
CAFE Challenge

COMPARATIVE AIRCRAFT FLIGHT EFFICIENCY, INC.
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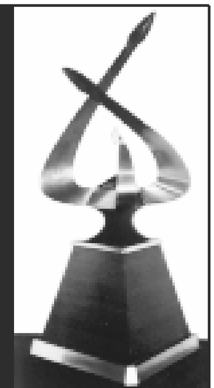
CAFE Triaviathon

AIRCRAFT PERFORMANCE REPORT

photo: Brien Seeley

Steve and Theresa Barnard's beautiful RV-6A is flown by Russell Scott over the hills of Sonoma County, shown here equipped with the wing-mounted CAFE Barograph and its free-swiveling pitot-static missile. Steve Barnard is in the left seat.

INTRODUCTION

This report is the first of many to be produced by the CAFE Foundation on popular amateur built aircraft. It is made possible by major support and cooperation from the Experimental Aircraft Association.

The general criteria for selecting test aircraft are those that are good examples of current designs, and are built and equipped to be light in weight without major modifications from the plans. The CAFE Foundation contacted the kit manufacturer to obtain their recommendation for an exceptional example of an RV-6A based near Sonoma County, California. The test aircraft is one that was so recommended.

The owners, Steve and Theresa Barnard of Cameron Park, California, were contacted approximately 6 weeks before the flight test date and were sent a list of the needed preparations. These included fabrication of left and right wing leading edge cuffs to attach the CAFE Barograph, video camcorder mount, FlowScan fuel flow sensor installation, manifold pressure and oil temperature "T" fittings, zero thrust switch crankcase mounting, 1/2" hole in firewall for wiring harness, and provision of 3 view drawings of the aircraft.

Wing cuffs were donated by John Harmon. With help from CAFE Director Otis Holt, the owners made the other preparations. They provided all of the fuel for the flights, and they elected to stay 2 days in Santa Rosa during the tests.

Upon arrival on May 21, the aircraft was de-fueled and Crandon Elmer obtained the empty weight and c.g. A digital tach and camcorder were installed. The first flight was made solo by test pilot Russell Scott to evaluate stability and handling. The Vetter D.A.D. engine monitor and barographs were then installed. Russell flew two performance flights beginning at 7:00 AM May 22. The final 3 flights were made solo at preset c.g.'s by C.J. Stephens. Finally, the test equipment was removed and the aircraft was returned to the owners.

RV-6A AIRCRAFT PERFORMANCE REPORT

photo: Larry Ford

Steve and Theresa Barnard with their beautiful RV-6A in the CAFE hangar. Their tireless enthusiasm and cooperation with the CAFE Foundation volunteers was a great help in the success of this inaugural flight test program.

MANUFACTURER

Van's Aircraft, Inc.
P.O. Box 160
North Plains, Oregon 97133
(503) 647-5117 Fax 647-2206

OWNER/BUILDER

Steve and Theresa Barnard
3327 Wood Lane
Cameron Park, CA. 95682
(916) 676-5601

MEASURED PERFORMANCE

Propeller static RPM, 28.3 in Hg M.P.	2218 RPM
Takeoff distance, 1645.5 lb @ 120' MSL	625 ft @ 70° F with 7 mph tailwind
Liftoff speed, per barograph data, CAS	52.6 kt/60.6 mph
Touchdown speed, barograph, CAS	54.9 kt/63.3 mph
Rate of climb, 2500-3500 ft, STD Day, V_y	1233.8 fpm
Cabin Noise, Dba, climb/max cruise	96/93
Stall speed, V_{S1}, clean, 1 G, CAS	51.0 kt/58.7 mph @ 1633lb
Stall speed, V_{SO}, landing, 1 G, CAS	45.2 kt/52.1 mph @ 1631lb
Vmax@ 24.2", 2618 RPM, 12.2 gph, TAS	173.4 kt/199.7 mph, 7079' dens., 1634 lb
Vmax@ 21.8", 2507 RPM, 11.3 gph, TAS	162.3 kt/191.6 mph, 9058' dens., 1626 lb
Vc@ 21.1", 2441 RPM, 10.2 gph, TAS	158.4 kt/182.5 mph, 9145' dens., 1623 lb
Vc@ 18.9", 2349 RPM, 7.8 gph, TAS	153.3 kt/176.6 mph, 9008' dens., 1622 lb
Vc@ 18.3", 2292 RPM, 7.4 gph, TAS	147.2 kt/169.5 mph, 8987' dens., 1621 lb
Vc@ 18.2", 2251 RPM, 7.7 gph, TAS	143.1 kt/164.8 mph, 8877' dens., 1620 lb

CALCULATED DATA

Flat plate drag area**	2.32 sq ft
Oswald's e, span efficiency**	.851
C_{do}, zero lift drag coefficient**	.021
C_l max, maximum lift coefficient**	2.136
Propeller efficiency, η, **	not available
Thrust horsepower @ 7079 ft.**	126 hp @ 199.7 TAS
Thrust horsepower @ 9058 ft.**	111 hp @ 191.6 TAS
Carson's speed, V for best speed/drag**	121.1 kt/139.5 mph
V for max lift to drag**	92.0 kt/106 mph
V for minimum sink**	69.9 kt/80.5 mph
Maximum lift to drag ratio (glide ratio)**	11.39
Minimum glide angle**	4.7 degrees
Minimum sink rate**	749 fpm
Minimum drag**	134.3 lb
CAFE Challenge score @ 176.6 TAS	687,385. (neglecting climb/descent legs)
CAFE Triaviathon score	148.8

RV-6A AIRCRAFT PERFORMANCE REPORT

MANUFACTURER'S INFORMATION

Cost of kit, without engine	$10,420
Cost of plans	RV-6A $205, RV-6 $195
Kits sold to date, RV-6 and RV-6A	1800
Plans sold to date, RV-6 and RV-6A	2900
Estimated hours to build, basic	1800-2000 hr
Prototype first flew, date	1988
Normal empty weight, with O-320	1000 lb
Design gross weight, with O-320	1600 lb
Recommended engine(s)	Lycoming O-320, or O-360
Advice to builders:	Recreational spins not advised, keep paint weight low if using fixed pitch prop to avoid aft c.g.'s

