Flight Test Measurements of the Longitudinal Stability and Performance of the Canard Sailplane Solitaire

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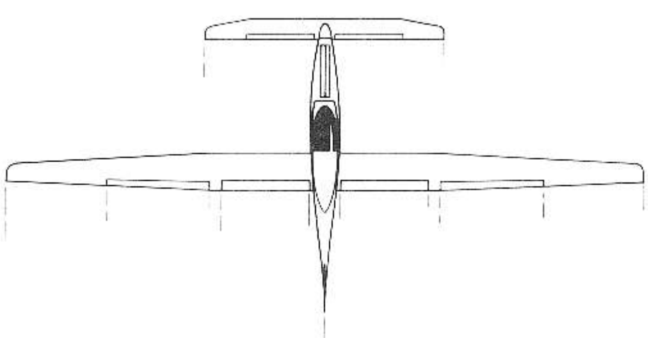
Introduction: This paper presents measurements of the longitudinal trim and static stability of the Solitaire, an analysis of the aircraft drag in steady gliding flight, and compares the performance of the Solitaire to the performance of an hypothetical aft-tail alternative of similar size.

A general description, performance summary, pitot-static calibration, handling qualities summary, and power-on performance summary were presented in the March 1984 Soaring Magazine.

Flight Test Measurements on the Rutan Solitaire Powered Sailplane



Performance: Figure 1 shows the straight-flight performance of the 1982 and 1983 versions of the Solitaire. The differences in the airplanes are discussed in the Soaring Magazine article. The 1982 version best represents the production kit version of the airplane. It is discussed in the following paragraphs.

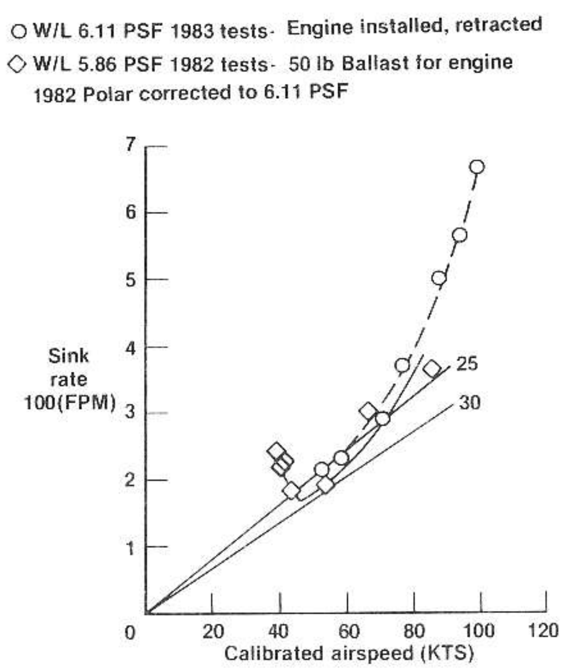


Figure 1

The timed sink test results are presented in the C_L^2 vs C_D format in Figure 2. The curve is faired through the 1982 data. The 1983 data show that a fairly constant drag increment was added to the 1983 airplane throughout its speed range. In 1982 the airplane was modified considerably before the 1983 flight tests. These modifications and additional modifications to alleviate the drag increases are also discussed in the Soaring article.

