Flight Test Plan (Sept 2010)

Beechcraft Bonanza S-35

Alpha Systems Angle of Attack Stall Warning System

by Al Aitken, a former Marine Aviator and graduate of the Patuxent River NAS Test Pilot School

The purpose of this Flight Test Plan is to organize the Flight Test steps required to safely analyze the information provided by the Alpha Systems Angle of Attack (AOA) Stall Warning System as displayed on the Legacy indicator in six normal flight configurations of the Beechcraft S-35 Bonanza aircraft to determine the usefulness of that information at enhancing safety in the operation of general aviation aircraft. More specifically:

- Is the "OAA calibration" technique[i] recommended by the Alpha Systems Angle of Attack Stall Warning System an accurate and repeatable method that can reliably be used to set an AOA target that will always be adequately above the aerodynamic stall AOA?
- Does that target AOA always present data to the pilot so as to warn early, thereby ensuring a safe margin above stall?
- Is the AOA instrumentation clear, un-ambiguous, and easy to comprehend?

I. Objectives
   a. In-flight verification, using standard instrumentation[ii], of approach-to-stall and stall characteristics against Pilot Operating Handbook data in three attitudes A: wings level, and B: 30 deg. banked flight—and in three configurations: 1: Clean, 2: Gear up/ approach flaps, and 3: Gear down/ Full flaps.
   b. Calibrate the Alpha Systems AOA Legacy Vertical LED Electronic Stall Warning display in accordance with the Alpha Systems installation manual for a target Optimum AOA of 1.3 x V_s and 1.3 x V_{so}.
   c. Compare the verified approach-to-stall and stall characteristics (I.a.) against the Alpha Systems installed AOA Stall Warning display in the configurations and bank angles of PP (!.a.) above
   d. Determine usefulness of the analyzed Alpha Systems AOA Stall Warning System displayed information in A: clean maneuvering flight, B: terminal area flight in gear-up, approach flaps configuration, and C: full flap configured landing approach flight in maintaining safe stall margins and optimum approach speeds.
   e. Explore, at the discretion of the pilots, whether the Alpha Systems AOA Stall Warning System continues to provide such guidance at extreme angles of bank, up to but below the Aerobatic Maneuvering limits (30 deg. pitch, 60 deg. roll) of normal flight.

II. Safety
   a. Test flights will be conducted during daylight hours at a minimum of 3,000 ft. AGL in weather conditions exceeding 5,000 ft and 5 miles visibility in relatively smooth air to enhance data fidelity. No aerobatic flight will occur. Surface wind conditions will not exceed 7 knots with no gusts, and crosswind conditions will not exceed 5 knots.

b. Test flights will be conducted with a flight test crew of two pilots qualified in the S-35 Bonanza. One pilot will be dedicated to flying the aircraft while the other pilot will record data and keep a vigilant lookout for traffic and obstacles.
c. Allowable weight conditions will extend from maximum gross weight at takeoff to 45 minutes fuel reserve at landing. Center of gravity will remain at mid-range as determined from the aircraft POH.
d. The normal airspeed indicator will remain the primary instrument for speed control throughout all maneuvers and approaches to stall and stall. The AOA Stall Warning system will be used only for data collection to compare with airspeed indications.
e. Slow flight test procedures will be conducted in a "build-up" phased fashion beginning with wings level in the clean configuration and progressing methodically through the gear-down, flaps full stall data point for each bank angle attitude. Results will be debriefed safely on the ground prior to proceeding to the next phase and configuration's data collection.
f. Data in each configuration and attitude will be collected throughout the approach-to-stall phase to the actual stall speed as defined by the test pilots.
g. Given that the design purpose of the Alpha Systems AOA Stall Warning system is to AVOID accidental stalls, it is not the intent of this research to explore AOA beyond the very first indication of a stall. In the event of a stall, recovery will be initiated immediately. Post stall gyrations and incipient phase spins will be avoided.

III. Test Procedures

a. Phase I: Stall Performance Data Verification Against Aircraft POH
    i. Clean configuration-Idle Power/Prop low pitch
        1. Approach-to-stall, stall warning, and actual stall speed data at representative weight and CG location: Flight No. 1
    ii. Gear-down, full flap configuration-15 in. Manifold Pressure/Prop low pitch
        1. Approach-to-stall, stall warning and actual stall speed data at representative weight and CG location: Flight No. 1
b. Phase II: Calibration of the Alpha Systems AOA Stall Warning system Legacy Vertical LED Electronic display: Flight No. 1
        1. In accordance with the appropriate installation manual
        2. Using the V_s +30% method (1.3 x V_s or 1.3 x V_{so})
        3. Condition of partially-stalled tufted wing[iii] will be compared to AOA target speed
c. Phase III: Representative weight flight for Alpha Systems AOA Stall Warning system
    i. Clean configuration-Idle power; wings level, and 30 deg. bank; fuel weight: ¾ fuel to full: Flight No. 2
    ii. Gear-up, approach flaps-15 in. Manifold Pressure; wings level and 30 deg. bank; fuel weight: ½ fuel to ¾ fuel: Flight No. 2
    iii. Gear-down, full flaps-15 in. Manifold Pressure; wings level and 30 deg. bank; fuel weight: ½ fuel to ¾ fuel: Flight No. 2
d. Phase IV: Operational scenario flights to determine usefulness of Alpha Systems AOA Stall Warning System

        i. Maneuvering flight in clean configuration; terminal area flight in gear-up, approach flaps configuration; and landing pattern flight in gear-down full flaps configuration: Flight No. 2
        ii. Pilot and observer's opinions of clarity, lack of ambiguity, and comprehension of AOA Legacy indicator: Flight No. 2
    e. Phase V: Free Flight. <u>ONLY after completion of Phases I-IV and at his sole discretion</u>, each pilot may choose to:
        i. explore free flight maneuvering in highly unusual attitudes, with particular attention being paid to whether the Alpha Systems AOA Stall Warning System continues to provide early warning of impending stall: Flight No. 3