DESIGN INFORMATION

Wingspan/chord	23 ft/57.4 in
Wing area	110 sq ft
Wing loading, 1650 lb gross weight	15 lb/ft
Power loading, 180 hp	9.17 lb/hp
Span loading, 1650 lb gross weight	71.74 lb/ft
Airfoil, main wing	23013.5
Airfoil, design lift coefficient	.3
Airfoil, thickness to chord ratio	13.5
Aspect ratio	4.8
Wing incidence	+1°
Wing dihedral	+3.5°
Wing taper ratio, root/tip	1.0
Wing twist or washout	None
Steering	Differential braking, swiveling nose gear
Landing gear	Tricycle, spring steel, Wheel pants
Horizontal stabilizer span/area	9 ft/13.73 sq ft
Elevator area	10.27 sq ft
Vertical stabilizer span/area	4 ft/8.35 sq ft, including fuselage
Rudder area	5.33 sq ft
Thrust line incidence, crankshaft	-.4° (nose down)
Tail incidence	0.0°
Fuselage length	19 ft 11 in
Height, static with 1/2 fuel	6 ft
Minimum turning circle	28 ft 6 in
Main gear track	82.5 in
Wheelbase, nose gear to main gear	54.25 in
Acceleration Limits	
At gross weight	+6, -4 G
At 1375 lb	+6, -6 G

PERFORMANCE FLIGHT TEST METHODS

The performance flight test consisted of a maximum performance takeoff at gross weight, followed by the protocol used in the CAFE Triaviathon. That is, a maximum performance climb to 6000 ft indicated altitude where the aircraft is accelerated to Vmax in level flight with maximum available power. The aircraft is then slowed and placed in the landing configuration while maintaining 6000 ft altitude. A 1 G stall is performed from level flight with less than 18" of manifold pressure and less than 1750 RPM, using a 1 kt per second deceleration. The stall is then repeated in a clean configuration, power off at 1 G in level flight.

The cruise airspeed values were obtained at an indicated 8000 ft altitude at a variety of power settings and fuel flows, as noted, and were controlled for smooth air and level flight as much as possible.

The zero thrust glide information is considered only an approximation on this aircraft due to atmospheric disturbances and technical problems during the glides. The zero thrust data in calculated data is thus marked with an **.

Takeoff distance was measured with runway observers stationed at 100 ft intervals. The distance is artificially lengthened since it was a slightly downwind takeoff in above standard temperature.

The Vetter Digital Acquisition Device (DAD) was used to record the following engine/airframe parameters: manifold pressure, RPM, induction air temperature, CHT, oil temperature, crankshaft incline angle, cabin noise level, pilot's yoke marker switch, fuel flow, and instantaneously updated aircraft weight.

Fuel flows were calibrated to .1 lb accuracy against the CAFE scales. Noise levels were measured on a Controls International CI-DBM135 Digital Sound Meter placed adjacent to the pilot's right ear with a forward facing mic.

All altitudes were corrected to density altitude as shown, and are accurate to about +- 1 ft. Airspeeds can be considered to be CAS with the pitot-static source routinely positioned more than 1 chord length ahead of the wing L.E. The barograph data compared closely to that indicated on the aircraft's instruments.

RPM were obtained with a Proptach optical tachometer facing forward from the glareshield and are +- 1 RPM.

A more comprehensive report of performance is anticipated in future reports.

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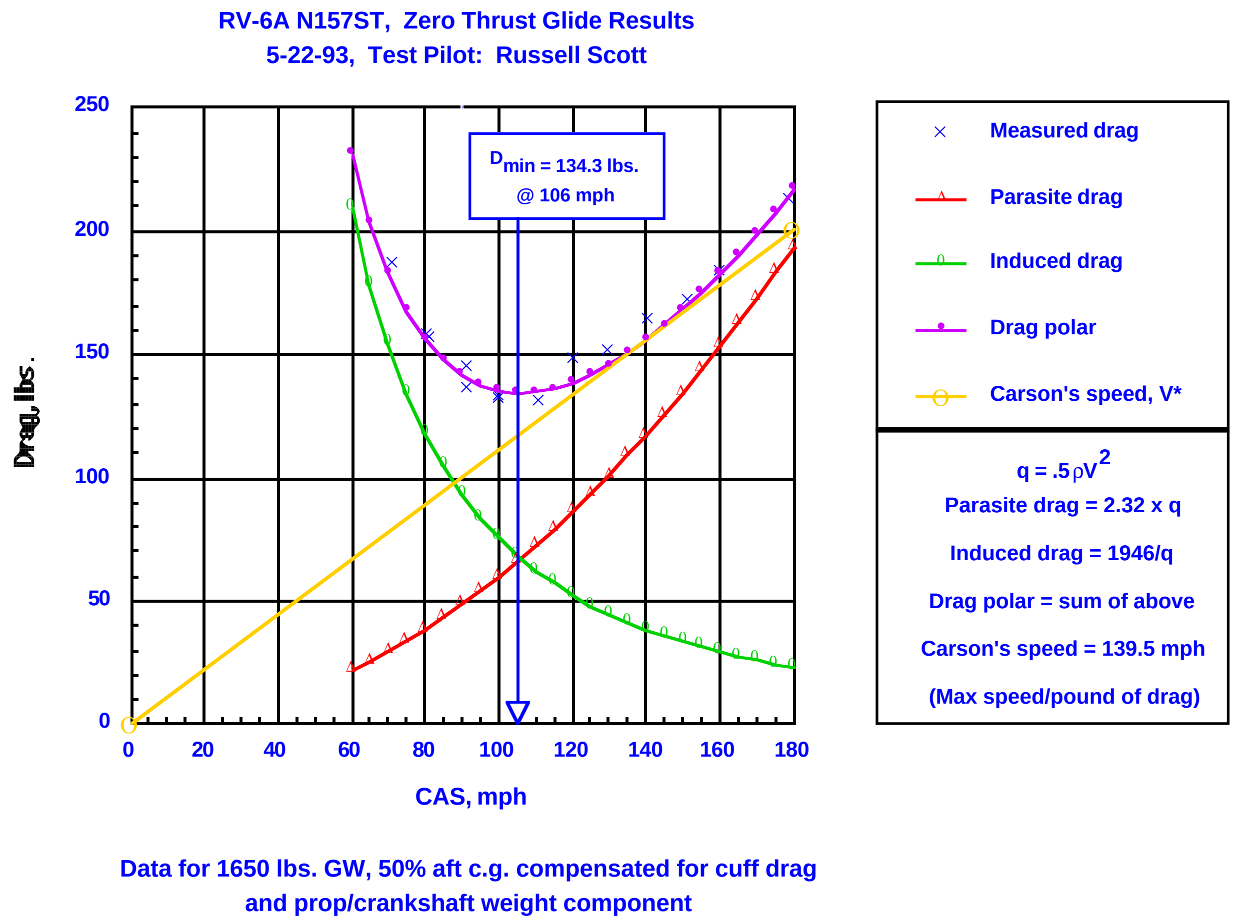