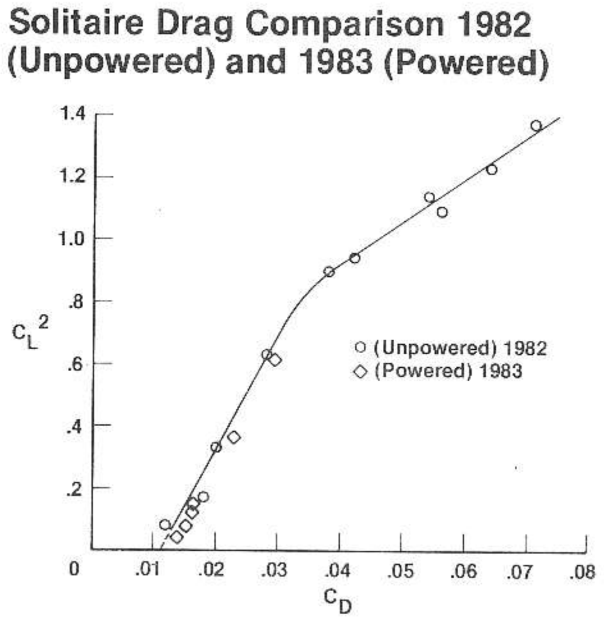


Figure 2

Figure 3 presents an accounting of the various components of the measured drag of the airplane. The trimmed airplane induced drag was computed from the standard computer program "VORTEX LATTICE". The induced drag of the whole airplane is equivalent to the induced drag of a 13.7 aspect ratio wing with a span efficiency of 1.0. The profile drag of the canard and the wing are taken from the airfoil designer's (RONCZ 1052 and 515 respectively) predictions. The predictions used the Eppler airfoil design synthesis program. Canard airfoil drag estimates are for the unflapped airfoil only. The fuselage and vertical tail drag were estimated from Hoerner. A small amount of unaccounted-for drag is present at C_L's below 0.9. At higher C_L's a significantly larger drag increment is unaccounted for. This could be due to separated flow on the canard with deflected flap, and perhaps the unfavorable effect of the separated canard wake on the wing. Tufted airfoil flights showed that separated flow exists over the rear half of the upper surface of the canard with the canard flap deflected down. Oil flow studies on

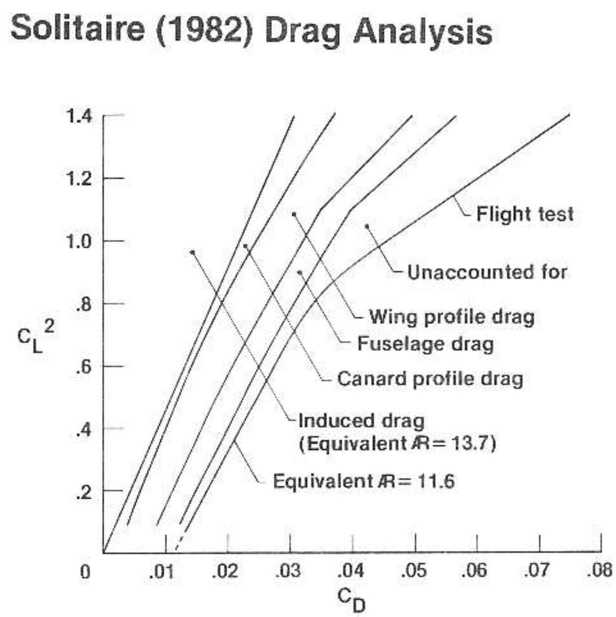


Figure 3

the wing showed that the part of the wing behind the canard had a fully turbulent boundary layer at C_L's above about 0.9.

The equivalent aspect ratio of the whole airplane at low and moderate C_L's is 11.6.

Longitudinal Trim and Static Stability

The elevator trim curves were easily obtained by mounting a quadrant on the canard and directly reading the canard flap deflection from the cockpit in steady flight. Figure 4 shows the elevator trim curves for two center-of-gravity positions.

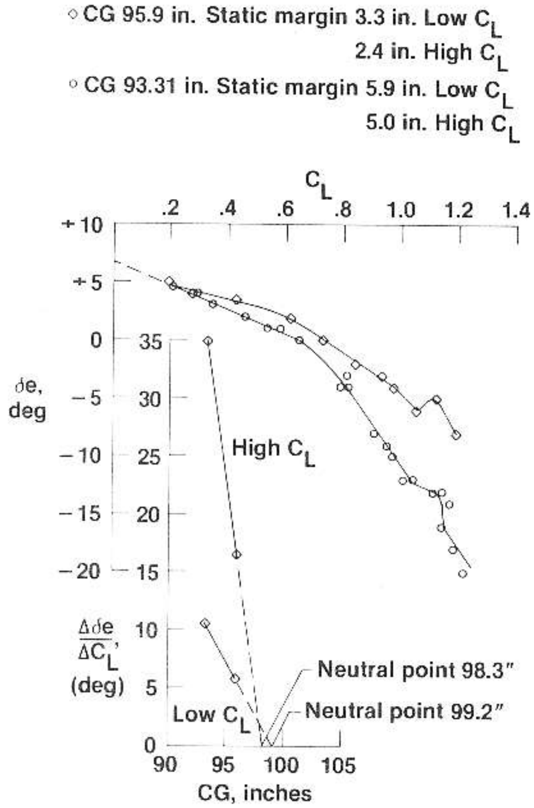


Figure 4

The reference datum is 9.9 inches foreward of the canard leading edge. The sharp break in the elevator trim curves is further evidence of flow separation over the top of the canard flap. Near C_L max there is evidence of a small local instability.

