

Design Report 04: Twin Sea Lion

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Nomenclature

| | | |
|---------------|---|---|
| AAA | = | Advanced Aircraft Analysis Program |
| AR_W | = | Wind aspect ratio |
| b_w | = | Wing span |
| c_w | = | Wing chord |
| D_{t_n} | = | Nosewheel tire diameter |
| D_{t_M} | = | Main gear tire diameter |
| d_{ns} | = | Nose strut diameter |
| d_{ms} | = | Main strut diameter |
| $d_{retract}$ | = | Gear bogey diameter while retracted |
| i_w | = | Wing incidence angle |
| l_f | = | Fuselage length |
| l_m | = | Length from x_{cg} to main gear |
| l_n | = | Length from x_{cg} to nose gear |
| n_m | = | Number of main gear |
| P_n | = | Maximum static load per nose bogey |
| P_m | = | Maximum static load per main bogey |
| S_W | = | Wing area |
| S_h | = | Horizontal stabilizer area |
| S_v | = | Vertical stabilizer area |
| $TDPF$ | = | Tail Damping Power Factor |
| W_{TO} | = | Takeoff weight |
| $w_{retract}$ | = | Gear bogey width while retracted |
| X | = | Distance of a component from the nose of the aircraft |
| Y | = | Distance of a component from the centerline of the aircraft |
| Z | = | Distance of a component from the belly of the aircraft |
| λ_w | = | Wing sweep angle |

$\Lambda_{c/4w}$ = Quarter chord sweep angle

Γ_w = Wing dihedral angle

ϵ_w = Wing twist angle

I. Introduction

This is the final report on development progress of the Twin Sea Lion. This report covers landing gear configuration, ground clearance and tipover calculations, spin characteristics and the flying qualities of the Twin Sea Lion.

II. Addendum to Report 3

Fuel x_{cg} was incorrectly placed at 22 ft while the wing x_{cg} was at 23 ft. Since the fuel cannot be before the wing, the fuel had to be moved back. This correction also improved the stability from 44% to 41%.

III. Landing Gear Layout Design

Tables 1, 2, and 3 summarize the results of the gear layout section.

Table 1 Summary of main gear and tire dimensions

| D_{t_m} [in] | b_{t_m} [in] | n_{mt} | l_m [ft] | P_m [lb] | P_m [%] | d_{ms} [ft] | L_{S_m} [ft] |
|----------------|----------------|----------|------------|------------|-----------|---------------|----------------|
| 30 | 9 | 2 | 3 | 16,152 | 42.86 | 0.3587 | 6.15 |

Table 2 Summary of nose gear and tire dimensions

| D_{t_n} [in] | b_{t_n} [in] | n_{nt} | l_n [ft] | P_n [lb] | P_n [%] | d_{ns} [ft] | L_{S_n} [ft] |
|----------------|----------------|----------|------------|------------|-----------|---------------|----------------|
| 23.4 | 6.5 | 2 | 18 | 5384.1 | 14.29 | 0.2244 | 5.36 |

Table 3 Summary and clearance and tip-over requirements

| Requirement | Sea Lion Value [deg] | Relation | Requirement [deg] | Satisfaction |
|-------------------------------|----------------------|----------|-------------------|--------------|
| Longitudinal Ground Clearance | 14.9 | ≠ | 15 | F |
| Lateral Ground Clearance | 15.68 | > | 5 | T |
| Longitudinal Tip-Over | 12.86 | ≠ | 15 | F |
| Lateral Tip-Over | 51.8 | < | 55 | T |

A. Sizing of the Landing Gear

Designers chose a tricycle configuration as it allows the most passenger comfort while the plane is on the ground. A tricycle configuration also makes the plane easier to steer on the ground. These gears will be retractable, with three total struts. The nose gear and main gear each have two tires per strut. Tires were selected to be similar to other regional turboprops of a similar weight. These tires will have a dual arrangement. Definitions of P_n (Equation 1) and P_m (Equation 2) come from Presentation 26[8]. For the Twin Sea Lion, $l_n = 18$ ft $l_m = 3$ ft, so $P_n = 5384.1$ lb = 14.29%

and $P_m = 16152 \text{ lb} = 42.86\%$.

$$P_n = \frac{W_{TO}l_m}{l_m + l_n} \quad (1)$$

$$P_m = \frac{W_{TO}l_n}{n_m(l_m + l_n)} \quad (2)$$

B. Location of the Landing Gear

Locations were originally chosen in order to put 10% of the weight on the nose gear with the main gear slightly behind the aircraft cg. Changes made in order to meet longitudinal ground clearance requirements took the nose gear loading up to 14.28%. This placed the main gear 3 ft behind the aircraft cg and the nose gear 18 ft in front of the aircraft cg.

1. Longitudinal Ground Clearance

The nose struts are 17 feet ahead of the apex of the wing and the empennage begins to sweep upwards 21 feet behind the main gear. The height above the ground of this corner is determined by the length of the struts so these struts were designed to ensure the required 15 degrees of clearance[8]. Clearance from the belly is calculated in Equation 3 as 5.36 feet. The belly is 9.5 inches below where the struts will begin, so the main landing gear struts are 6.15 feet long.

$$h = 21 \tan(\alpha) = 21 \tan(15 \text{ deg}) = 5.36 \text{ ft} \quad (3)$$

2. Lateral Ground Clearance

With 5.36 feet of clearance below the belly at the main landing gear, 32 feet from the main landing gear to the wingtip, and a wingtip height of 8.94 feet, the wingtips have a clearance of 15.68 degrees from the ground location of the main gear. This is greater than the 5 degrees required[8]. Propeller strikes are not a risk because the propellers are directly above the main gear.

3. Longitudinal Tip-Over

Longitudinal tip-over depends on the gear placement and tire separation as input to AAA in Figure 2. Nose strut diameter is 0.2244 feet and main strut diameter is 0.3587 feet as determined from Equations 4 and 5 respectively. As determined from the longitudinal clearance requirement, the main gear struts are 5.36 feet + 9.5 in = 6.15 ft long. The

nose gear strut is 5.36 feet long.

$$d_{ns} = (0.041 + 0.0025\sqrt{P_n}) = 0.2244 \quad (4)$$

$$d_{ms} = (0.041 + 0.0025\sqrt{P_m}) = 0.3587 \quad (5)$$

With two wheels on each strut align in the y direction, lateral tip-over depends on the y separation of the wheels. This separation needs to be slightly more than the sum of two half thicknesses of the tires and the strut diameter as seen in Equation 6.

$$St_{yn} = 1.05(t_n + d_{ns}) = 0.8044 \quad (6)$$

$$St_{ym} = 1.05(t_m + d_{ms}) = 1.1642 \quad (7)$$

Table 9.1 Typical Landing Gear Wheel Data ($n_s = 2$)

| Type | W_{TO} lbs | Main Gear | | | | Nose Gear | | | |
|--|-----------------|-------------------------------|---------------|-----|----------|-------------------------------|--------------|-----|----------|
| | | $D_t \times b_t$ in. x in. | $2P_m/W_{TO}$ | PSI | n_{mt} | $D_t \times b_t$ in. x in. | P_n/W_{TO} | PSI | n_{nt} |
| Homebuilts | 600 | 13x5 | 0.80 | 25 | 1 | 9x3.4 | 0.17 | 25 | 1 |
| | 1,200 | 12x5 | 0.78 | 45 | 1 | 12x5 | 0.22 | 45 | 1 |
| | 3,300 | 16x6 | 0.87 | 45 | 1 | 16x6 | 0.13 | 45 | 1 |
| Single Engine Prop. Driven | 1,600 | 15x6 | 0.80 | 18 | 1 | 15x5 | 0.20 | 28 | 1 |
| | 2,400 | 17x6 | 0.84 | 19 | 1 | 12.5x5 | 0.16 | 22 | 1 |
| | 3,800 | 16.5x6 | 0.84 | 55 | 1 | 14x5 | 0.16 | 49 | 1 |
| Twin Engine Prop. Driven | 5,000 | 16x6 | 0.83 | 55 | 1 | 16x6 | 0.17 | 40 | 1 |
| | 8,000 | 22x6.5 | 0.88 | 75 | 1 | 17x6 | 0.12 | 40 | 1 |
| | 12,000 | 26.6x7 | 0.84 | 82 | 1 | 19.3x6.6 | 0.16 | 82 | 1 |
| Agricultural | 3,000 | 22x8 | 0.95 | 35 | 1 | 9x3.5* | 0.05* | 55* | 1* |
| | 7,000 | 24x8.5 | 0.92 | 35 | 1 | 12.4x4.5* | 0.08* | 50* | 1* |
| | 10,000 | 29x7.5 | 0.85 | 35 | 1 | 25x7 | 0.15 | 35 | 1 |
| *Note: these are tailwheel data | | | | | | | | | |
| Regional Turbo- propeller Driven Airplanes | 12,500 | 18x5.5 | 0.89 | 105 | 2 | 22x6.75 | 0.11 | 57 | 1 |
| | 21,000 | 24x7.25 | 0.90 | 85 | 2 | 18x5.5 | 0.10 | 65 | 2 |
| | 26,000 | 36x11 | 0.92 | 40 | 1 | 20x7.5 | 0.08 | 40 | 1 |
| | 44,000 | 30x9 | 0.93 | 107 | 2 | 23.4x6.5 | 0.07 | 77 | 2 |
| Business Jets | 12,000 | 22x6.3 | 0.93 | 90 | 1 | 18x5.7 | 0.07 | 120 | 1 |
| | 23,000 | 27.6x9.3 | 0.95 | 155 | 1 | 17x5.5 | 0.05 | 50 | 2 |
| | 39,000 | 26x6.6 | 0.92 | 208 | 2 | 14.5x5.5 | 0.08 | 130 | 2 |
| | 68,000 | 34x9.25 | 0.93 | 174 | 2 | 21x7.25 | 0.07 | 113 | 2 |

Fig. 1 Landing gear of similar airplanes

With all this input into AAA, Figure 2 gives $\phi_{gear_{cg}} = 12.86$ deg. The requirement for longitudinal tip-over is that $\phi_{gear_{cg}} > 15$ [8]. This requirement is not met but is close enough to accept for the first round of design.

$$\phi = 12.86 \text{ deg} \not> 15 \text{ deg} \quad (8)$$

4. Lateral Tip-Over

Lateral tip-over is determined by the same AAA module as longitudinal tip-over. Figure 2 gives $\psi = 51.8$ deg. In order to pass this requirement $\psi \leq 55$ deg[8]. This requirement is easily satisfied. The Sea Lion will not tip-over laterally.

$$\psi = 51.8 \text{ deg} < 55 \text{ deg} \quad (9)$$

Landing Gear Geometry: Flight Condition 1

| Input Parameters | | | | | |
|--------------------|-----------------|--------------------|---------------------|--------------------|--------------------|
| X_{cg} | 24.32 | ft | Y_{cg} | -0.11 | ft |
| | | | Z_{cg} | 2.95 | ft |
| | | | X_{cg_E} | 24.80 | ft |
| | | | Z_{cg_E} | 3.47 | ft |
| Output Parameters | | | | | |
| $X_{gear_{forw}}$ | 6.00 | ft | $Z_{gear_{forw}}$ | -6.33 | ft |
| $Y_{gear_{forw}}$ | 0.00 | ft | $X_{gear_{aft}}$ | 26.50 | ft |
| | | | $Z_{gear_{aft}}$ | -6.60 | ft |
| Ψ | 51.8 | deg | $Z_{gear_{crit}}$ | -6.60 | ft |
| | | | $\phi_{gear_{cge}}$ | 9.58 | deg |
| $X_{gear_{crit}}$ | 26.50 | ft | $\phi_{gear_{cg}}$ | 12.86 | deg |
| | | | Coordinates Defined | | |
| Landing Gear Table | | | | | |
| # | Landing Gear | $N_{side-by-side}$ | N_{inline} | D_{wheel} ft | w_{wheel} ft |
| 1 | Nose Gear: Down | 2 | 1 | 1.95 | 0.54 |
| 2 | Main Gear: Down | 2 | 1 | 2.50 | 0.75 |
| 3 | Main Gear: Down | 2 | 1 | 2.50 | 0.75 |
| | | X_{wheel} ft | Y_{wheel} ft | Z_{wheel} ft | $S_{B_{wheel}}$ ft |
| | | 6.00 | 0.00 | -5.35 | 0.00 |
| | | 26.50 | 9.10 | -5.35 | 0.00 |
| | | 26.50 | -9.10 | -5.35 | 0.00 |
| | | | | $S_{T_{wheel}}$ ft | |
| | | | | 0.80 | |
| | | | | 1.16 | |
| | | | | 1.16 | |

Fig. 2 AAA results for tip-over conditions

C. Gear Retraction Volume

Expansions of the tires in inches are given by Equations 10 and 11 for tire width and diameter respectively[8]. Total retraction volume is estimated using these new dimensions and modeling the set of tires as a cylinder.

$$w_{retract} = w + 0.04w + 3 \quad (10)$$

$$d_{retract} = d + 0.1d + 3 \quad (11)$$

Based on the above, each main gear tire was assumed to expand to a diameter of 36 inches and width of 12.36 inches

Table 4 Expanded gear dimensions.

| Gear | Individual D [in] | Individual W [in] | Total D [ft] | Total W [ft] | Volume [ft^3] |
|------|-------------------|-------------------|--------------|--------------|-------------------|
| Nose | 26.634 | 9.76 | 2.2195 | 1.851 | 7.1616 |
| Main | 36 | 12.36 | 3 | 2.4187 | 17.0967 |

in cruise. By approximating the two tires and the diameter of the gear strut as a cylinder with length equal to twice the width of the wheel plus the strut diameter and a diameter equal to the tire's expanded diameter, the retracted volume of the main gear is calculated to be the following on each side and is tabulated in Table 4.

$$V_{h_{main}} = 17.0967 \text{ ft}^3 \quad (12)$$

From Report 02[2], the Twin Sea Lion requires 10,679 pounds of fuel and the wings have room for 20,559 pounds or 407.76 ft^3 of fuel. This leaves 195.96 ft^3 across both wings or 97.98 ft^3 in each wing for things other than fuel. The retracted gear would take up 17.4% of the remaining gear volume, leaving a very reasonable 82.6% of the non-fuel wing volume for other materials like tanks, wires, and hydraulics.

The nose gear expands in a similar manner. Each expanded tire was calculated as 26.634 inches in diameter and 9.76 inches in width. Again accounting for both tires and the diameter of the nose gear strut, the retracted volume of the nose gear is as follows.

$$V_{h_{nose}} = 7.1615 \text{ ft}^3 \quad (13)$$

The total diameter of the nose gear cylinder is 2.2195 ft and the total length is 1.851 ft. From Report 02[2], the back half of the cockpit has 17.55 in or 1.4625 ft from the floor to the outer shell. This is too small for the nose gear to fit either way so the gear will be retracted as far as possible and a clam shell used to cover the remaining.

IV. Aircraft Dimensions and Three-View

A. Geometric Summary

Wing design variables and fuselage length were determined in Report 02[2], and tail areas were determined in Report 03[3].

Table 5 Geometric design variables

| $S_W [ft^2]$ | $b_w [ft]$ | AR_W | $c_w [ft]$ | λ_w | $\Lambda_{c/4w} [^\circ]$ | $\Gamma_w [^\circ]$ | $i_w [^\circ]$ | $\epsilon_w [^\circ]$ | $l_f [ft]$ | $S_h [ft^2]$ | $S_v [ft^2]$ |
|--------------|------------|--------|------------|-------------|---------------------------|---------------------|----------------|-----------------------|------------|--------------|--------------|
| 837 | 81.8 | 8 | 10.16 | 0.6 | 0 | 5 | -1 | 0 | 47.58 | 190.0 | 137.0 |

B. Aircraft Three-View

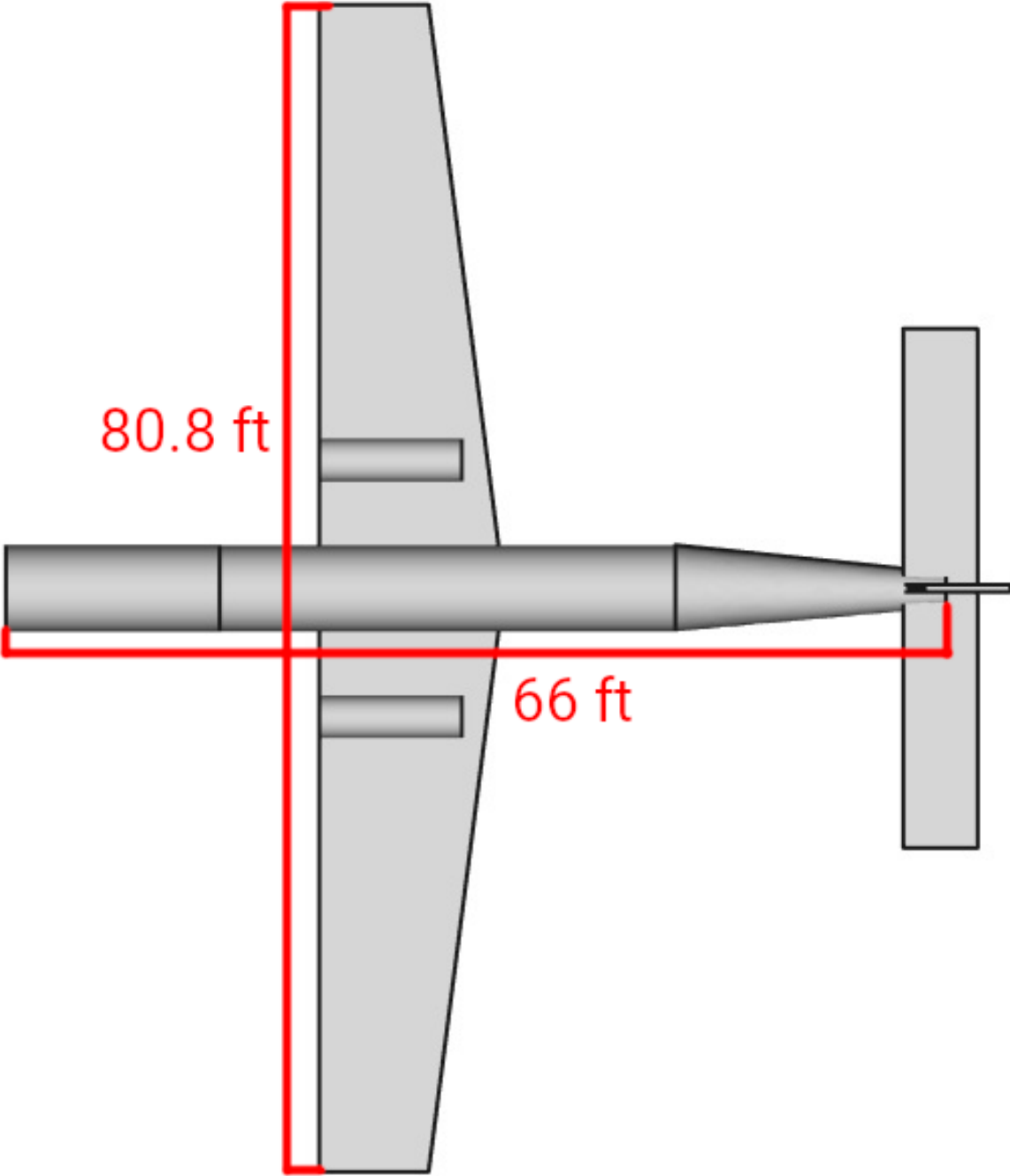


Fig. 3 Top view of the Twin Sea Lion

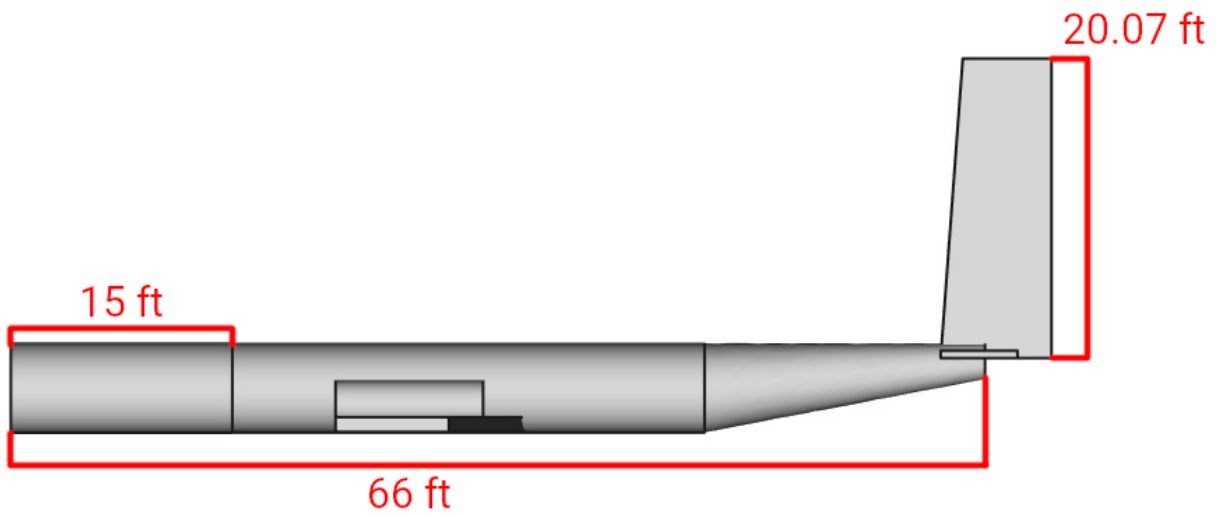


Fig. 4 Side view of the Twin Sea Lion

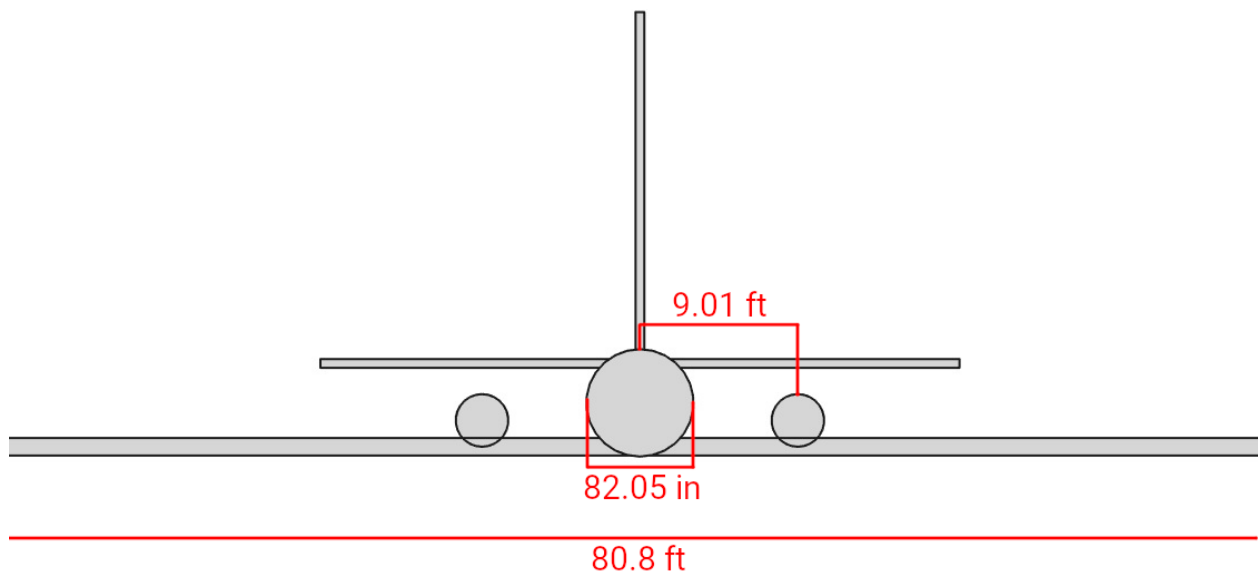


Fig. 5 Front view of the Twin Sea Lion

Note that while the length of the cockpit has been included in this model, the precise details are not included and it is simply replaced with a cylinder.