IV. Data Analysis
    a. Phase I
        i. Analysis of the Phase I data will consist of comparison of the in-flight observed air-speed data with airspeed data presented in the Pilot Operating Handbook
        ii. Compared data will be reviewed for verification of POH and in-flight observed air-speed data will be used in subsequent Phases of this Flight Test Plan
    b. Phase II
        i. Phase II flights will consist of calibration of the Alpha systems AOA Stall Warning Legacy Display. Once the display is accurately calibrated, display indications will be correlated with the primary airspeed indicator data in miles per hour (MIAS) for wings level cruise through the approach to stall and actual stall phases of flight in both Flight Test Plan configurations and two bank angle attitudes.
    c. Phase III
        i. Analysis of the Phase III data will consist of comparison of the Alpha systems AOA Stall Warning Display to in-flight airspeed indicator data for both Flight Test Plan configurations and two bank angle attitudes.
    d. Phase IV – A subjective analysis.
        i. The two test pilots will offer their professional opinions on the usefulness of the Alpha Systems AOA Stall Warning system for avoiding stall conditions in common flight scenarios of: 1: slow flight steep-bank maneuvering in clean configuration; 2: terminal area flight in gear-up, approach flaps configuration, 3: landing pattern flight in gear-down full flaps. Their suggestions for improvement will be reported.
        ii. Pilots will report on their clarity of understanding and comprehension of the Legacy display and its aural component. Their suggestions for improvement will be reported.
    e. Phase V: Free Flight (optional), a subjective analysis.
        i. Pilots will offer their professional opinions on the usefulness of the Alpha Systems AOA Stall Warning system for avoiding stall conditions in unusual attitudes of non-aerobatic flight.

V. Test Report
    a. The Flight Test Report will include an executive summary as well as a detailed description of test conditions and data results. Data will be presented in textual and graphic format.
    b. The Flight Test Report will be organized by test phase with data and conclusions presented for each phase.

DISTRIBUTION

- The Flight Test Report will placed in the public domain by its authors and will initially be distributed by them to the manufacturer of the Alpha Systems AOA Stall Warning System as well as to the FAA if installation guidance is sought for the Alpha Systems AOA Stall Warning Systems. Any applicant for any FAA Supplemental Type Certificate, PMA certification, or TSO approval, etc.) may use this data freely.

- This Flight Test Report will also be available to the American Bonanza Society' s Air Safety Foundation, to the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation, and to the Experimental Aircraft Association (EAA) as well as others seeking information on the applicability of AOA Stall Warning Systems on general aviation aircraft. Other than payment for reproduction costs, no charge may be made for use of this research.

+++++++++

This research was initiated and funded by friends of skilled aviators, gone west.
It is placed in the public domain

IN HONOR OF

David Ingalls Brown and **Robert H. Baldwin**
who died after a low level stall/spin in a Bonanza BE36TC N202EN, North Garden, VA 6/14/2006

TWA Captain Ray Rotge and **TWA Captain Mack Johnston**
who died after a low level stall/spin in a Vans RV8 N901X, Truckee CA 6/17/2010

May they be the last to die.

END NOTES

[i] **ALPHA SYSTEMS CALIBRATION PROCEDURE**

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

1.) Aircraft is at a safe altitude for slow flight maneuvers,

2.) Minimum controllable flight, lower power setting, (such as a down wind or landing pattern power setting),

3.) Able to hold altitude, 0 Vertical Speed, **not descending, zero sink (5 to 10 fpm climb OK if your aircraft looses fight control stability at 0 VS)**

4.) Full aileron, elevator and rudder control, pilot to identify the set point by pitching back slowly to a pitch no longer able to climb but able to hold altitude with full control of the airplane.

[ii] **David F. Rogers, PhD, ATP, Professor of Aerospace Engineering (Emeritus),** Aerospace Engineering Department, United States Naval Academy will undertake a static calibration -- as seen below -- of the airspeed indicator to determine instrument error. This will be done using an accurate barometer to determine field barometric pressure and the pressure bulb from a classic blood pressure rig and/or a water manometer. The Naval Academy owns this calibration rig, which has been used repeatedly to calibrate similar test flights in Dr. Rogers' personal Bonanza. His Bonanza and Laminar Flow research is widely published. We are immensely grateful to him for his advice in designing this Flight Test Plan.


Dr. Rogers; Naval Academy's water manometer


A tufted wind in near-stall, leading edge to the right

[iii] A tufted wing of a S-35 Bonanza, seen just above. The inboard portion is stalled. The aircraft is under full control, no shudder, no bobbing, no stall horn: