stall noting the speed and add 15%.

- ◇ M. Clear the area while slowing to the airspeed where you would like to get an angle warning in the clean configuration.

- ◇ N. Note that you are already in the angle advisory page as indicated by the display



Push and hold the record switch.

- ◇ O. At exactly 1.15 Vs descending with a typical approach power setting and in smooth air, release the red record button. The AOA LCD displays



to indicate the coefficient of pressure has been calculated and recorded in RAM.

- ◇ P. Push and release the black page switch several times to get to the save page as indicated by



on the AOA LCD.

- ◇ Q. Push and release the red record button to record the zero "g" and the angle advisory data points into the EEPROM for the clean/cruise configuration. The display should momentarily indicate a



to indicate that the data was recorded as requested.

PRO CALIBRATION

- ◇ R. The AOA Instrument is now back in the flight mode and should be displaying AOA as you fly along. Pull back and push forward on the controls and see if the display is working. If so continue.
- ◇ S. Configure the aircraft in the landing configuration with flaps and gear down. The donut should be on. Repeat the above calibration sequence starting at paragraph "H" substituting 1__ for 0__ and landing for cruise. Be careful not to push the red record button when in the HC page. This would be putting bad data in place of the good data you entered during the hangar calibration process. To skip over a page, just push and release the black page button again. The same is true if you feel the data put into RAM is not good. When you get to the SA page, just push and release the black page button and the RAM data will not be saved to the permanent EEPROM memory.

You have finished the basic calibration process. If you want to change the approach AOA or adjust the performance AOA, or activate the gear warning features, see the section on advanced applications.

- ◇ T. At a safe altitude, slow to the angle advisory AOA in both the cruise and the landing configuration. Does the advisory activate where expected in relation to the airspeed indicator? Accelerate to the optimum approach AOA in the landing configuration. Is this the speed and AOA that is right for an approach according to your pilot's operating handbook? While flying at the performance AOA in the landing configuration, begin a flap retraction. The AOA LCD should

immediately show less margin from an angle advisory.

- ◇ U. Head back to the airport in the landing configuration and shoot a visual approach. The Navy teaches that using the elevator to keep the light bars abeam the donut and the power to control the rate of descent is the proper AOA approach technique. Your approach IAS is primary and should be at about 1.4Vs assuming you used 1.15Vs for your angle advisory calibration point.
- ◇ V. Cross check the AOA to the IAS. If the angle advisory (AA), the approach (AP) and performance (PF) AOAs are at proper relative to the indicated air speeds for the conditions, you are calibrated. To tweak the approach and performance AOA, see the Chapter on advanced applications.
- ◇ W. Use the yellow verification checklist to insure your calibration data is within acceptable limits.

XV. Advanced Applications

Gear Warning

The gear warning is a standard feature of the Pro and an option on the Sport.

The gear warning “Landing Gear” will activate when the speed is less than the landing gear extend speed (LE) and the gear is not down. The gear warning system does not arm until the IAS is greater than the LE speed. LE is set during the calibration process in flight by flying at the desired LE IAS.

It is recommended that the LE speed be set at about 15 knots above the typical final approach speed at maximum gross weight or V_{le} which ever is less. Note that if you take off and retract the gear, the software will **not** issue a false gear warning even though you are flying for a short time under the LE speed with the gear not down.

Warning, if you take off and retract the gear and never exceed the LE speed, the landing gear warning system will not be armed and cannot issue warnings. This is one of the limitations to airspeed based gear warning systems. If the system is not armed, it cannot issue a Landing gear warning regardless of the gear position. Likewise if the pitot static system is inoperative, the landing gear system and AOA will not work properly.

The safest way to get a position indication for the AOA gear warning system is to install a separate switch. Specifically, sharing a down and locked switch with the Glasair Landing Gear Position Indicator or other gear

warning systems is not advisable. Some gear warning installations may be installed using a single gear switch providing position information for multiple gear warning systems. However, systems using a push to test system for the gear down and locked lights may cause unintended consequences such as canceling the landing gear warning aural and visual indications.

Adjusting Pressure Amplifier Gain

Testing has shown that the pressure transducers and gain provided will provide excellent results over large ranges of pressures. The pressure transducers provide a maximum signal of $\pm 18\text{mV}$ at ± 2 p.s.i. This voltage is conditioned and amplified in order to provide maximum fidelity input to the analog to digital converter (ADC) which operates between 0 to 5 VDC. The pressure transducer and conditioning should provide adequate results for most aircraft operating in the speed range between Lancair IV's and TaylorCrafts without any changes to either the gain or the pressure transducers. However, for those of you tweaking to get the optimum or perhaps flying aircraft with IAS greater than 300 knots, the following may be helpful.

Two p.s.i. will be adequate to measure pitot static pressures up to 293 KCAS. If your aircraft's V_{ne} is considerably faster than 293 KCAS or your wing loading less than 10 pounds per square foot, you may want to adjust the amplifier gain to decrease or increase the fidelity of your AOA.

ADVANCED APPLICATIONS

The gain adjustment is accomplished by changing out a resistor with another value. The standard resistance is 2.94K ohms. The above table may be referenced to select other values depending upon your aircraft speed and or wing loading. The resistor either R16 for the Sport or R4 for the ProII is silk screened on the AOA CPU PCB.

Sport Gain Adjustments

Amplifier Gain	Maximum Speed	Maximum Wing Loading	Maximum AOA CPU range
R16 ohms	Vne KCAS	p.s.f.	p.s.i.
4.41K	359	430	±3.0
2.94K	293	288	±2.0
2.21K	254	216	±1.5
1.47K	207	144	±1.0
732	146	72	±0.5

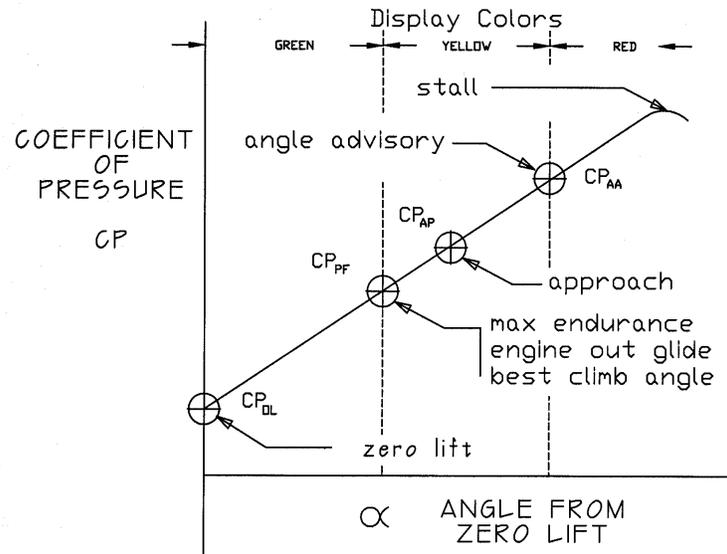
Pro Gain Adjustments

Amplifier Gain	Maximum Maneuver Speed	Maximum Wing Loading	Maximum AOA CPU range
R4 ohms	Vne KCAS	p.s.f.	p.s.i.
4.41K	359	430	±3.0
2.94K	293	288	±2.0
2.21K	254	216	±1.5
1.47K	207	144	±1.0
732	146	72	±0.5

ADVANCED

Sluing Angle advisory and Performance Data

(only available on the Pro)



We shall assume that the angle advisory coefficient of pressure was established by flying at 1.15Vs and the local pressures vary linearly with AOA. The design of the display is such that by maintaining an AOA abeam the donut (light bars 16 through 31), the aircraft is operating at about 1.4Vs. An AOA that lights up the split green segment and above (light bars 12 through 31) would result in the aircraft operating at about 1.5Vs.

If the angle advisory coefficient of pressure was established by flying at 1.265Vs (10% faster than 1.15Vs) then the AP and PF AOAs are at 1.54 (1.1 x 1.4) and 1.65Vs (1.1 x 1.5) respectively.

Generally using 1.15Vs is an excellent speed for the angle advisory to activate, using 1.4Vs for the approach and 1.5Vs for the performance. But these multipliers are just a good guess for the aircraft at hand.

Therefore, it may be required and is possible to adjust the angle advisory, approach and the performance AOAs to any angle of attack desired provided one condition is met. The condition is that the AOA at the angle advisory (CP_{AA}) is greater than the approach AOA (CP_{AP}), is greater than the performance AOA (CP_{PF}), is greater than the zero lift AOA (CP_{0L}). This prevents more than one AOA solution for a given coefficient of pressure “ERROR 21”.

With this knowledge you should now understand that the AOA Instrument could be set up in any manner desired and be able to accomplish this with ease.

It should be obvious that if new hangar calibration data points were written to the EEPROM, then coefficient of pressure calibration points 0L, AA and perhaps AP, PF and LE must also be re-calibrated.

ADVANCED

Open Collector Wiring Options

The AOA Sport and Pro both have an "open Collector" pin which may be used to drive a stick/rudder shaker, warning light or other user supplied device. The "open collector" pin sinks current to ground when the AOA issues high angle warnings. If for example you want to install a rudder shaker, install the shaker to the rudder pedal, provide a 6-28VDC power supply to the shaker, wire the negative side of the shaker to the AOA pin identified "open collector". When the AOA issues a high angle warning, the "open collector" pin is sinked to ground which will turn on the shaker. See Appendix B for the electrical pin assignments and Appendix D for the current limitations.

Backup Power Wiring Options

For AOA Sport serial numbers 750 and higher, power input pins 15 and 2 have been separated by diodes. This allows the AOA to be powered from two power supplies without one power supply back feeding the other.

ADVANCED

Intentionally Blank

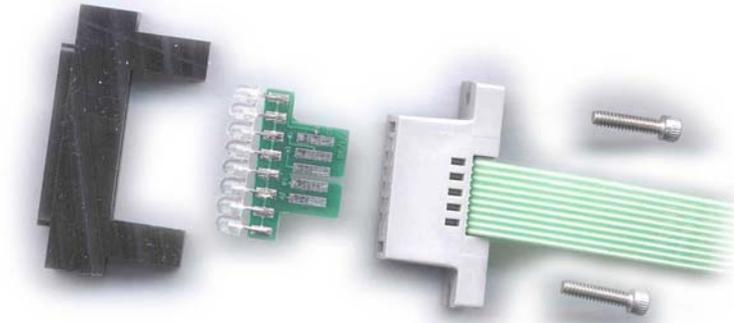
XVI. Warranty Repairs and Cleaning

Maintenance Service

If warranty is required, contact us for authorization and shipping instructions.

Since there are no moving parts, there is no maintenance required other than keeping the ports clear of debris and the air water separator drained. If water or debris gets into the colored tubing, it will cause false AOA readings and must be removed.

Cleaning the Sport Display

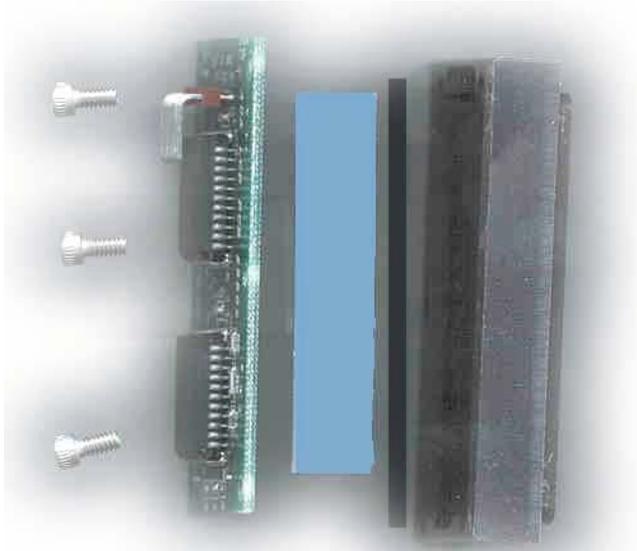


Remove the display from the panel. Remove the two screws from the back of the display. Remove the edge card connector and LED PCB. Clean the bezel, LED

PCB using soapy water. Air-dry the parts prior to re-assembly.

Cleaning the Pro Display

Cleaning the glass of the LCD may be done using a new clean cotton swab (Q-Tip). For finger marks on the glass, a very lightly dampened swab with Isopropyl rubbing Alcohol works best. Do not dip the swab into the Alcohol, as this would be way too wet. Splash some Alcohol on the side of the container and dampen the swab. Paper towels will scratch the filter on the glass.



REPAIRS CLEANING

For very stubborn glass marks or debris in the corners of the display, or perhaps debris causing missing segments of the display, remove the display from the panel.

WARRANTY REPAIRS AND CLEANING

Remove the six screws from the back of the display. Remove the PCB and glass from the bezel. Remove the glass from the elastomeric connectors and remove the elastomeric connectors from the PCB. Do not touch the elastomeric connectors with your bare hands. Clean the glass, elastomeric connectors and the PCB contacts using very little alcohol on a cotton swab.

Inspect the parts for dust particles that can be removed by blowing. Reassemble by tightening the six screws a turn at a time and reinstall in the panel.

Should the glass become scratched, a new glass insert is available at a reasonable price.

Intentionally Blank

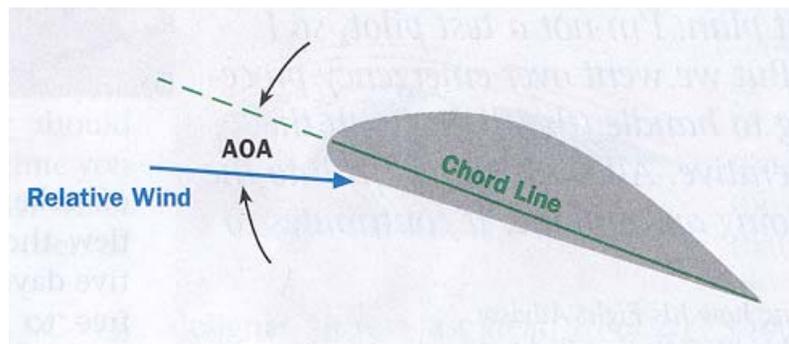
REPAIRS CLEANING

APPENDIX

A. AOA Review

Basic Aerodynamic Principles

Before flying Angle-of Attack during landing, takeoff, and in flight maneuvers, pilots must be familiar with the aerodynamic principles



involved in producing lift and drag.

Lift (L) acts 90° to the direction of flight and is the result of the air being deflected by the wing. More air being moved equates to more potential for lift.

Basic Lift Formula

The basic lift formula is stated as follows:

$$L = \frac{1}{2} C_L \rho V^2 S$$

$$L = \text{Lift}$$

$$C_L = \text{Coefficient of Lift}$$

$$\rho = \text{Air Density}$$

V = Aircraft Velocity

S = Surface Area of Wing

The Coefficient of Lift (C_L) is determined by the shape of the wing, or airfoil, and Angle-of Attack. The shape of the wing includes thickness, chord, camber, leading edge radius, and aspect ratio. This is all determined by the type of aircraft being designed, such as a Lancair or an F-18.

Airfoil Terminology

Mean Camber Line	the locus of points equidistant between the upper and lower surfaces of an airfoil
Chord Line	a straight line joining the ends of the Mean Camber Line
Relative Wind	is equal to and opposite the flight path velocity of the airfoil passing through the air and equal to the True Airspeed
Angle-of-Attack (AOA)	the angle measured between the Relative Wind of the flight path and the Chord Line of the airfoil
Zero Lift AOA	the angle of attack where the airfoil creates no lift
Angle from Zero Lift	the angle measured from the AOA at Zero Lift <i>Note: For symmetrical airfoils AOA and Angle from zero lift are equal.</i>

To insure that you gain a full understanding of Angle-of-Attack AOA and Angle from Zero Lift the aerodynamic principles involved must be understood. A review of the terminology above associated with airfoils is required.

Coefficient of Lift C_L and Flaps

If a wing is to have good qualities at both high and low airspeeds, then the wing must be able to change its shape in flight. Lift, the primary support force of an aircraft, is usually thought of as a force acting in an upward direction, giving support to the aircraft, although it can, and does, act in any direction. Flaps are used to change the shape of a wing in flight so as to produce a higher coefficient of lift at slower airspeeds and thus reduce landing airspeeds.

Coefficient of Lift and Stall

As pointed out earlier, Angle-of-Attack is that angle created between the chord line of the wing and the relative wind. Relative wind is always opposite to the direction of flight. As the Angle-of-Attack increases, so does the C_L , provided that the airflow over the wing remains attached. A separation of the airflow due to excessive Angle-of-Attack reduces the C_L and is the beginning of a stall. This occurs at the Angles-of-Attack where C_L is at its maximum and is called the critical angle-of-attack.

Air Density (ρ)

Air density is affected primarily by barometric pressure and temperature and to some degree, by humidity. A general gas law can be used to define the relationship of density, pressure, and temperature, when there is no change of state or heat transfer. Simply stated, "density varies directly with pressure, and inversely with temperature." However, as an aircraft climbs to altitude, the decreasing pressure causes the density to also decrease, even though the temperature usually drops with altitude until you reach approximately 35,000 feet.

Surface Area of Wing (S)

Wing surface area usually cannot be changed in flight, except with certain types of flaps, and is therefore assumed to be a constant. Most types of flaps are used to change the shape of a wing, but in general, do not change the area of the wing.

Drag

Drag is defined as a force that acts on the aircraft and is in the opposite direction of flight. When airspeed is constant during straight and level flight, drag is always equal to the amount of engine thrust being produced. Total drag on an aircraft can be broken down into two types, Parasite Drag and Induced Drag.

Parasite Drag

Parasite Drag, or Profile Drag, is due to skin friction and the form or frontal area of the aircraft. This includes the leading edge of the wing, fuselage, tail, canopy, and any other part of the aircraft that hinders the airflow about the aircraft. The important factor to remember about parasite drag is that it increases by the square of the change in velocity, that is, as the aircraft doubles its velocity, the drag increases four times. For example, if an aircraft were only subject to parasite drag and requires 300 pounds of thrust to maintain a constant true airspeed of 150 knots, the same aircraft would require approximately 1,200 pounds of thrust to maintain a constant true airspeed of 300 knots. The velocity is doubled, which increases the drag four times to 1,200 pounds. Since thrust must equal drag, then 1,200 pounds of thrust are needed.

Induced Drag

Induced drag is created along with, and is a result of, producing lift. The important factor affecting induced drag is the coefficient of lift, which is primarily determined by the Angle-of-Attack. As the Angle-of-Attack is increased, as in a high "g" pull-up for example, the coefficient of lift goes up to produce more lift. This produces more induced drag, which results in rapidly decreasing airspeed. For straight and level flight, as the airspeed increases, the C_L must decrease if lift is held constant, causing the induced drag to decrease.