V. Moments of Inertia and Spin Characteristics

A. Moments of Inertia

The empty weight table seen in Figure 6 was populated with all empty weight groups and supplemented with the aircraft load split as much as possible with the available boxes. Note that the component names in the table were ignored in order to fit as many parts of the aircraft into the table as possible.

The actual names associated with each item are as follows.

- | | |
|---------------------------|--------------------------|
| 1) Furnishings | 12) Nose gear |
| 2) Other fixed equipment | 13) Main gear 1 |
| 3) Engine 1 | 14) Main gear 2 |
| 4) Engine 2 | 15) Fuel 1 |
| 5) Propeller 1 | 16) Fuel 2 |
| 6) Propeller 2 | 17) Cargo |
| 7) Wing 1 | 18) Baggage |
| 8) Wing 2 | 19) Crew |
| 9) Fuselage | 20) Trapped fuel and oil |
| 10) Horizontal Stabilizer | 21) Passenger group 1 |
| 11) Vertical Stabilizer | 22) Passenger group 2 |

Items split into groups 1 and 2 denote equipment that is on the right and left side of the aircraft respectively.

Class II Empty Weight Moment of Inertia: Flight Condition 1

Input Parameters

| | | | | | |
|-----------|----------|-----------|---------|-----------|---------|
| X_{cgE} | 24.80 ft | Y_{cgE} | 0.00 ft | Z_{cgE} | 3.47 ft |
|-----------|----------|-----------|---------|-----------|---------|

Output Parameters

| | | | | | | | |
|-----------|-------------------------------|-----------|------------------------------|-----------|-------------------------------|-----------|-----------------------------|
| I_{xxB} | 200121.1 slug-ft ² | I_{yyB} | 51880.2 slug-ft ² | I_{zzB} | 245693.0 slug-ft ² | I_{xzB} | 4375.6 slug-ft ² |
|-----------|-------------------------------|-----------|------------------------------|-----------|-------------------------------|-----------|-----------------------------|

Class II Empty Weight Moment of Inertia Table

| Component | Weight lb | I_{xxB} slug-ft ² | I_{yyB} slug-ft ² | I_{zzB} slug-ft ² | I_{xzB} slug-ft ² | X_{cg} ft | Y_{cg} ft | Z_{cg} ft |
|----------------------------------|-----------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|-------------|-------------|-------------|
| Wing | 83.4 | | | | | 41.63 | 1.96 | 4.21 |
| Horizontal Tail | 5192.0 | | | | | 21.41 | 0.00 | 3.50 |
| Vertical Tail | 1896.3 | | | | | 23.80 | 9.00 | 3.80 |
| Fuselage | 1896.3 | | | | | 23.80 | -9.00 | 3.80 |
| Nose Landing Gear | 901.8 | | | | | 20.00 | 9.00 | 3.80 |
| Main Landing Gear | 901.8 | | | | | 20.00 | -9.00 | 3.80 |
| Propeller | 1693.1 | | | | | 23.00 | 18.75 | 3.50 |
| Turboprop Engine | 1693.1 | | | | | 23.00 | -18.75 | 3.50 |
| Fuel System | 4455.6 | | | | | 21.41 | 0.00 | 3.50 |
| Air Induction System | 445.6 | | | | | 62.00 | 0.00 | 6.00 |
| Propulsion System | 267.3 | | | | | 62.00 | 0.00 | 16.00 |
| Flight Control System | 245.9 | | | | | 6.00 | 0.00 | 0.98 |
| Hydraulic and Pneumatic System | 696.9 | | | | | 27.00 | 9.10 | 2.38 |
| Instruments/Avionics/Electronics | 696.9 | | | | | 27.00 | -9.10 | 2.38 |
| Electrical System | 5348.6 | | | | | 23.00 | 18.75 | 2.00 |
| Air Cond./Press./Icing System | 5348.6 | | | | | 23.00 | -18.75 | 2.00 |
| Oxygen System | 2020.0 | | | | | 33.00 | -2.00 | 0.00 |
| Auxiliary Power Unit | 605.0 | | | | | 28.92 | 0.00 | 3.00 |
| Furnishings | 525.0 | | | | | 12.05 | -0.56 | 5.00 |
| Cargo Handling Equipment | 188.4 | | | | | 21.41 | 0.00 | 3.50 |
| Operational Items | 875.0 | | | | | 28.92 | 21.57 | 5.00 |
| Other Items | 875.0 | | | | | 28.92 | -21.57 | 5.00 |

Fig. 6 AAA inertia inputs

B. Spin Characteristics

The spin recovery criterion is described in Equation 14. S_{R_1} is the usable area of the rudder above the horizontal stabilizer. L_1 is the length from aircraft cg to the center of S_{R_1} . S_{R_2} and L_2 are similarly related. These parameters are taken from Presentation 27[9]

$$SRC = \frac{I_x - I_y}{b^2(W/g)} \quad (14)$$

$$TDPF = (TDR)(URVC) \quad (15)$$

$$TDR = \frac{S_F L^2}{S_W (b/2)^2} \quad (16)$$

$$URVC = \frac{S_{R1} L_1 + S_{R2} L_2}{S_W (b/2)} \quad (17)$$

$$\mu = \frac{W/S}{\rho g b} \quad (18)$$

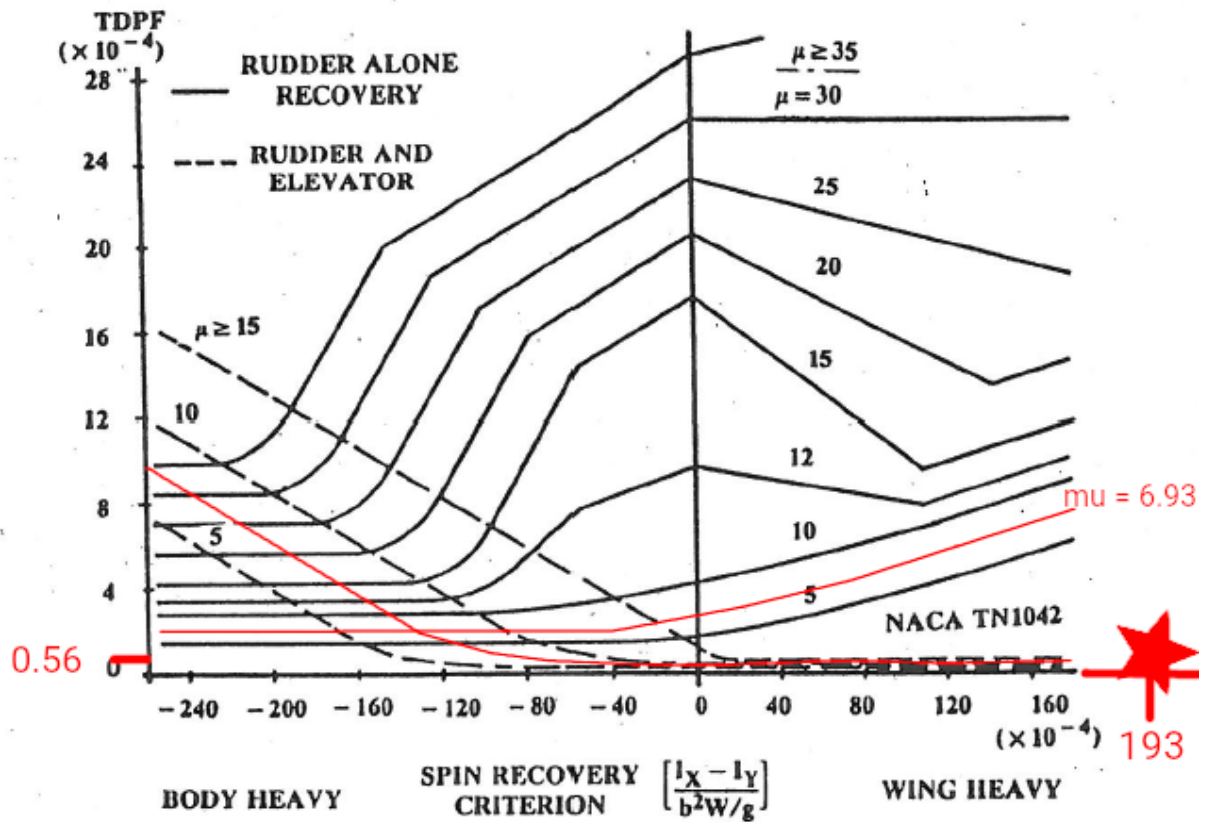


Fig. 16.31. Spin recovery criteria.

Fig. 7 Spin recoverability prediction, with the Twin Sea Lion's location marked

Thanks to the tall, single vertical stabilizer, $S_R = 8.19 ft^2$ and $L_R = 42 ft$ at most aft CG. A small amount of the vertical stabilizer aside from the rudder is not blanketed, so $S_F = 5 ft^2$ and $L_f = 39 ft$. From these, $TDPF = 0.566 \times 10^{-4}$, $\mu = 6.93$ at sea level, and $SRC = 193 \times 10^{-4}$. From the above graphic, it is apparent that the Twin Sea Lion is very

wing heavy and because its rudder is blanketed almost entirely by dirty air, it has next to no chance of recovery if a spin is encountered. However, this is acceptable for a FAR 25 certified aircraft.

In addition, the authors note that while no testing is planned, it may be possible to arrest a spin with differential thrust.

VI. Stability and Control Derivative

A. Longitudinal Stability Derivatives

All longitudinal stability derivatives and coefficients were determined from AAA using handout #2[5] and results from handout #1[4]. AAA printouts for this section can be found in Figures 33 through 54, with background calculations in Figures 12 through 32.

Table 6 All longitudinal stability derivatives

| | | | | | |
|---------------------------------------|-----------------|-----------------|-----------------|--------------------|---------------|
| Steady State Coefficients | C_{L_1} | C_{D_1} | $C_{T_{x_1}}$ | $C_{m_{T_1}}$ | C_{m_1} |
| | 0.1076 | 0.0177 | 0.0177 | -0.0013 | 0.0013 |
| Aerodynamic Speed Derivatives | C_{D_u} | C_{L_u} | C_{m_u} | $C_{T_{x_u}}$ | $C_{m_{T_u}}$ |
| | 0 | 0.0586 | 0.0106 | -0.0531 | 0.0038 |
| Angle of Attack Derivatives | C_{D_α} | C_{L_α} | C_{m_α} | $C_{m_{T_\alpha}}$ | |
| | 0.0972 | 6.1586 | -3.5082 | -0.0251 | |
| Change of Angle of Attack Derivatives | $C_{D'_\alpha}$ | $C_{L'_\alpha}$ | $C_{m'_\alpha}$ | | |
| | 0 | 3.6077 | -12.7779 | | |
| Pitch Rate Derivatives | C_{D_q} | C_{L_q} | C_{m_q} | | |
| | 0 | 14.1354 | -32.5032 | | |

B. Lateral-Directional Stability Derivatives

Calculations for lateral-directional stability derivatives were done in AAA as described in handout #2 with printouts from Figures 55 through 71.

Table 7 All lateral stability derivatives

| | | | | | |
|----------------------------------|----------------|----------------|----------------|------------------|------------------|
| Aerodynamic sideslip derivatives | $C_{y\beta}$ | $C_{l\beta}$ | $C_{n\beta}$ | $C_{Y_{T\beta}}$ | $C_{n_{T\beta}}$ |
| | -0.9179 | -0.3025 | 0.3995 | 0 | 0 |
| Sideslip rate derivatives | $C_{y'_\beta}$ | $C_{l'_\beta}$ | $C_{n'_\beta}$ | | |
| | -0.0066 | -0.0017 | -0.0029 | | |
| Roll rate derivatives | C_{y_p} | C_{l_p} | C_{n_p} | | |
| | -0.1342 | -0.5259 | -0.0193 | | |
| Yaw rate derivatives | C_{y_r} | C_{l_r} | C_{n_r} | | |
| | 0.7794 | 0.2663 | -0.3678 | | |

C. Longitudinal Control Derivatives**Table 8 All longitudinal control derivatives**

Longitudinal control derivatives were calculated in AAA, resulting in Figures 72 through 75.

| | | | |
|----------------------------------|--------------------|--------------------|--------------------|
| Longitudinal control derivatives | $C_{D_{\delta_e}}$ | $C_{L_{\delta_e}}$ | $C_{M_{\delta_e}}$ |
| | 0.0087 | 0.5482 | -1.9416 |

D. Lateral-Directional Control Derivatives

Lateral-directional control derivatives were calculated in AAA as shown in Figures 76 through 81.

Table 9 All lateral control derivatives

| | | | |
|-----------------------------|--------------------|--------------------|--------------------|
| Aileron control derivatives | $C_{y_{\delta_a}}$ | $C_{L_{\delta_a}}$ | $C_{n_{\delta_a}}$ |
| | 0 | 0.1629 | -0.0044 |
| Rudder control derivatives | $C_{y_{\delta_r}}$ | $C_{L_{\delta_r}}$ | $C_{n_{\delta_r}}$ |
| | 0.2717 | 0.0726 | -0.1380 |

VII. Static Stability and One Engine Inoperative Analyses

A. Static Longitudinal Stability

With the updates from Handouts #1 through #4, the Twin Sea Lion now has a static margin $SM = 56\%$. This is far in excess of the typical 10% to 15% that most aircraft have. The most forward cg in cruise comes directly after adding baggage when the airplane takes off. This gives 24.27 ft. The most aft cg in cruise comes after unloaded fuel and gives 24.83 ft. The initial calculations were done at 24.32 ft. The static margin at the most forward cg is then 57.44% and the is 52.07%. All of these are stable but none of of them are acceptable for controllability. Static margin could be improved by a revised horizontal stabilizer or a complete overhaul of fuselage design.

B. Static Lateral-Directional Stability

From Table 7, $C_{n\beta} = 0.3995$. This is suitably positive for positive stability and so is an acceptable value for lateral directional stability.

C. One Engine Inoperative Stability Analysis

Thanks to substantial rudder area, the Twin Sea Lion appears to have no issues with an engine out. As seen in Figures 85 and 86, the Twin Sea Lion needs to only deflect its rudder by 0.28 degrees at cruise altitude and speed, or 0.82 degrees at takeoff speed and altitude. However, V_{mc} is 420 knots at cruise and 168 knots at takeoff. Both these numbers are above the normal flying speeds of the aircraft. This is something of a contradiction, because the rudder deflections given are not anywhere near their maximums. This indicates that in reality the rudder could be more useful than AAA is calculating.

VIII. Transfer Function and Flying Quality Analyses

A. Transfer Function Analysis

1. Longitudinal Transfer Functions

Longitudinal transfer functions were determined through AAA in Figure 87. The following printouts, Figures 8 through 10 through the actual transfer functions as produced by AAA.

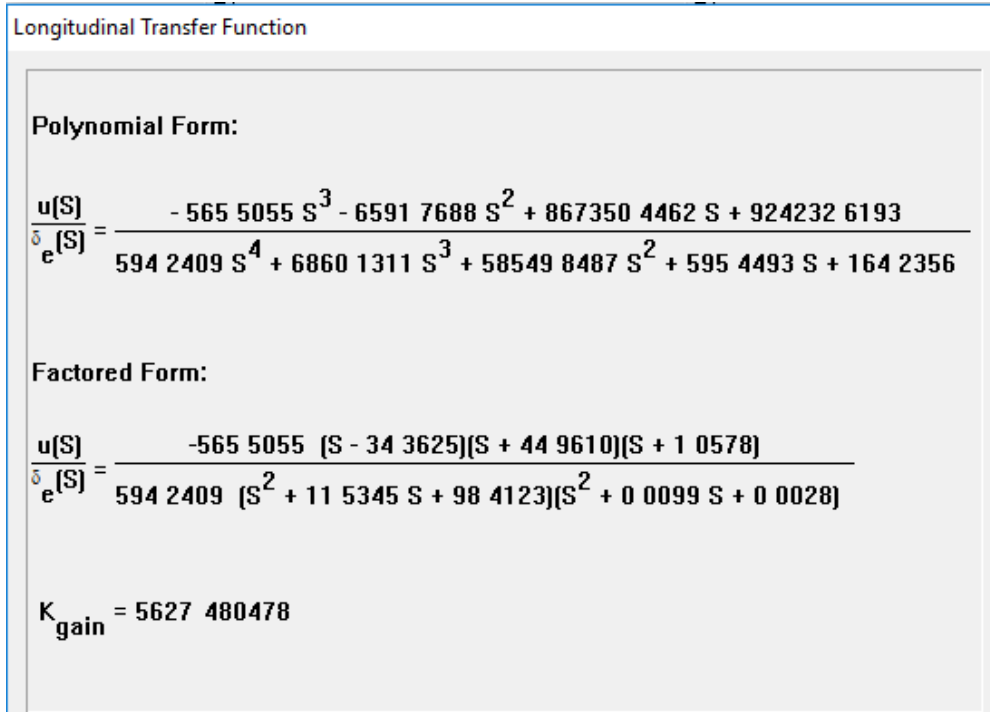


Fig. 8 Airspeed response to elevator deflection transfer function

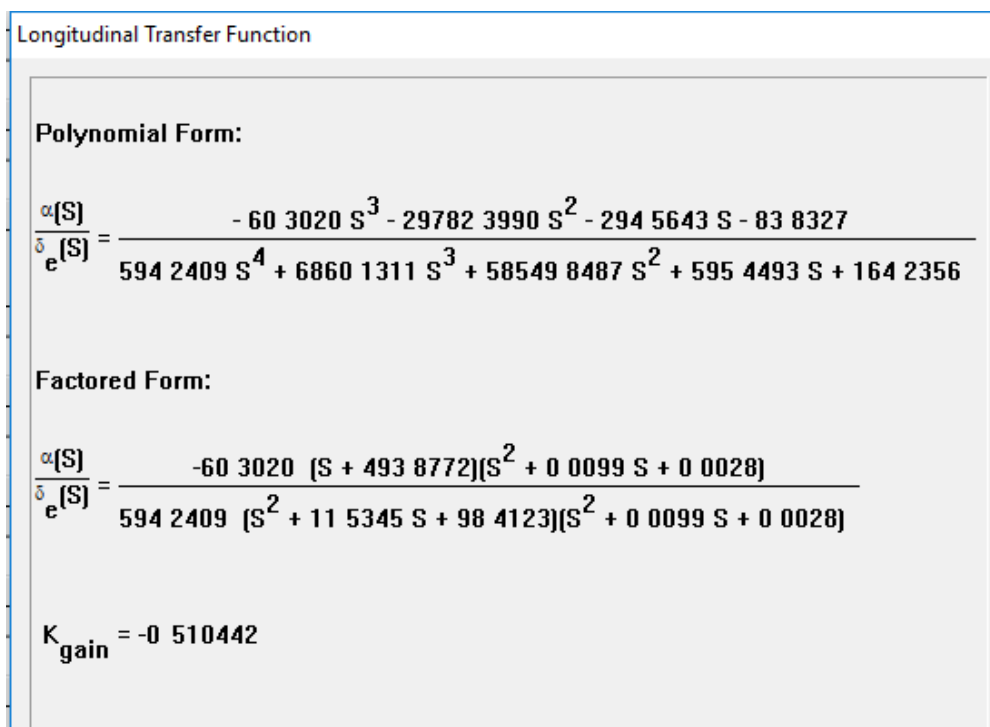


Fig. 9 Angle of attack response to elevator deflect transfer function

Longitudinal Transfer Function

Polynomial Form:

$$\frac{\theta(S)}{\delta_e(S)} = \frac{-30026\ 8919\ S^2 - 29254\ 7017\ S - 294\ 3308}{594\ 2409\ S^4 + 6860\ 1311\ S^3 + 58549\ 8487\ S^2 + 595\ 4493\ S + 164\ 2356}$$

Factored Form:

$$\frac{\theta(S)}{\delta_e(S)} = \frac{-30026\ 8919\ (S + 0\ 9641)(S + 0\ 0102)}{594\ 2409\ (S^2 + 11\ 5345\ S + 98\ 4123)(S^2 + 0\ 0099\ S + 0\ 0028)}$$

$$K_{\text{gain}} = -1\ 792125$$

Fig. 10 Flight path angle response to elevator deflection transfer function

2. Lateral-Directional Transfer Functions

Lateral transfer functions were determined through AAA in Figure 88 for aileron and 89 for rudder.

3. Aileron Transfer Functions

4. Rudder Transfer Functions

B. Flying Qualities Analysis

1. Longitudinal Flying Qualities

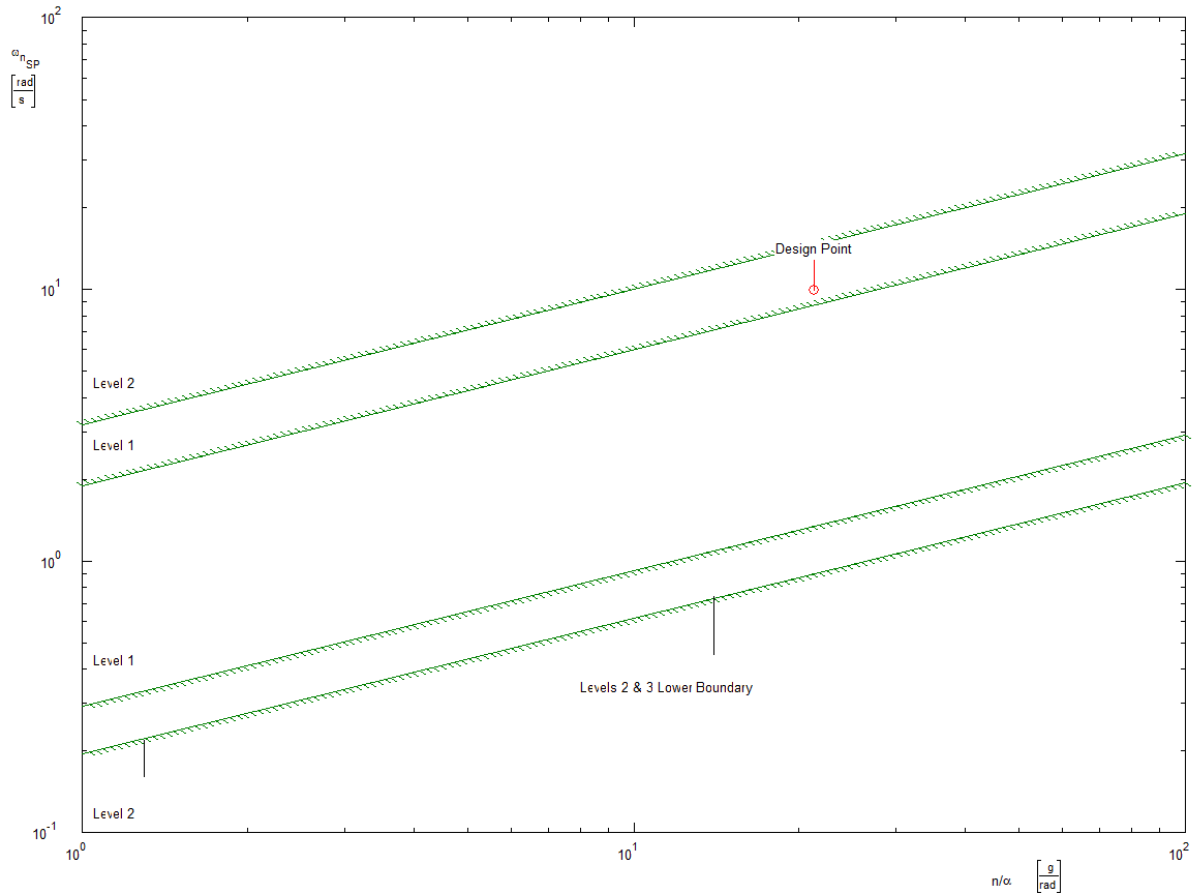


Fig. 11 Short period response is slightly outside level 1 requirements

AAA predicts that the Twin Sea Lion will have excellent flying qualities. AAA lists the relevant coefficients in Figure 87. In the phugoid mode, $\omega_P = 0.053s^{-1}$ and $\zeta_P = 0.093$. Short period has $\omega_{SP} = 9.92s^{-1}$ and $\zeta_{SP} = 0.581$. The detailed transfer functions are in Figures 8, 9, and 10.

With the exception of short period frequency, all the flying qualities of the Twin Sea Lion are considered Level 1, indicating that they are acceptable without further modification. Short period frequency is considered Level 2. This means that it can probably be corrected. The abnormally high short period frequency is consistent with the abnormally high static margin of the Twin Sea Lion. Future revisions can probably correct both issues simultaneously by redesigning

the horizontal stabilizer.

2. Lateral-Directional Flying Qualities

Notably, the Twin Sea Lion is stable in spiral and dutch roll modes. This is unusual as most aircraft are either stable in dutch roll or spiral, but the unusual weight configuration distribution of the Twin Sea Lion, along with substantial dihedral and a very large tail mean that it manages stability in both modes.

IX. Design Changes Needed to Meet Mission Requirements or Improve Mission Performance

A. Conclusions

The Twin Sea Lion has begun to embody its name quite well. It is large, heavy, and likely quite loud. While its handling qualities are predicted to be quite fair, they are not perfect and many parts of the plane are perhaps over specialized. It has fallen short of its original range and payload requirements in order to maintain high cruising altitude and top speed. Whether this is a fair tradeoff is a decision for the pilot or operator, but the designers think they may have missed the mark. Nevertheless, the Twin Sea Lion represents a unique set of capabilities based around speed and altitude not normally seen in the turboprop class.

B. Recommended Design Changes

Large design changes ought to be considered for the Twin Sea Lion. Chief among them is whether the performance targets are feasible with current technology. In an effort to fly far, fast, and high, the aircraft has mostly become wing and engine at the expense of cargo and payload space. By flying shorter missions, more weight could be moved towards cargo and passengers instead of fuel. By altitude requirements, the wings and control surface sizes could be reduced. Finally, takeoff altitude and speed requirements would allow for reductions to maximum engine power. In addition, reworking the horizontal stabilizer could reduce pitch stiffness and make the plane more flyable overall.

However, these are all substantial and require significant extra work. Smaller changes might include moving to composite construction. An all carbon fiber aircraft would have savings not only from reduced structural weight, but all the efficiencies that follow as fuel and powerplant requirements also decrease. That room could be used for cargo, stronger landing gear, and better high lift devices to maintain the original goals of STOL performance and long range. In addition, fewer rivets would decrease drag moderately.

In either case, the authors believe that the first changes should be made to the empennage. The high aspect ratios of the horizontal and vertical stabilizers make the aircraft excessively stiff in pitch and yaw and smaller surfaces would likely suffice. If the elevator and rudder authorities are insufficient, the elevators and rudders could be made into all-moving tailplanes in order to keep adequate area for the aerodynamic surfaces.

References

- [1] Junker and Killelea, "Design Report 01: Twin Sea Lion."
- [2] Junker and Killelea, "Design Report 02: Twin Sea Lion."
- [3] Junker and Killelea, "Design Report 03: Twin Sea Lion."
- [4] Gerren, "Handout #1", <https://canvas.colorado.edu>
- [5] Gerren, "Handout #2", <https://canvas.colorado.edu>
- [6] Gerren, "Handout #3", <https://canvas.colorado.edu>
- [7] Gerren, "Handout #4", <https://canvas.colorado.edu>
- [8] Gerren, "Presentation 26", <https://canvas.colorado.edu>
- [9] Gerren, "Presentation 27", <https://canvas.colorado.edu>

X. Appendix

A. AAA: Stability and Control Derivatives

| Wing Lift Curve Slope: Flight Condition 1 | | | | | | | | | | | | | |
|---|---------------------|---------------------|--------------------------|-------------------------|--------------------------|-------------------------------|------------------------|------------------------------------|--------------------------|---------------------------------|--------------------------|--------------------|--------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | $C_{L_{\alpha_0}}$ | 6.3598 rad ⁻¹ | AR _c | 0.00 | Y_{trim} | 0.00 ft | $\text{span}C_{L_{\alpha_0}}$ | 2.00 % | M_{trim} | 6.83 ft | | |
| ΔT | 0.0 deg F | $C_{L_{\alpha_0}}$ | 6.3598 rad ⁻¹ | λ_w | 0.60 | $\text{span}C_{L_{\alpha_0}}$ | 12.00 % | $M_{\text{trim}}/C_{L_{\alpha_0}}$ | 76.20 % | | | | |
| U_1 | 350.00 kts | S_w | 837.00 ft ² | λ_{trim} | 0.0 deg | $\text{span}C_{L_{\alpha_0}}$ | 12.00 % | D_{trim} | 6.83 ft | | | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | ξ_{trim} | 0.93 | $C_{L_{\text{trim}}}$ | 7.9041 rad ⁻¹ | S_{trim} | 751.13 ft ² | $C_{L_{\text{trim}}}$ | 5.2621 rad ⁻¹ | $C_{L_{\alpha_0, \text{trim}}}$ | 4.5851 rad ⁻¹ | $C_{L_{\alpha_0}}$ | 5.3724 rad ⁻¹ |
| K_u | 1.0003 | $C_{L_{\alpha_0}}$ | 6.3598 rad ⁻¹ | $C_{L_{\alpha_0}}$ | 7.9041 rad ⁻¹ | AR _{trim} | 7.49 | $C_{L_{\alpha_0, \text{trim}}}$ | 5.3706 rad ⁻¹ | $C_{L_{\alpha_0, \text{trim}}}$ | 5.3724 rad ⁻¹ | | |
| ξ_{trim} | 0.91 | $C_{L_{\alpha_0}}$ | 7.9041 rad ⁻¹ | $C_{L_{\text{trim}}}$ | 75.00 ft | λ_{trim} | 0.62 | $C_{L_{\alpha_0, \text{trim}}}$ | 4.5851 rad ⁻¹ | $C_{L_{\alpha_0}}$ | 5.3706 rad ⁻¹ | | |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | τ_1 % | τ_0 % | c/c_w % | δ deg | | | | | | | | |
| 1 | Single Slotted Flap | 8.0 | 55.5 | 30.0 | 0.0 | | | | | | | | |