The graph above was obtained in accordance with the zero thrust glide method developed by CAFE Board Member Jack Norris working with his partner, Dr. Andrew B. Bauer. A zero thrust switch was installed on the engine crankcase so as to detect the aft displacement of the crankshaft during windmilling flight. By sensing the transition point from tractoring to windmilling, the zero thrust condition can be detected. At zero thrust, the propeller effectively becomes “invisible” and the aircraft becomes a “pure” glider. The barograph accurately records airspeed and sink rate while gliding in the zero thrust condition. Simultaneous recording of fuel flow, crankshaft position (zero thrust), RPM, takeoff weight, incline angle of the aircraft and time in seconds during each glide at each different airspeed, yields data that can be entered into the following formula:

W x Sink Rate = Drag x TAS

Where W = instantaneous aircraft weight, lbs.
TAS = true airspeed in feet per minute
Sink Rate is in feet per minute
and Drag is in pounds.

The graph is a plot of indicated airspeed (CAS) versus drag and is called the aircraft’s “drag polar”. From this graph can be derived a multitude of aircraft characteristics including equivalent flat plate drag, Oswald’s efficiency factor, speed for best lift to drag ratio, minimum sink rate, minimum drag, etc. The term Carson’s speed refers to Professor Bud Carson of the U.S. Naval Academy, whose excellent paper, “Fuel Efficiency of Small Aircraft”, (AIAA-80-1847, 1980) defines this speed using the prior work of Gabrielli and von Karman as the maximum speed per unit of fuel burned.

The lowest point on the drag polar is the point of minimum drag and this occurs at 106 mph CAS, which is the speed for maximum lift to drag ratio. Carson's speed can be calculated as 1.316 times this speed for maximum lift to drag ratio, which, in turn, is 1.316 times the speed for minimum power and minimum sink rate. From the graph's parasite drag equation in the legend above, comes the value of 2.32 which is the flat plate drag area in sq ft.

The confidence factor for this data is about 4%, principally due to less than ideal atmospheric conditions during the tests. The calculated values noted with ** in this report are derived from this data.

RV-6A AIRCRAFT PERFORMANCE REPORT

SPECIFICATIONS AND DIMENSIONS

RV-6A N157ST Serial Number 20075

Estimated Cost: $35,000 parts/materials with used Lycoming engine

Estimated hours to build: 2500-3000 hr in 42 months

Empty weight/gross weight	1078.65 lb/1650 lb
Payload with full fuel	345 lb
Useful load	571 lb
Engine make, model	Lycoming, O-360 A1A
Engine horsepower	180 BHP
Engine TBO	2000 hr
Engine RPM, maximum	2700 RPM
Man. Pressure, maximum	29 in Hg
Turbine Inlet, maximum	NA
Cyl head temp., maximum	500° F
Oil pressure range	25-100 psi
Oil temp., maximum	245° F
Fuel pressure, range	.5-8.0 psi
Weight of prop/spinner/crank	67.4 lb
Induction system	MA4-5 carb, bottom mount
Induction inlet	8 sq in
Exhaust system	2 into 1crossover, stainless
Oil capacity, type	8 qt, 15W-50
Ignition system	Magneto
Cooling system	Pitot inlets, downdraft
Cooling inlet	62 sq in
Cooling outlet	47 sq in
Propeller	Fixed pitch
Make	Bernard Warnke
Material	Maple, 52 laminations
Diameter/pitch	70 x 74 in
Prop extension, length	4 in
Prop ground clearance, 1/2 fuel	11.25 in
Electrical system	35 amp alternator
Fuel system	2 pumps , 1 tank in each wing
Fuel type	100 octane
Fuel capacity	226.3 lbs/ 37.72 US gal
Fuel unusable	2 oz
Braking system	Cleveland discs, dual
Flight control system	Dual center sticks, push-pull tubes, rudder cables
Hydraulic system	NA
Tire size, main/nose	5:00 x 5 , Lamb tire
Cabin entry	Forward hinged canopy
Seats	2
Baggage capacity	80 lb
Cabin width at elbows	43 in
Approved maneuvers	Loops, Immelmanns, aileron rolls, snap rolls, vertical rolls, split-"S", horizontal 8's, barrel rolls
CENTER OF GRAVITY	
Range, % MAC	15% to 29%
Range, in. from datum	70.2 in to 78.3 in
Empty weight c.g., by CAFE	72.5 in
From datum location	forward tip of spinner
AIRSPEEDS PER P.O.H, IAS	
Never exceed, V_{ne}	182 kt/210 mph
Maneuvering, V_a	117 kt/135 mph
Best rate of climb, V_y	87 kt/100 mph
Best angle of climb, V_x	71 kt/82 mph
Stall, clean at GW, V_s	54 kt/62mph
Stall, landing, GW, V_{so}	48 kt/55 mph
Flaps, 20°, 40°, V_f	87 kt/100 mph for both
Landing gear transit,V_l	NA
Landing gear down, V_{le}	NA

Photo: Otis Holt

Test Pilot Russell Scott

Test Pilot Flight Report

by Russell Scott

INTRODUCTION

This report is based on a two flight qualitative and quantitative evaluation of RV-6A N157ST. This evaluation was conducted over a two day period and included 2.5 hours of flying time. The first flight was flown at a take off weight of 1,500 pounds and the second flight at the max allowable gross weight of 1,650 pounds. A c.g. in the middle of the allowable c.g. range was flown on each flight. The example aircraft was superbly constructed and was a winner of both the Bronze Lindy at Oshkosh and the Grand Champion at the Copperstate Fly-In.

PURPOSE

The purpose of these flights was to evaluate the general flying qualities, performance, stability, and control of this RV-6A. The intent was to not fly to any flight envelope limits, or go beyond any flight condition accomplished by the owner-builder. Therefore, it should be realized that all pilot comments are based on a "middle of the flight envelope" evaluation.

PREFLIGHT

Preflight requires nothing unusual to a standard walk around inspection. The only access to the engine compartment without removing the cowling is the oil dipstick access panel which has two tab fasteners. Little of the engine compartment can be seen through this opening.

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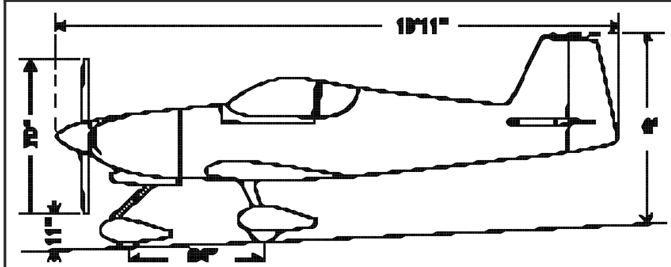
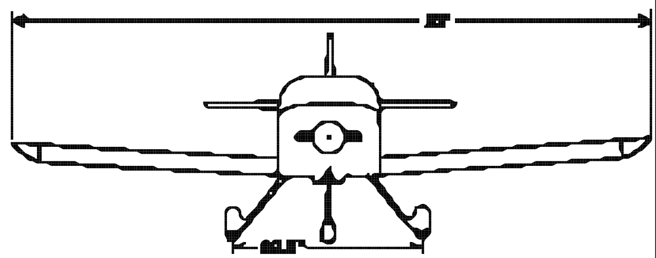
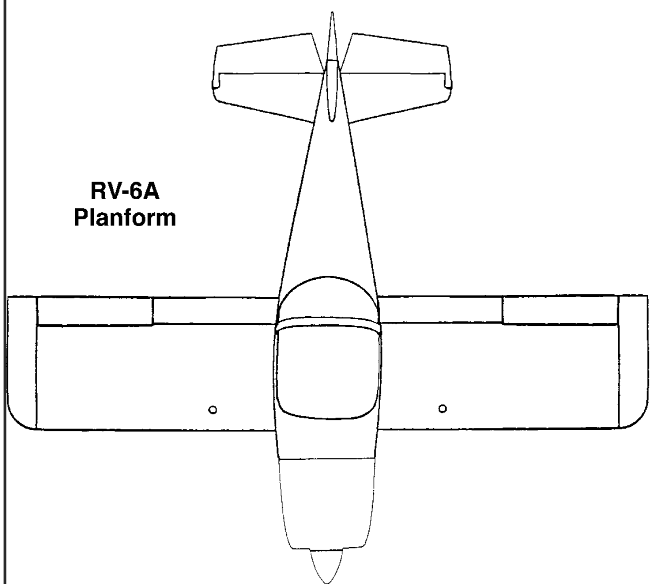
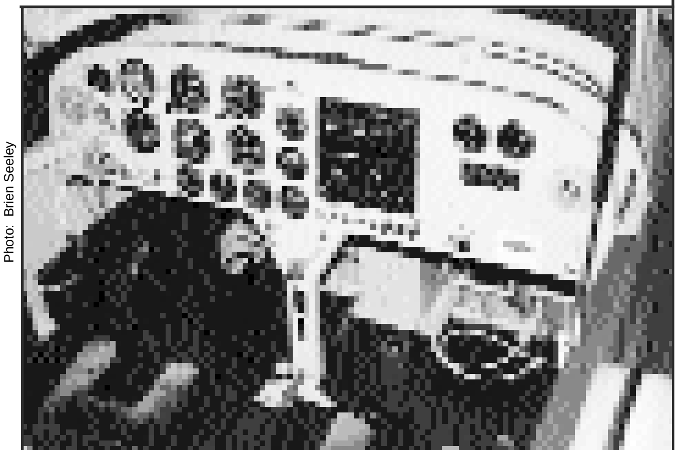






RV-6A Planform

Photo: Brien Seeley



Optional equipment included an Apollo Flybuddy Loran receiver (2.75 lbs), Narco Mark-12D with Glide Slope (4.4 lbs), Narco AT-150 Transponder (2.3 lbs), dual brake controls and control sticks, Whelen strobes (3.2 lbs), a 35 amp alternator and electric elevator trim.

THE CAFE CHALLENGE AND TRIAVIATHON

The CAFE Challenge is a flight efficiency competition for propeller driven light aircraft of under 4000 lbs gross weight flying a closed 500 statute mile course. The aircraft's score is computed by the following CAFE Challenge formula:

$$\text{Speed}^{1.3} \times \text{MPG} \times \text{Payload}^{.6} = \text{Score}$$

with speed in miles per hour and cabin payload in pounds. This formula is a useful and appropriate guide to an aircraft's transportation efficiency, and typically optimizes at 60-75% cruise power settings for a given aircraft. The current all-time high score is 1,315,396.

The CAFE Triaviathon is a maximum performance competition for propeller driven, non-turbine aircraft of under 4000 lbs gross weight. The 3 elements comprising the score are Vmax at 6000' indicated altitude, rate of climb (ROC) from 2500' through 3500' on a STD day, and V_{SO}, or stall speed. These elements are combined in this CAFE Triaviathon formula:

$$\frac{28110625 \times [\text{Vmax} \times \text{ROC}]^2}{[4100625 + V_{SO}^4] \times 10^9} = \text{Score}$$

with speeds in miles per hour, and ROC in feet per minute. The Triaviathon score measures the aircraft's extreme performance and ignores fuel consumption. It serves as an index of the aircraft's "exhilaration factor". The current all-time high score is 1316.45.

Test Pilot Flight Report (Cont.)

COCKPIT EVALUATION

Cockpit entry is without difficulty from either side of the aircraft. There are protective walk strips beginning forward of the wing flap and extending to the front of the cockpit. Stepping from ground level to the walk strip is made easier with the flaps fully extended. The flap handle is accessible from the outside by leaning over the canopy rail and reaching its location between the pilot and passenger seats. The ease of this access would depend on pilot stature (this pilot is 6'2" and 185 pounds). Entry into the cockpit from the wing can be easily accomplished by stepping into the seat and then to a sitting position. This pilot was able, by hand bracing on the side canopy rails, to step directly to the cockpit floor and into a sitting position. The cockpit seats were very comfortable even through a two hour period in the cockpit. The ergonomics of the cockpit arrangement of instruments, switches and comm/nav panels was good. The side by side seating with

RV-6A AIRCRAFT PERFORMANCE REPORT

Test Pilot Flight Report (Cont.)

center pedestal mounting of the throttle, mixture, carburetor heat, and pitch trim controls, and the fuel tank selector on the floor at the base of the center pedestal provides for flying the aircraft from either seat. This pilot elected to fly from the right side due to a higher proficiency level with a control stick in the right hand. The cockpit instrument layout did not include an attitude or heading (other than whiskey compass) indicator. A device, on the order of the attitude reference devices mounted on the wings of aerobatic aircraft, was mounted on the glare shield in front of the pilot for bank angle reference. Additionally, a battery powered proptach was mounted on the glare shield, and a camcorder with audio pick-up through the pilot micro-phone was mounted in the upper rear of the cockpit to record the instrument panel and pilot comments. The only other piece of test equipment was a hand held force gauge.

CANOPY

The clamshell bubble canopy, hinged in front, is supported by a damper strut on both sides when in the open position. The full-open canopy is well out of the way for ingress to and egress from the cockpit. Closing the canopy from the cockpit sitting position is achieved by grasping the side canopy rail with one hand and pulling down. As the canopy travels down, one reaches up with the other hand to grasp a handle on the rear canopy frame and continue the downward motion of the canopy and also prevent the canopy from slamming closed as the side struts travel over center. After the canopy is closed, the handle on the rear canopy frame is rotated 90° so that one end of the handle extends under the rear cockpit bow and prevents inadvertent opening of the canopy in the event there is some malfunction of the canopy locking lever. This lever is located on the left canopy rail and is moved to an aft locking position. The reverse of this procedure opens the canopy. All in all, simple and safe. The shortcomings of this system and the bubble canopy is that the aircraft cannot be taxied with the canopy open. For cockpit cooling air on the ground, the canopy must be held up slightly by hand. In flight, the cockpit is a real greenhouse and gets very warm even in moderate outside air temperature. Also, rapid emergency egress could be very difficult, especially, if for any reason, the aircraft was upside down on the ground. A sliding canopy would be preferred.

START AND TAXI

The before start and start checks following strap-in with seat belt and shoulder harness are minimal and uncomplicated, as they should be for this type of aircraft. The Lycoming O-360 started after turning only two to three blades of the fixed pitch, Berne Warnke, maple wood propeller. Taxi and ground handling characteristics were good. Engine idle RPM was low enough (approximately 750 RPM) so that taxi speed could be kept slow without braking. Directional control was good with differential braking and the free-to-swivel nose wheel. Before takeoff checks were, again, minimal and simple. The only construction change from plans was replacing the manual pitch trim control with an electric trim control which was a weight savings change. As noted earlier, the pitch trim control switch was mounted on the lower center pedestal and is a rocker type switch which generates nose up trim by pushing on the bottom of the switch, and nose down trim by pushing on the top of the switch. A green light is mounted directly under the trim switch, and lights when the pitch trim is neutral. It can take some searching to find the neutral position before takeoff. The pitch trim has a rather fast trim rate, but is not excessive. Very exact pitch trim can be obtained by using a “beeping” technique when trimming the aircraft.

TAKEOFF AND CLIMB

Takeoff from Santa Rosa airport (elevation 125 feet) was on runway 19, wind 230° at 15 knots, temperature 72°, at an aircraft gross weight of 1,500 pounds. Brake release with full throttle at 2240 RPM gave good acceleration, and tracking down the runway centerline was easy with good, responsive, positive directional control. Rotation for takeoff was begun at 55 MPH to 60 MPH (the airspeed indicator was in both MPH and knots with MPH being more prominent on the outer ring of the indicator. Also, the owner-builder used MPH and his recommended climb and approach to landing speeds were in MPH). Liftoff was at approximately 65 MPH, 13 seconds after brake release and approximately 650 feet of ground roll (with flaps up). The RV-6A has very strong elevator power and the nose can be rotated off the ground well below flying speed. If one were attempting a short field takeoff one could unin- tentionally extend the takeoff roll, or pull the aircraft into the air on the back side of the power curve by using poor pilot technique. This could be done even more easily with an aft c.g. After takeoff and acceleration, climb was established at 100 MPH as recommended by the owner-builder. The average rate of climb from liftoff to 8,000 feet was 1236 feet per minute. The engine RPM had decreased to 2200 at 8,000 feet. The aircraft response to pitch inputs and pitch damping was excellent. Airspeed could be controlled to plus or minus one MPH during climb. However, significant right rudder was required to keep the aircraft flying straight. The aircraft demonstrated deadbeat damping in pitch and yaw. Damping was within 1 to 1.5 cycles during the climb.

STALL CHARACTERISTICS

After accelerating to a Vmax level flight speed of 180 MPH indicated, stalls were performed at 8,000 feet from straight and level one G flight at just under 1400 pounds gross weight. The stall speed was determined by maintaining one G level flight and no more than a one MPH per second deceleration rate to the stall. In the cruise configuration (flaps up) the stall occurred at 55 MPH indicated, preceded by very mild onset buffet at 62 MPH and heavy onset buffet at 57 MPH. With 20° of flaps the stall occurred at 50 MPH, preceded by very mild onset buffet at 55 MPH and heavy buffet at 52 MPH. There was little or no difference in the buffet onset speed and the stall speed with 45° of flaps. The 45° flap position appears to add only more drag. The stalls were sharp with immediate nose drop and a slight wing drop. The wing drop could have been influenced by being out of lateral trim (more on that later). Stall recovery was immediate with release of back stick force.

LONG PERIOD FLIGHT CHARACTERISTICS

The long period (phugoid) was evaluated at 8,000 feet, from an initial condition of straight and level flight

RV-6A AIRCRAFT PERFORMANCE REPORT

Test Pilot Flight Report (Cont.)

at 2300 RPM and 155 MPH. The ability to accurately trim the aircraft with the electric trim is excellent. The power was reduced to initiate a rate of descent and then returned to the initial condition. The phugoid was well damped and return to trim conditions required a period of 64 seconds. This would indicate an ease of maintaining altitude and trim during cross country flight, and very good pitch control.

SHORT PERIOD CHARACTERISTICS

The short period characteristics were evaluated at 8,000 feet at 155 MPH. Pitch damping, both stick-fixed and stick-free, were evaluated using nose down, nose up stick doublets. The stick was returned to neutral and held for the stick-fixed test, and the stick was released after the nose up doublet for the stick-free test. Damping was deadbeat both stick-fixed and stick-free.

Stick-fixed and stick-free pitch damping were evaluated at 7,000 feet at 80 MPH, both flaps up and flaps down, to simulate approach to landing conditions. The pitch damping was deadbeat, stick-fixed, both flaps up and flaps down. The return to trim required two seconds following stick release flaps up, and five seconds to return to trim flaps down. With an aft c.g. the return to trim would require even more time.

LATERAL-DIRECTIONAL CHARACTERISTICS

Lateral-directional characteristics were evaluated at 8,000 feet. Full rudder deflection, steady heading sideslips were restricted to 100 MPH maximum because the owner-builder had not performed full rudder deflections above 100 MPH. The only sideslip indicator was a yaw string which had poor accuracy at its canopy location so the sideslip angles achieved are approximate. Full rudder, steady heading sideslips were done both to the right and left. Roll due to yaw was positive (stick left with right rudder and stick right with left rudder). Full rudder deflection generated a sideslip angle of approximately 15˚, a bank angle of approximately 15˚, and a lateral stick force of three pounds. The lateral stick force measurements were less than accurate due to the aircraft being out of trim laterally. There is no lateral trim control and attempting to maintain lateral trim is done by alternately burning fuel from the left and right fuel tanks. Lateral trim control would be a definite asset to this aircraft.

Spiral stability was also evaluated at this time by establishing a 15˚ bank angle and releasing the controls. The spiral stability appeared to be near neutral as the aircraft tended to roll in the direction of the heavy wing. Spiral stability in the approach to landing configuration, 80 MPH, full flaps, also appeared to be near neutral.

Lateral-directional evaluation was done at 7,000 feet at 80 MPH flaps up and flaps down to simulate approach to landing. Full rudder, steady heading sideslips generate a sideslip angle of approximately 20˚ and a light lateral stick force of two to three pounds. Rudder input with hands off the stick does result in gradual roll in the direction of the rudder input but is not abrupt. Releasing the rudder results more in a directional oscillation rather than a dutch roll. The aircraft tends to return to wings level while the yaw is damping in 1.5 cycles.

CONTROL BREAKOUT

The control breakout forces were measured with the hand held force gauge while trimmed for straight and level flight at 7000 feet and 120 MPH. Nose up, nose down, right wing down, and left wing down break out force all measured 1/2 pound. The rudder pedal breakout force was qualitatively estimated to be one pound. The pitch and roll control forces were not excessive during any flight condition evaluated. Control harmony was good, and stick centering was positive. Some form of rudder trim should be available as right rudder input was required at most flight conditions to keep the sideslip to zero.

STATIC LONGITUDINAL STABILITY

The static longitudinal stability or speed stability was evaluated by trimming at 130 MPH at 6,000 feet for straight and level flight. An acceleration to 180 MPH followed by a deceleration to 80 MPH was accomplished, and stick force was measured at each end point. At 180 MPH the push force was +7 pounds and at 80 MPH the pull force was -3 pounds. The stick force gradient is rather shallow with more push force required during an acceleration of 50 MPH than pull force during a deceleration of 50 MPH. This is probably influenced by power effects. However, the pilot must pay attention to airspeed when decelerating because he will get little notice from the change in the stick force.

MANEUVERING PERFORMANCE

Maneuvering performance was evaluated in both the cruise configuration at a Va of 120 MPH, and in the landing configuration at 80 MPH and full flaps. At the Va of 120 MPH the pull force was 7 pounds at 2Gs and 15 pounds at 3 Gs, which indicates a linear stick force gradient. At 80 MPH, full flaps, the pull force was 9 pounds at 2 Gs. This rather light stick force gradient for the mid-center of gravity is acceptable to this pilot . At an aft c.g., one would expect a lighter stick force gradient. Maneuvering this aircraft is easy, and with the good response to control input and high pitch damping, there was no tendency to overshoot desired G or attitude. Control inputs to attain desired pitch attitude, both nose up and nose down, result in responsive and accurate pitch control.

ROLL PERFORMANCE

Full aileron deflection roll performance was evaluated at 6,000 feet at a Va of 120 MPH, and in the landing configuration with the flaps at 45˚. At Va, full deflection aileron rolls both to the right and to the left from 60˚ to 60˚ bank produced a roll rate of 80˚ per second. The full deflection roll rate at 80 MPH, full flaps, 45˚ to 45˚ bank was 36˚ per second. Roll performance is adequate for this type of aircraft, and enjoyable aerobatics can be accomplished. Roll control is responsive, and bank angle capture can be done accurately with no tendency to overshoot the desired attitude.

TRIM vs. CONFIGURATION

Trim change with configuration change was evaluated at 4,000 feet

Test Pilot Flight Report (Cont.)

while changing from the cruise configuration at 80 MPH to the landing configuration with 45˚ of flaps, and the reverse. There is a definite nose down pitching moment when lowering the flaps, and a definite nose up pitching moment when raising the flaps. Three pounds of pull force was required to maintain level flight at 80 MPH after lowering the flaps, and two pounds of push force was required to maintain level flight at 80 MPH when raising the flaps. However, due to the rather light stick force gradient, the configuration change can be easily handled without retrimming. Lowering the flaps at a speed above 80 MPH (full flap limit speed is 100 MPH) is very difficult with one hand. If the pilot lets go of the stick to use both hands to lower the flaps, the resulting nose down pitching moment is rather distracting if one is on final approach. This pilot found the most comfortable technique was to zoom the aircraft slightly to decelerate below 80 MPH, and then comfortably lower the flaps to the 45 degree position with one hand.

APPROACH and LANDING

The wind conditions in the traffic pattern were gusty with a slight cross wind from the left at landing, so this provided a good flying qualities evaluation. The aircraft was well damped on all axes so that maintaining a heading and a desired rate of descent to landing touchdown was not a high gain task. Airspeed control was good, and while 80 MPH was the recommended approach speed, 70 MPH was very comfortable. The aircraft was easy to land using the necessary wing down into the wind, and compensating with the opposite rudder. Tracking down the runway centerline during landing rollout was positive, with no tendency to over-control. Braking was effective, and a slight nose wheel shimmy was encountered at about 40 MPH. Releasing and reapplying the brakes let the shimmy damp out.

CONCLUSIONS

The RV-6A evaluated is a pleasant and simple aircraft to fly. Takeoff performance is good, but the pilot must use good technique so as to not over-rotate the aircraft with the elevator power that is available, especially at an aft center of gravity. General flying qualities and performance are good, and the airplane can be controlled to exact pitch and bank attitudes. The ability to trim the aircraft for hands off flight is good, especially with the electric trim control. Lateral trim capability is poor since fuel balance between the left and right wing fuel tanks is the only available means to accomplish this. The aircraft is comfortable in the traffic pattern, and good speed and altitude control is possible even in moderate turbulence. The tricycle gear makes the landing and ground handling an easy task.

Russell Scott, Test Pilot
CAFE Foundation

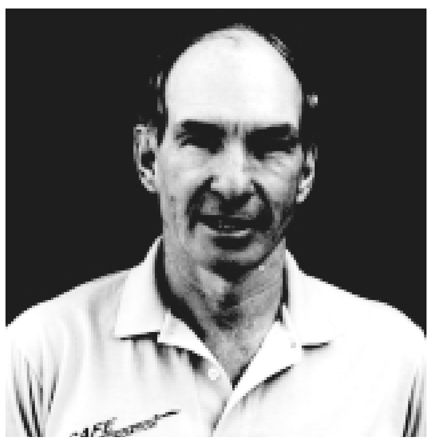


Photo: Otis Holt

Chief Test Pilot, C.J. Stephens

CAFE APR
RV-6A N176ST
PILOT: C.J. STEPHENS MAY 22, 1993

QUALITATIVE EVALUATION

Preflight was easy with all necessary inspection areas accessible except for the engine compartment. Without removal of the cowling only small sections of the engine were visible through two access panels.

The RV-6A is light in weight and one person can easily move it about on the ramp. The nose wheel has turning limits that restrict sharp turns and backing. It was necessary to push the tail down to raise the nose wheel off the ground and spin the plane around on the main gear. It would prove difficult for a small person to accomplish this task.

There was no easily accessible grounding point that was adequate for use during refueling operations. 100 octane fuel was required.

The cockpit was uncluttered and roomy. This pilot is 5'10" and used a 2" seat pad to get the proper sitting height. Even with that there was still 2-3" of head clearance. It appeared a pilot as tall as 6'3" would be comfortable although two people of that size would sit shoulder-to-shoulder. Access into the cockpit required a large step to get up and over the flap which was placarded "no step". A lady in a tight skirt would find it awkward to step up on to the wing walk strips.

The bubble canopy, hinged at two forward points, allowed easy entrance. It was difficult to step inside without stepping on the upholstery. The interior was beautifully done with attention to every last detail. The canopy latching system was easy to understand and left no doubt as to the security. A single latch locked two hooks at the rear corners of the canopy with solid positive mechanisms. The latch had a lock that clicked in place and was located to the left of the pilot's seat out of easy reach of the passenger. A second, simple, turn-to-lock handle provided a redundancy lock. Gas loaded springs held the canopy in the open position.

The baggage compartment was located just behind the seats. Access was through the cockpit. Both seats, hinged at the bottom, allowed fairly easy use although a very large bag would be difficult to manage. The published capacity is 100 lbs.

A very nice looking pilots operating handbook was presented. It was detailed and easy to understand. A complete checklist was available. It was laminated in plastic and was above average in utility.

Cockpit layout was very efficient. Obviously a lot of thought had been given. All primary controls were easy to reach and operate. Start up was straightforward. On every start the engine performed flawlessly. The light wooden propeller caused the engine to respond very quickly to all calls for power changes.

Taxiing was easy using differential brakes for directional steering. The plane tracked straight on the taxiway. At very slow taxi speeds the directional control seemed almost too quick, causing some oversteering. As the speed picked up to about 10 mph it was very stable. Very slight power was needed to attain taxi speed. At idle the plane would slow down. Visibility for ground maneuvering was excellent in all directions. With the forward hinge point mounting of the canopy it was necessary to close the canopy for taxiing.

It was a warm 87˚ F day and got quite warm in the cockpit with the canopy locked. There was an intermediate canopy position of about 3" open that was recommended not to be used due to the noise and vibration of the canopy sitting ajar. It was not used but could have provided better circulation in the runup area. In flight the cabin ventilation was excellent with two "eyeball" vents on the panel. Even at moderate taxi speeds there was some cooling from these vents. There were no vents directed at the windshield and though not tested I would suspect in a very humid environment condensation would accumulate, restricting the visibility.

A very nice electric elevator trim system was installed. A green light on the switch indicated neutral trim which was used for takeoff. No flaps were recommended for normal takeoff. A vernier throttle control gave good control of the power settings. 2,250 rpm was achieved at the start of the takeoff roll due to the coarse pitch of the propeller. As speed was gained the rpm increased accordingly. Even at maximum weight, nearly standard day, and about 4 kts of tail wind, a minimum run (flaps 20) takeoff roll was only 625 ft. Directional control during takeoff was very easy to maintain. Climb was at 100 mph indicated. Stick forces on rotation with the c.g. at 50% range were light yet comfortable. Cooling of the engine was good. The warmest cylinder reached 430˚F and cooled to 375˚F immediately on level off. Visibility during climb was excellent in all directions except to the 12-1:30 position. Due to the height of the cowl there were mild visibility restrictions in that location.

The initial feel of the controls was light and brisk. The controls are very responsive and well balanced to each other in all axes. By that, I mean that it is not a heavy aileron and light elevator situation.

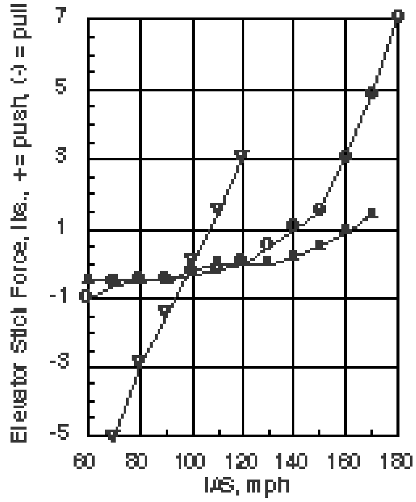


Figure 1.

Static Longitudinal Stability

Trimmed hands-off at V_a

@50% aft c.g.

Cessna 152

@85% aft c.g.

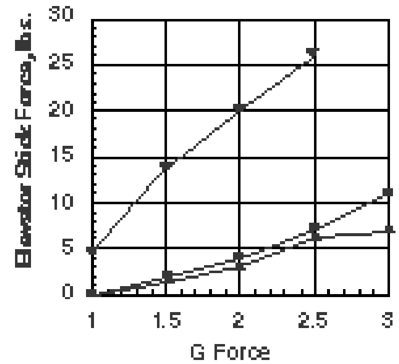


Figure 2 Maneuvering Stability @ V_a

Stick Force @ 50% aft c.g

Cessna 152

Stick Force @ 85% aft c.g.