The static neutral point is estimated by extrapolating the * δ_e / C_L at two Center of Gravity (C.G.) positions to the C.G. at which $\delta_e / C_L = 0$. The static margin, or distance that the C.G. is in front of the neutral point is given in inches. While it is customary to give C.G. in percent MAC, there is no universally accepted non-dimensionalizing quantity such as M.A.C. for a canard configuration. The static margin is given in inches here. From a handling qualities point of view, the more forward C.G. airplane flew well while the aft C.G. airplane was somewhat less steady, and undesirably light on the controls in pitch. At both C.G. positions the response to turbulence was excessive, although more so in the aft C.G. configuration. The stalling behavior at both C.G. positions was excellent, with no evidence of wing-stall during any maneuver. The local instability in the trim curve was noticeable as a slight unsteadiness in pitch near full aft stick.

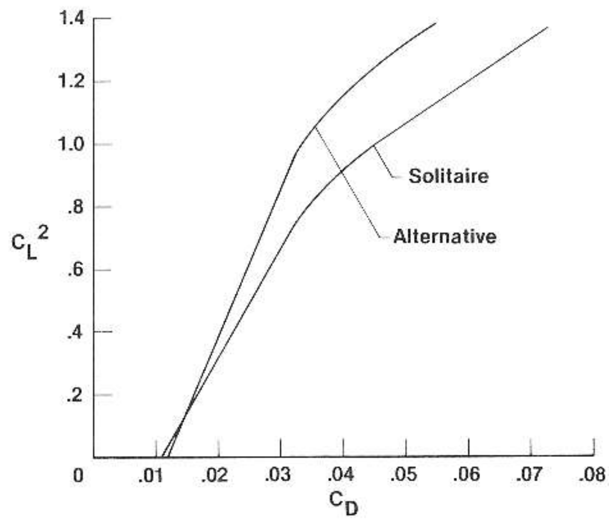
* δ_e = canard flap deflection in degrees.

Solitaire Specifications	
Span	41.7 ft.
Area	
Wing	83 sq. ft.
Canard	19 sq. ft.
	102 sq. ft.
Aspect Ratio	
Wing	21
Combined wing/canard	17
Weights	
Structure	320 lbs.
Engine	50 lbs.
Battery	15 lbs.
Miscellaneous	10 lbs.
Pilot & 'chute	225 lbs.
Max gross weight	620 lbs.
Limits	
V_{IAS} (demonstrated)	115 kt.
g	+7, −4
(+4 flight demonstrated, +7 static loaded)	
Performance	
Max L/D (flight test)	30:1

Comparison with Aft Tail Alternatives:

In view of the promising performance of the Solitaire it is of interest to see how an aft tail alternative might compare. The ground rules listed on the figure are intended to provide a fair comparison. The large tail volume coefficient is used to account for some possible awkwardness in mounting the engine in an aft tail airplane. Figure 5 shows a considerable performance improvement for the alternative at high C_L's with a small penalty at

Comparison of Solitaire With Hypothetical Aft Tail Alternative



Alternative;

- Same span as Solitaire
- Same wing area as Solitaire combined wing and canard
- Same wing airfoil
- 20 ft^2 horizontal tail (tail vol. coeff. = 1.0)
- Same zero lift drag as Solitaire plus 20 ft^2 horizontal tail

Figure 5

Comparison of Solitaire With Hypothetical Aft Tail Alternative

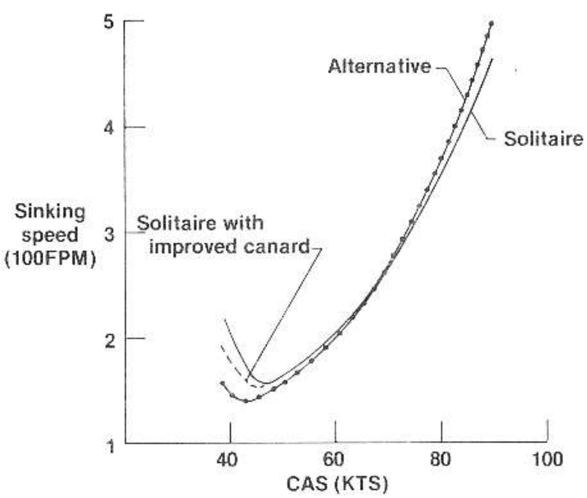


Figure 6

low C_L's. The resulting performance polar, Figure 6, shows better low speed performance and an appreciably better prospect for thermalling flight. It also shows that if an improved canard airfoil could be found for the Solitaire, a worthwhile improvement in its thermalling performance might be obtained.