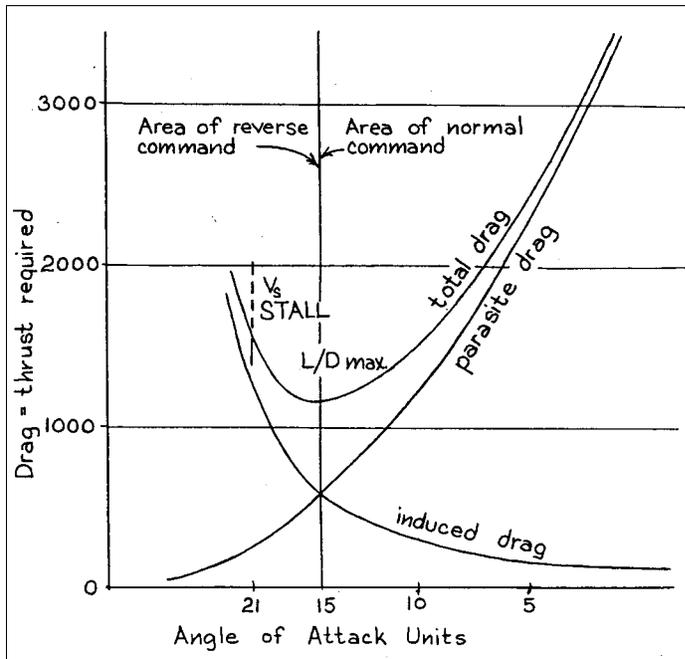


Figure 2

Total Drag Curve

As indicated in Figure 2, adding both induced drag and parasite drag together forms a "U" shaped total drag curve. At the airspeed where induced drag equals parasite drag, the total drag is at a minimum, and the ratio of lift to drag produced is at a maximum. This is referred to as " L/D_{MAX} ".

Ignoring propeller effects, L/D_{MAX} generally has great significance for high performance aircraft. If drag is at a minimum and thrust equals drag, then the fuel flow will also be at a minimum; therefore, the aircraft has maximum endurance at this airspeed. Maximum climb angle is achieved at L/D_{MAX} because thrust available in excess of drag is at a maximum. This is not the case with maximum rate of climb. In case of a flameout or engine failure, maximum glide range is also obtained. If L/D_{MAX} equals 15:1, then the glide ratio is also 15:1.

Ignoring propeller effects:

- Maximum Endurance occurs at L/D max.
- Maximum Climb Angle occurs at L/D max.
- Maximum Glide Range occurs at L/D max.

Regions of Normal and Reverse Command

L/D_{MAX} is also the point which divides the flight envelope between the region of normal command (green area of the display) and the region of reverse command (yellow and red area of the display). Flying in the region of reverse command is also known as being "on the back side of the speed stability or power curve." In the region of normal command, less thrust is needed to maintain level flight at a slower airspeed. In the region of reverse command, more thrust is needed to maintain level flight at a slower airspeed. In the region of reverse command, not only is the aircraft closer to stall, but any increase in nose attitude greatly increases the induced drag, resulting in a rate of descent if power is held constant. To stop the rate of descent, power must be added without changing the nose attitude. If the engine is already at 100% power, the only way to stop the rate of

descent is to lower the nose in order to reduce induced drag and increase the airspeed. The initial effect of lowering the nose will be an increased sink rate due to the loss of lift because of the decreased angle-of-attack. On an approach to landing there may not be enough altitude available to recover.

Ideal approach speed would be at L/D_{MAX} (on the transition between green and yellow) since the wing is most efficient at that speed, but for most aircraft, L/D_{MAX} velocity is too fast. Speed limitations determined runway lengths, and tire/brake limits often preclude landing approaches at L/D_{MAX} velocity.

Variables Affecting Required Airspeed

When discussing the drag or thrust required curve in relation to airspeed, certain conditions must be specified, such as flap configuration, fuel weight, angle-of-bank, and G loading. As depicted in Figure 3, any one of these factors can change the position of the curve in relation to speed. For example, stall and approach speed is less when flaps are down or the aircraft is lighter.

Fuel weight of a high performance aircraft can easily account for

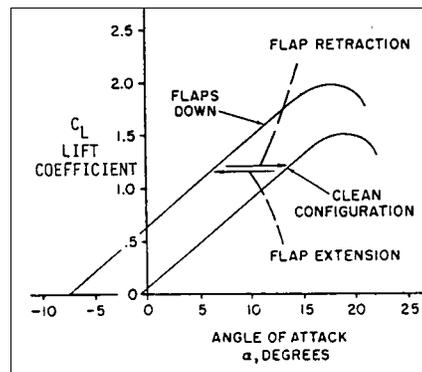


Figure 3

20% to 40% of the total gross weight. Landing with full fuel or low fuel is definitely going to make a difference in the approach airspeed.

Stall speed is increased as the angle-of-bank increases because of the greater G loading required. The same is true concerning an accelerated stall. For the pilot landing with reference to airspeed, he must take into consideration the effects caused by these many variables.

Angle-of-Attack or Angle from Zero Lift

Remember Figure 2 the C_L curve with respect to Angle-of-Attack or Angle from Zero Lift? Nothing was mentioned about fuel weight, G loading, or angle-of-bank in regards to stall. The reason is that, as a general rule, they have no effect on the critical (stalling) Angle-of-Attack. During normal low altitude approach maneuvering, an aircraft in the landing configuration will stall at approximately the same Angle-of-Attack. If the stalling AOA is constant during these different conditions just described then the optimum approach or landing Angle-of-Attack is also constant. This is one advantage for using Angle-of-Attack during landing. Another is that as airspeed decreases, the error of the pitot-static system increases. The opposite is true with the Angle-of-Attack indicator. It is very sensitive at high Angles-of-Attack or low airspeeds, making it easier for the pilot to control his speed. For example, a change from 14.0 to 15.0 units AOA is easier to see than a change of airspeed from 106 knots to 103 knots IAS as would be the case for the Navy T-2C.

Angle-of-Attack vs. Airspeed (T-2C)		
Angle-of-Attack (units)	Fuel lbs.	
	1,000	2,000
14.0	102 kts	106 kts
15.0 optimum	99 kts	103 kts
16.8 stall warning	93 kts	97 kts
19.7 stall	86 kts	89 kts

With the T-2 and other Navy fleet type aircraft, the optimum approach AOA is just slightly less than that at L/D max. If the nose is raised at AOAs well above the optimum AOA in an attempt to flare the landing, the aircraft is now deep in the region of reverse command and instead of gaining additional lift, only more drag is produced. Generally the same is true for high performance propeller driven aircraft with high wing loading.

A pilot using the Angle-of-Attack Indicator for proper airspeed and landing attitude along with glide slope information, can be guaranteed a precise landing every time. This is a prerequisite for making a carrier landing.

Effects of Icing and Contaminants

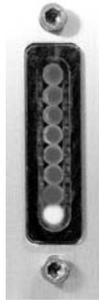
Wing icing will affect the pilot who flies by either Angle-of-Attack or Indicated Airspeed. If the indicated airspeed and AOA indicators are operating properly they may now indicate a stall at a different Angle-of-Attack and airspeed than is normal. Therefore, if wing icing has accumulated, the pilot must fly this approach at a lower than normal Angle-of-Attack, which will also be a higher than normal IAS. However icing could prevent either device from providing accurate information. For highly laminar airfoils, even

insect contaminants would be reason to fly approaches at lower AOA's and higher airspeeds.

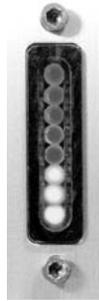
Angle-of-Attack Systems

Angle-of-Attack systems present visual indications of optimum aircraft performance and are primarily used during the approach and landing phases. AOA is also useful in high performance maneuvers. Aerodynamically in 1 "g" flight, Angle-of-Attack is airspeed. Or to put it another way, by controlling the Angle-of-Attack, you are actually controlling airspeed. When an aircraft is flown in a steady flight path at the best prescribed Angle-of-Attack, the resulting airspeed will be correct. When the pilot computes airspeed for a specific phase of flight, he is actually computing the best Angle-of-Attack. Angle-of-Attack is not directly affected by gross weight, angle-of-bank, g loading, or density altitude. Variations of these factors result in airspeed changes to maintain the Angle-of-Attack. Proper use of the Angle-of-Attack Indicator will aid the pilot in obtaining optimum performance from his aircraft and can relieve him of many airspeed calculations.

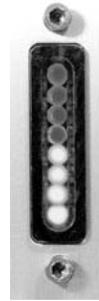
Ignoring propeller effects, the transition between green and yellow on the display is L/D_{max} , best engine out glide, best angle of climb (V_x), and maximum endurance. The top red indicator is where the critical angle of attack is reached. The optimum approach angle of attack is when the display is half lit or lit abeam the donut on the Pro display.



Cruise



*Best
Glide*



*Best
Approach*



*High
Angle*



*Stall
Critical*



*Zero
Lift*



*Best
Glide*



*Best
Approach*



*High
Angle
Warning*

Review Questions

- X. Statement blank statement continued Statement blank
statement continued. (pick one or more of these words)
correct answer first blank correct statement second blank
1. The result of an airfoil forcing air to move over the top of the wing and the bottom of the wing is called _____.
lift
 2. Most flaps change the shape of the wing, producing a _____ (higher /lower) Coefficient of Lift and thereby allowing the aircraft to be flown at a _____ (faster/slower) airspeed.
higher slower
 3. An aircraft will stall about where the _____ is at a maximum.
Coefficient of Lift
 4. When the artificial horizon (attitude indicator) and AOA indicator are compared, they vary by a fixed constant in climb, cruise and descent. (True/False)
False
 5. The total drag affecting high performance aircraft consists of _____ and _____ type drag.
Parasite Induced
 6. It is possible with the aircraft climbing straight up for the AOA to be at zero AOA. (Yes/No)
Yes
 7. For any given airfoil the difference between AOA and angle from zero lift is a fixed constant. (True/False)
True
 8. For symmetrical airfoils AOA and angle from zero lift is the _____.
same
 9. Increasing fuel weight, angle of bank, CG, or "g" loading _____ (increases/decreases) stall speed.
increases

10. As a general rule, changing fuel weight, angle of bank, CG, or "g" loading _____ (does/does not) affect the stalling angle of attack.
does not
11. Aircraft will stall at the same _____ (AOA/airspeed) regardless of fuel weight, "g" loading, CG, or angle of bank.
AOA
12. As airspeed decreases the error in the airspeed indicator _____ (increases/decreases).
increases
13. Because it is more sensitive at high angles of attack and low airspeeds, the _____ (AOA/IAS) system makes it easier for a pilot to control his airspeed during approaches.
AOA
14. With wing ice, insects, dust or frost, a pilot must fly his approach at a _____ (higher/lower) than normal AOA and a _____ (faster/slower) than normal IAS.
lower faster
15. During an approach the rate of descent is best controlled by _____ (power/AOA) adjustments.
power
16. During an approach the speed is best controlled by _____ (power/AOA) adjustments.
AOA
17. If an aircraft stalls at 80 knots true airspeed and 8 units AOA and everything else being equal, in a 60 degree bank turn the aircraft will stall at a higher airspeed (about 113 knots) and at the same AOA of 8 units. (True/False)
True
18. Aerodynamically in 1 "g" flight, angle of attack is _____; that is, by controlling AOA, the pilot is controlling _____.
airspeed airspeed

19. When the AOA display is in the green you are flying in _____ command and when the AOA display is in the yellow or red you are flying behind the power curve or in _____ command.

normal reverse

20. All normal approaches should be flown at the _____ AOA no matter the GW, bank angle, fuel load, etc.

same or optimum

21. For propeller driven aircraft (ignoring propeller effects) when the AOA display is indicating at the transition between green and yellow, the aircraft is being flown at either the _____.

Maximum L/D, V_x , Best Engine out glide or Maximum Endurance

22. When the entire AOA Sport display is lit up, you are at the critical angle and about to _____. (stall/loop)

stall

23. For a properly calibrated AOA, normal approaches should be flown with the AOA Sport display lit up through the middle _____ LED of the display and in the case of the Pro with the light bars abeam the donut. (yellow/red)

yellow

24. During an approach when the aircraft appears to be low on the glide slope _____. (add power/increase AOA)

add power

25. During an approach if the AOA indicates in the red the aircraft's AOA is way too _____ and very near the critical angle.

high

26. During the pull-up of a high speed flyby, the _____ (ADI/AOA) responds immediately showing less margin above stall. During this maneuver IAS _____ (will/will not) change noticeably for several seconds even though the stall is approaching rapidly.

AOA will not

27. During an approach the flight path is low while the AOA is right on. Corrective action would be to _____ (pull on the stick/add power).

add power

28. During an approach you are on glide slope while the AOA is indicating too high and approaching the red. Corrective action would be to _____ (push on the stick/reduce power).

push on the stick or yoke

28. During an approach you are below glide slope while the AOA is too high and approaching the red. Corrective action would be to _____.

push on the stick to reduce AOA and add power

29. What pilot action has the greatest effect on AOA, power changes; elevator movement, aileron movement, or rudder movement?

elevator movement

30. The bottom of the green arc on the indicated airspeed indicator is where the aircraft should stall flaps up at all bank angles in level flight at the aircraft's maximum gross weight. True/False

false

31. An aircraft could stall anywhere in the green arc of the indicated airspeed indicator. True/False

true

32. An aircraft could stall anywhere in the green or yellow band of the AOA indicator. True/False

false

31. Stalls always occur at the critical _____ but may occur at any IAS.

AOA

Intentionally Blank

APPENDIXES

B. Electrical Connections

Sport Pin Out

Dsub Pin #	Description	Label	Wire AWG
1*	Ground	Ground	#20
14*			
2	Vin 9 to 28 VDC	Vin	#20
15	Aux Power 9-28VDC on ser# 750 and higher		
3	Spare 1		#22
16	Display LED0 green Ribbon 1 (RED)		#26
4	Display LED1 green Ribbon 2		#26
17	Display LED2 amber Ribbon 3		#26
5	Display LED3 amber Ribbon 4		#26
18	Display LED4 amber Ribbon 5		#26
6	Display LED5 red Ribbon 6		#26
19	Display LED6 red Ribbon 7		#26
7	Display LED7 red Ribbon 8		#26
20	Display Anode Ribbon 9		#26
8	Display Anode Ribbon 10		#26
21	Flap switch	Flap	#22
9	Dimmer/Page switch	Dimmer	#22
22	PTT/Record switch	PTT	#22
10	gear switch (required for gear warning)		#22
23	analog output 0-5VDC on ser# 750 and higher		
11	open collector		#22
24*	audio shield ground (ground at one end only)	Audio	
12	audio 26 ohm impedance (optional speaker)		#22
25	audio 560 ohms impedance (audio panel,		#22
13*	audio ground (recommended)		#22

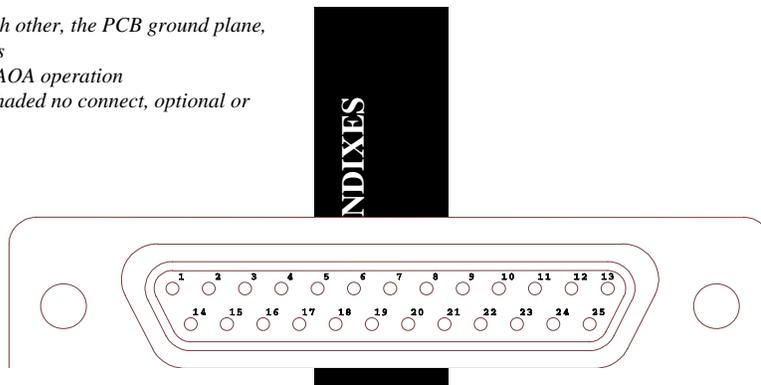
**these pins are internally connected to each other, the PCB ground plane, and the tray via the PCB mounting screws*

unshaded minimum mandatory connects for AOA operation
 shaded see advanced installation for the shaded no connect, optional or recommended connects

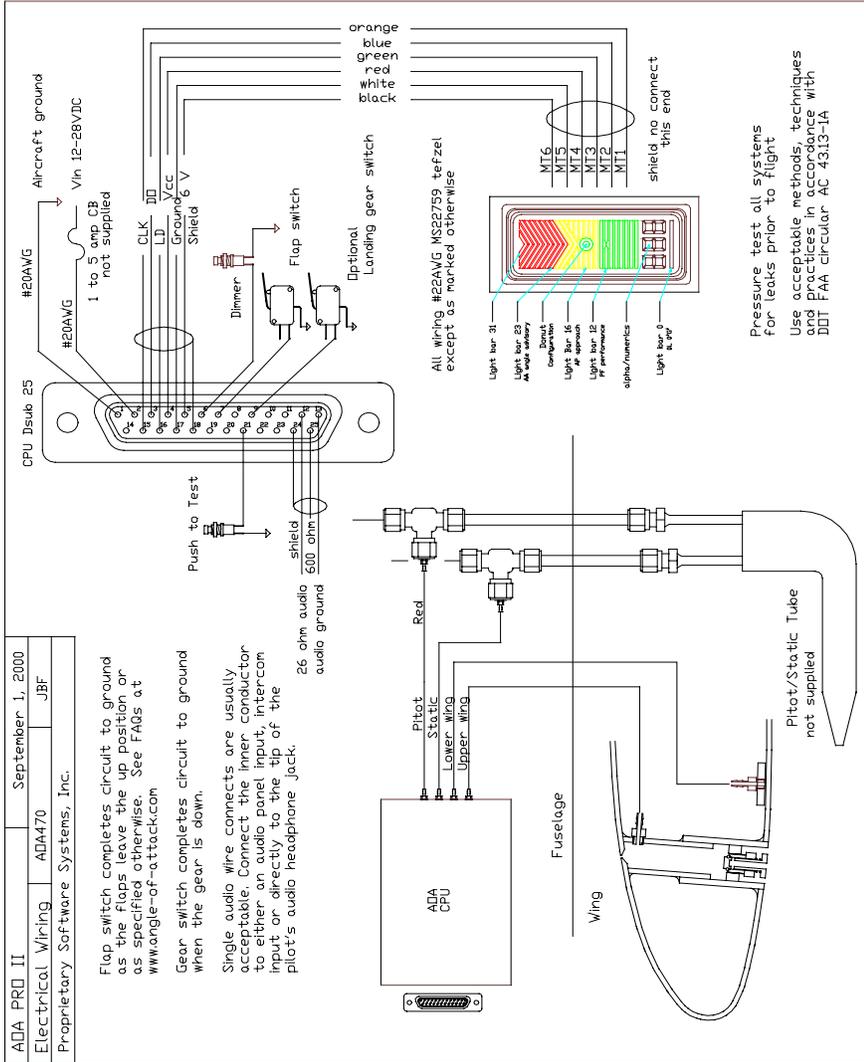
Pro Pin Out

Dsub Pin #	Description
1*	Aircraft Ground
14	TD 232
2	Vin 12 to 28 VDC
15	AOA LCD clock CLK orange MT1
3	AOA LCD data DO blue MT2
16	AOA LCD load LD green MT3
4	AOA LCD Vcc VCC red MT4
17*	AOA LCD ground GND white MT5
5	AOA LCD back light 6V black MT6
18*	AOA LCD cable shield ground (no connect at the LCD)
6	Dimmer Button
19	flap up switch
7	flap down switch
20	RD 232
8	CTS 232
21	PTT push to test push button
9	landing gear switch (required for landing gear warning)
22	RTS 232
10	Spare 1
23	Spare 2
11	open collector
24*	audio shield ground (ground at CPU end only)
12	audio 26 ohm impedance (optional speaker)
25	audio 560 ohms impedance (audio panel, headset or intercom)
13*	audio ground (recommended)

* these pins are internally connected to each other, the PCB ground plane, and the tray via the PCB mounting screws
 white minimum mandatory connects for AOA operation
 shaded see advanced installation for the shaded no connect, optional or recommended connects

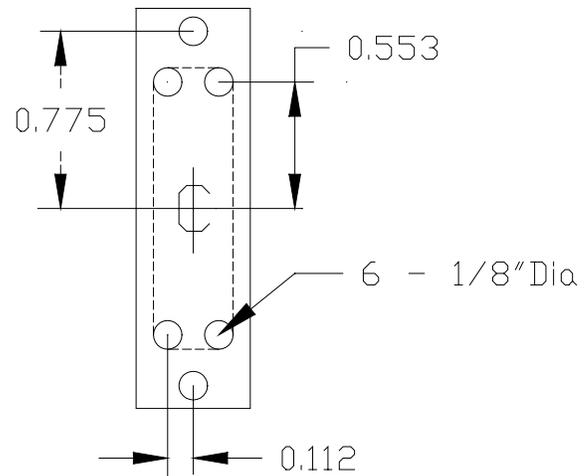


Pictorial Schematic Pro



C. Panel Cutout

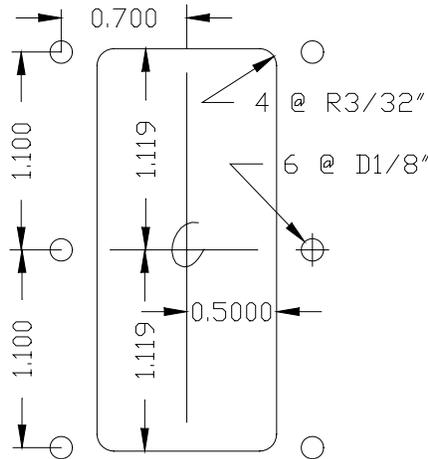
Panel Cutout Sport



We recommend that the instrument be mounted vertically as shown. Locate the center of the instrument cutout template pictured above on the instrument panel. Insure there is adequate room behind the instrument panel 0.5" x 1.75" keeping in mind that the real estate behind the panel is slightly larger than the area required for the front panel. The cutout dimensions shown allows .005" all the way around the instrument bezel.

Using a drill bit, the two template mounting holes should be used to center spot the instrument panel. Then the instrument panel should be bored through using a 1/8" drill bit.

Panel Cutout Pro



The dimensions above are the actual bezel size. For a milling layout use a measured from center approach and a 3/16" diameter end mill. Enlarge the cut out by .005" all sides for a nice fit.

Locate the center of the instrument cutout on the instrument panel. Insure there is adequate room behind the instrument panel 1.700 x 2.600" keeping in mind that the real estate behind the panel is larger than the area required for the front panel. The cutout dimensions shown should be used for the first cut. Enlarging the cut by .005" on the second pass resulting in a 1.010 x 2.248 inch cutout.

The mounting holes should be center spotted and then bored using a 1/8" bit. Any combination of two or four or six mounting holes are acceptable at the installer's option.

D. Specifications

AOA CPU	Sport	Pro II
<i>Volts</i>	12 to 28	
<i>Current amps</i>	.3 max.	.5 max.
<i>Internal fuse</i>	1 amp Wickmann #3721100041	
<i>Circuit Breaker</i>	1 to 5	
<i>Weight</i>	8 oz	
<i>Audio impedance ohms</i>	560 and 26	
<i>Open collector</i>	.5 amp @ 28V	
<i>Pressure Transducers</i>	5 p.s.i. operating 20 p.s.i. burst	
<i>Operating Temperature</i>	30 to 110°F	
<i>Storage Temperature</i>	-40 to 160 °F	
<i>Repeatability</i>	5%	
AOA Display		
<i>weight</i>	1 oz.	2 oz
<i>dimming</i>	two step	
<i>colors</i>	3	4
Air Water Separator	3 oz	

Intentionally Blank

APPENDICES

E. Error Messages

CAWS message	LED display	Description
error one	00000001	not used at this time
error two	00000010	not used at this time
error three	00000011	not used at this time
error one one	00001011	Reasonableness ramp check of the wing differential pressure transducer is not within acceptable limits. This may be due to wind or might be due to damage of the differential pressure transducer. If the system re-tests OK in a hangar, assume the problem was due to wind. If the error persists, a re-calibration of the AOA may fix the problem. If the test function was activated during flight, this error message is expected and normal.
error one two	00001100	Reasonableness ramp check of the pitot/static differential pressure transducer is not within limits. This may be due to wind or might be due to damage of the differential pressure transducer. If the system re-tests OK with the aircraft turned perpendicular to the wind or in a hangar, assume the problem was due to wind. If the error persists, a re-calibration of the AOA may fix the problem. If the test function was activated during flight, this error message is expected and normal.
error one three	00001101	The check sum error on the EEPROM is in error. This is an expected error upon the first ever cold boot of the AOA CPU PCB. The error indicates the possibility of corrupted or missing data in the EEPROM. Calibration of the AOA in the existing aircraft configuration should fix the problem.
error two one	00010101	The slope of the line connecting the mandatory and optional calibration points are either zero or negative. The slopes of the lines connecting the coefficient of pressure for OL to PF to AP to

		AA must have a positive slope. Recalibrate the AOA instrument for the flap setting selected insuring that the 1 "g" speed flown for AA < AP < PF. Check that the pressure tubes did not get reversed.
error two two	E22	not used at this time
error two three	E23	not used at this time
error three one	E31	not used at this time
error three two	E32	not used at this time
error three three	E33	A previous error or errors were reported. The previous error or errors should be noted and/or corrected.

F. Checklists

Preflight Check List

Wing Pressure Ports..... CHECKED
 Pitot/Static System CHECKED
 Air/Water Separators DRAINED

Before Take off Check List

Angle of Attack..... TEST/CHECKED

Annual Condition Check List

Wing Pressure Ports..... CHECKED
 Pitot/Static Ports CHECKED
 Air/Water Separator CLEAN/DRAINED
 Angle of Attack..... CHECKED
 Wiring Condition & Security OK
 Px Tubing Condition & Security OK
 TEE's Condition & Security OK
 Wing Pressure Ports.... LEAK CHECKED
 Pitot/Static LEAK CHECKED

At each annual condition inspection, the results of the AOA Instrument inspection and test must be recorded on an annual condition inspection checklist.

Any errors during any of the above tests, inspections or checks shall be noted in the aircraft log book and the instrument disconnected and placarded as inoperative in accordance with MELs and FARs. If the pressure tubes are disconnected they must be capped to prevent errors in the pitot/static system. Water found in the pressure tubing indicates failure of the air/water separator or an improper installation, which must be corrected.

G. Inventory

Quan	Kit	Item
20'	A	1/16"ID tubing blue for upper wing port
20'	A	1/16"ID tubing green for lower wing port
5'	A	1/16"ID tubing red for pitot pressure
5'	A	1/16"ID tubing clear for static pressure
1	A	wing air/water kit with drain valve (aluminum or composite)
1	A	black dimmer momentary switch
1	A	red push to test momentary switch
1	A	flap microswitch
2	A	nylon tees with brass barbs for pitot/static
4	A	white nylon tubing inserts
1	A	#60 drill bit
1	A	"AOA PRESSURE PORT" decal (paint mask on request)
1	A	Owner, Installation and Education Manual
1	A	AOA Video
1	B	AOA central processing unit (CPU) Pro/Sport
1	B	Aluminum bezel panel cutout template Pro/Sport
1	B	AOA display either Pro/Sport
1	B	Wiring Harness with Dsub attached either Pro/Sport
1	B	MT connector shell Pro only
6	B	MT crimp connectors Pro only
	B	Verification Checklist
	B	Calibration Checklist Pro, Sport or Sport w/Gear

A wing kit

B balance of kit when ordered in two parts

Intentionally Blank

APPENDIXES

H. Trouble Shooting

Symptom	Possible Cause	Solution
No audio, and no display	Faulty power supply or wiring harness	Unplug the connector from the AOA CPU and check pins for a proper ground and power supply.
	Too long screw that penetrated the AOA CPU causing blown fuse	Push the push to test red button. If no audio or LED lighting replace the 1 amp cylindrical fuse located on the AOA CPU PCB with Wickmann #3721100041 one amp T-Lag.
	Reverse Polarity causing blown fuse	Correct polarity and replace the fuse in the CPU with Wickmann #3721100041 one amp T-Lag.
	Display cable miswired or shorted at the display causing blown fuse	Correct the wiring error and replace the fuse in the CPU with Wickmann #3721100041 one amp T-Lag.
The display all or part does not light up but audio is OK	Cable or connector at the display faulty.	Do a continuity check on the cable and connectors to the display and repair.
	Faulty display	Return the AOA display for service.

No audio but the display works OK	Audio turned off at the audio selector panel or intercom	Turn on the audio at the audio selector panel or intercom.
	Audio volume not adjusted loud enough	Remove the AOA CPU, remove the cover and adjust the volume pot rotating the screw 8 turns clockwise.
	Faulty wiring	Insure the audio center cable is not shorting out on the cable shield
	Faulty AOA CPU	Return the AOA CPU for service.
Error messages	Plugged pressure ports, hardware problems	See Appendix E.
Will not calibrate	reversed green and blue tubes at the CPU	At the CPU disconnect and blow on each tube and observe air coming out of the proper wing port.
	plugged wing port	Verify air exits the wing port when blowing on the tube at the CPU
	crimped pressure tube	minimum bend radius is 3/4"
	flap switch faulty	repair the flap switch
	page skips	Cycle the buttons 20 times to clean the contacts.
	Faulty AOA CPU	Return the AOA CPU for service.
Other Problems		call for assistance

I. Port Locations/Flap Switch Closures

The ports are typically located forward of the ailerons and between 15% and 40% of the chord. Following are some typical locations that have worked well. Offset the ports from each other span wise by 2" to 4".

See www.angle-of-attack.com/FAQ.htm for the most up to date information.

Aircraft	Wing span location	Wing chord location	Flap Switch
AirTractor 802A on Wipline 1000 floats	Left wing bay just outboard of the tie down	20" aft of the leading edge at 25% chord	Contacts closed at all but flaps up
Glasair II	upper port 25 1/4" and lower port 27 1/4" inboard of the outboard wing rib	Just aft of the main spar 13.25" aft of the leading edge	During flap extension closed prior to 1/3 flaps
Glstar	Just inboard of the most outboard wing rib	Just aft of the main spar 11 inches aft of the leading edge.	During flap extension closed prior to 1/3 flaps
Lake LA4-200	Upper port 7" and lower port 5" inboard of the outboard wing skin	8" aft of the leading edge. See drawing S-LA4.	Closed when flaps down
Lancair Legacy	Ports are pre-installed	Ports are pre-installed	During flap extension closed prior to 1/3 flaps
Lancair 235/320/360	Upper port 2" inboard of the most outboard wing rib. Lower port just inboard of the most outboard rib.	"D" section just forward of the electrical conduit. 3 1/4" aft of the leading edge(12% chord).	During flap extension closed prior to 1/3 flaps

Lancair ES	Upper port 3" inboard of BL202.5 rib inboard face. Lower port 1.5" inboard of BL202.5 inboard face.	9" aft of the leading edge along the cord line right wing.	During flap extension closed prior to 1/3 flaps
Lancair IV with winglets	Inboard winglet right wing	7.5" aft of the leading edge	During flap extension closed prior to 1/3 flaps
Lancair VI w/o winglets	Pitot tube dry bay opposite wing	15 to 40% chord	During flap extension closed prior to 1/3 flaps
Murphy Moose	Middle of the outboard wing bay. Upper port 6" and lower port 4" inboard of the wing skin outer end.	2 1/2" forward of the wing skin break at the spar	During flap extension closed prior to 1/3 flaps
RV 4, RV6, RV7, RV8	Middle of the outboard wing bay. Upper port 4 3/4" and lower port 7 1/2" inboard of the wing skin outer end.	6" forward of the wing skin break at the spar about 12" aft of the leading edge	During flap extension closed prior to 1/3 flaps
RV9	Middle of the outboard wing bay. Upper port 4 3/4" and lower port 7 1/2" inboard of the wing skin outer end.	11" aft of the leading edge measured along the chord line	During flap extension closed prior to 1/3 flaps
RV10	Middle of the outboard wing bay. Upper port 9 1/4" and lower port 7 1/4" inboard of the wing skin outer end.	9" forward of the wing skin break at the spar	During flap extension closed prior to 1/3 flaps

**The flap switch is generally set up so that the flap switch electrical contacts are open when the flaps are up and closed completing a circuit to ground immediately after the flaps start down. This provides the most conservative results for in-between flap settings for aircraft with inboard flaps. If the lever arm of the flap switch is activated when the flaps are up, wire the AOA "FLAP" wire to the microswitch lug labeled NC. If the flap switch lever arm is activated after the flaps start down, wire the AOA "FLAP" wire to the microswitch lug labeled NO.*

Intentionally Blank

APPENDIXES

J. Revisions

Revision	Date	Changes
00	Sept 10, 2002	New combined AOA Manual
1	Feb 6, 2003	Add Flap closure
2	Dec 1, 2003	Add Drawings
3	Jan 1, 2004	New Pictures, Bleed Tabs, Formatting and Text changes
4	March 1, 2004	Darken Tee picture
5		
6		

NOTES

APPENDIXES