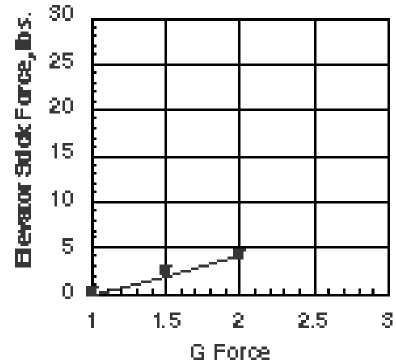


Figure 2. Maneuvering Stability @ 1.3 V_{so}

ROLL RATE, degrees/sec.		
Speed	Va	1.3 Vso
RV-6A	80	36
Cessna 152	52	38

The spiral stability was neutral. Once established in a shallow bank it didn't overturn or level out. There was no roll trim installed so any wing heaviness due to uneven fuel burn would be the deciding factor as to whether the plane would roll out or overbank. This was true with and without flaps and at 1.3Vs and Va.

Dynamic stability was explored over the entire green arc by inducing pitch doublets to determine the natural damping qualities of the RV-6A. It was virtually deadbeat at all speeds with both stick free and stick fixed. In stick fixed mode the elevators can add to the pitch dampening reflecting a different amount of natural stability.

Figure 1 shows the static longitudinal stability. With the use of a stick force gauge we measured the amount of pressure on the stick as the airspeed was increased in 10mph increments above, the below, a constant trim setting for a known airspeed.

Roll due to yaw was explored by establishing a 15 degree bank, then with no aileron input seeing if the rudder alone will level the wings. The RV-6A responded very promptly and correctly. It could be controlled accurately to about 30 degrees either direction with rudder alone.

Adverse yaw was looked at by roll inputs with aileron only at 1.3Vs. Initial adverse heading displacement was only 4 degrees. This very mild adverse yaw adds to the pleasant flying qualities.

Maneuvering stability was investigated. Figure 2 above shows a positive increase in the stick force required to generate more G force. This quality aids the pilot in preventing G overshoots during any pull-up maneuver. This adds to the airplanes overall safety.

Stall characteristics were examined with and without flaps at 50% and 85% aft c.g. locations. All stalls exhibited a crisp break with mild left wing drop. The only buffet occurred 1-2 mph above the stall. This very low amount of warning prior to a stall could be a potential problem to a low experience pilot. The nose drops crisply upon stall at all c.g. positions tested and the plane recovers nicely hands off. Recovery was instantaneous in all cases upon reposition of the stick. Control of the angle of attack was positive throughout the recovery. 100'-150' was typical altitude loss for full recovery. The aircraft was not equipped with leading edge stall strips, however, this is a possibility that could be explored to improve to the minimal natural stall warning, and improve the overall characteristics. The stalls occurred at 55 and 51 mph IAS flaps up and down respectively.

During the flight with the c.g. @ 85% aft of the forward limit the already light controls became even lighter. On takeoff practically no stick force was required to raise the nose to the proper attitude. I feel an inexperienced pilot has the potential to overrotate. Adequate care and training would be recommended for this situation. The static margin with the aft c.g. is diminished (see fig. #1). This is true with most airplanes for that matter. Particular attention would be necessary as the airplane gets loaded toward the aft limit. I feel the envelope defined within the POH is adequate. The several lazy eights that were attempted felt a smooth blend of controls throughout.

During descent the field of view is excellent, and with the easy maneuverability, dropping a wing further improves the view. The plane accelerates quickly when descending which requires a little planning for approach. When using flaps beyond the 20 degree setting considerable force is required to operate the manual flap handle. At 80 mph IAS the final approach is very easy to control. Even as the speed bleeds to around 70 mph in the flare with the power at idle there is no difficulty in gently rolling the tires on touch down.

It is this pilot's opinion that in a crash landing situation the aircraft has very good survivability due to its slow landing speeds, fuel contained solely in the wings, engine forward of the occupants design. If, though,during an off runway landing, the airplane should stop upside down, escape from the cockpit would be extremely difficult since the plane would then rest on top of the bubble canopy. It would prove beneficial to develop some method of egress or a canopy breaking tool for this situation.

It is hoped that this series of reports will serve as a guide for potential builders to help with that all important question: which airplane should I take on as a project? The answer would certainly vary with the individual, based on experience, needs, and use. We found the RV-6A to be a simple, straight forward airplane that looked and flew like an airplane should. It was very responsive, making it a joy to fly yet not so much that a low time aviator would find it a problem to fly. It is the kind of plane in which the pilot and a full size friend could take a normal amount of baggage and travel a good distance, at a good speed, without any difficulty. Its minimum runway requirement would not limit the places chosen as destination. It seems well suited for fun local flying and easy gentlemanly aerobatics. The aircraft presented was not equipped for instrument flying. However, if it had been, the light stick forces and quick flying qualities, would make heavy duty instrument cross country flight difficult.

The quality of construction on this plane, N 176ST, was near perfection. It is obvious that a very high level of "pride of workmanship" was present throughout the building of this wonderful homebuilt. It was a joy to fly and will provide years of enjoyment for the owner.

GLOSSARY

Doublet: Rapid push pull movement of a control
Deadbeat:Damped without overshoot
Stick free: Stick released after doublet input
Stick fixed: Stick rigid after doublet input
Vs: Stall speed
Va: Maneuvering speed
Fs: Stick force

IMPORTANT NOTICE

The purpose of this report is to provide to prospective buyers of kit-built aircraft a body of information that can help them select the type of aircraft that is best for their needs. The reports may also serve to estimate the incremental gains in performance or flying qualities that may be obtained by the application of various types of aircraft modifications to a given aircraft design. It must be emphasized that this information is not intended to serve as a Pilot's Operating Handbook for the operation of any aircraft.

Every effort has been made to obtain the most accurate information possible. The data are presented as measured and are subject to errors from a variety of sources. The qualitative assessments represent the opinions of the reporting test pilot.

ACKNOWLEDGEMENTS

The CAFE Foundation gratefully acknowledges the professional assistance of test pilots Doug Shane, Mike Melvill, and Al Aitken, aeronautical engineers Burt Rutan, John Roncz, Ray Hicks, J.R. Underwood, Donald Crawford, Andy Marshall, Alfred Scott, Ray Schrenkengast, William P. Kelly Jr., Nils Eyton, Bill Mruch, Kevin Horton, Scott Larwood, Alan Wadcock, Jerry Kirk, and the staff at the 7x10 windtunnel at NASA Ames Research Center, EAA Chapter 124, Rob Bachert, the Sonoma County Airport FAA Control Tower Staff, Airport Mantenance Staff, and the Airport Administrator.