Fig. 12 Wing lift curve slope

| Wing Lift Coefficient at Alpha = 0 deg: Flight Condition 1 | | | | | | | | | | | | | |
|--|---------------------|---------------|--------------------------|-----------------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|------------------------------|----------|------------------------------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | S_w | 837.00 m ² | $\Lambda_{w,0}$ | 0.0 deg | $C_{L_{w,0}}$ | 5.3724 rad ⁻¹ | $C_{L_{w,0}}$ | 6.3598 rad ⁻¹ | i_w | -1.0 deg | $(C_{L_{w,0}})_{\text{eff}}$ | 12.00 % |
| ΔT | 0.0 deg F | AR_w | 8.00 | $C_{L_{w,0}}$ | 5.3706 rad ⁻¹ | $C_{L_{w,0}}$ | 5.3724 rad ⁻¹ | $\beta_{w,0}$ | -3.0 deg | $\beta_{w,0}$ | 0.0 deg | | |
| U_1 | 350.00 kts | S_w | 8.60 | $C_{L_{w,0}}$ | 5.3706 rad ⁻¹ | $C_{L_{w,0}}$ | 6.3598 rad ⁻¹ | $\beta_{w,0}$ | -3.0 deg | $(C_{L_{w,0}})_{\text{eff}}$ | 12.00 % | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | i_w | 0.0 deg | $C_{L_{w,0}}$ | 6.3598 rad ⁻¹ | $\beta_{w,0}$ | -3.0 deg | $\Delta C_{L_{w,0}}$ | 0.0000 | $C_{L_{w,0}}$ | 0.2812 | | |
| $\beta_{w,0}$ | -3.0 deg | $C_{L_{w,0}}$ | 7.9041 rad ⁻¹ | $C_{L_{w,0}}$ | 7.9041 rad ⁻¹ | $\beta_{w,0}$ | -3.0 deg | $\Delta C_{L_{w,0}}$ | 0.0000 | $(C_{L_{w,0}})_{\text{eff}}$ | 0.1875 | | |
| $\beta_{w,0}$ | -3.0 deg | $C_{L_{w,0}}$ | 7.9041 rad ⁻¹ | $\beta_{w,0}$ | -0.4 | $\beta_{w,0}$ | -2.0 deg | $C_{L_{w,0}}$ | 0.2012 | $C_{L_{w,0}}$ | 0.1875 | | |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_i % | η_o % | c_l/c_{l_0} % | δ deg | $\Delta C_{L_{w,0}}$ | | | | | | | |
| 1 | Single Slotted Flap | Input | Input | Input | Input | Output | | | | | | | |
| | | 9.0 | 55.5 | 30.0 | 0.0 | 0.0000 | | | | | | | |

Fig. 13 Wing lift coefficient at zero angle of attack

| Horizontal Tail Lift Curve Slope: Flight Condition 1 | | | | | | | | | | | | | |
|--|-----------------------|---------------|--------------------------|-----------------------|---------|------------------------------|--------------------------|------------------------------|--------------------------|---------------|--------------------------|---------------|--------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | $C_{L_{w,0}}$ | 6.2504 rad ⁻¹ | AR_w | 7.00 | Y_{stab} | 0.00 ft | $\beta_{w,0}$ | 2.00 ft | | | | |
| ΔT | 0.0 deg F | $C_{L_{w,0}}$ | 6.2504 rad ⁻¹ | S_w | 1.00 | $(C_{L_{w,0}})_{\text{eff}}$ | 12.00 % | $(C_{L_{w,0}})_{\text{eff}}$ | 0.00 % | | | | |
| U_1 | 350.00 kts | S_w | 190.00 m ² | $\Lambda_{w,0}$ | 0.0 deg | $(C_{L_{w,0}})_{\text{eff}}$ | 12.00 % | $(C_{L_{w,0}})_{\text{eff}}$ | 70.00 % | | | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | AR_w | 6.62 | S_{stab} | 34.47 m | $C_{L_{w,0}}$ | 5.3097 rad ⁻¹ | S_{stab} | 1.00 | $C_{L_{w,0}}$ | 7.7681 rad ⁻¹ | $C_{L_{w,0}}$ | 7.7681 rad ⁻¹ |
| S_{stab} | 179.58 m ² | S_{stab} | 1.00 | $K_{stab} = K_{stab}$ | 1.12 | S_{stab} | 1.00 | $C_{L_{w,0}}$ | 6.2504 rad ⁻¹ | $C_{L_{w,0}}$ | 7.7681 rad ⁻¹ | $C_{L_{w,0}}$ | 5.7070 rad ⁻¹ |

Fig. 14 Horizontal stabilizer lift curve slope

| Horizontal Tail Downwash Gradient: Flight Condition 1 | | | | | | | | | | | | | |
|---|-----------------------|-----------------|------------|-------------------------------|--------------------------|-------------------------------|--------------------------|-------------------------------|---------|-------------------------------|---------|-------------------------------|---------|
| Input Parameters | | | | | | | | | | | | | |
| S_w | 837.00 m ² | $\Lambda_{w,0}$ | 0.0 deg | Z_{stab} | 2.00 ft | $C_{L_{w,0}}$ | 4.5051 rad ⁻¹ | AR_w | 7.00 | $\beta_{w,0}$ | 0.0 deg | Z_{stab} | 6.00 ft |
| AR_w | 8.00 | K_{stab} | 23.00 | i_w | -1.0 deg | $C_{L_{w,0}}$ | 5.3706 rad ⁻¹ | S_w | 1.00 | K_{stab} | 60.00 | | |
| S_w | 0.60 | Y_{stab} | 0.00 ft | $C_{L_{w,0}}$ | 5.3706 rad ⁻¹ | S_w | 190.00 m ² | $\Lambda_{w,0}$ | 0.0 deg | Y_{stab} | 0.00 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| Z_{stab} | 6.00 ft | i_w | 35.11 ft | $(dC_{L_{w,0}})_{\text{eff}}$ | 0.4274 | $(dC_{L_{w,0}})_{\text{eff}}$ | 0.3356 | $(dC_{L_{w,0}})_{\text{eff}}$ | 0.3931 | $(dC_{L_{w,0}})_{\text{eff}}$ | 0.3931 | $(dC_{L_{w,0}})_{\text{eff}}$ | 0.3931 |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_i % | η_o % | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | | | | | | | | | | |

Fig. 15 Horizontal stabilizer downwash gradient

| Horizontal Tail Downwash Angle: Flight Condition 1 | | | | | | | | | |
|--|--------------------------|----------------------------------|------------|----------------------|------------------------|-----------------------|---------|---------------------|---------|
| Input Parameters | | | | | | | | | |
| $C_{l_{\alpha_{\text{clean}}}}$ | 5.3706 rad ⁻¹ | $(d\delta_r/d\alpha)_{M=0}$ | 0.3356 | i_w | -1.0 deg | AR_w | 8.00 | $Z_{c_{\text{th}}}$ | 6.00 ft |
| $C_{l_{\alpha_{\text{clean}}@M=0}}$ | 4.5851 rad ⁻¹ | α_{clean} | -3.0 deg | S_w | 837.00 ft ² | $Z_{c_{\text{th}}@w}$ | 2.00 ft | | |
| Output Parameters | | | | | | | | | |
| $\Delta\delta_{\text{th}}^{\text{hd}}$ | 0.0 deg | $\delta_{\text{th}}^{\text{hd}}$ | 0.7 deg | δ_{th} | 0.8 deg | | | | |
| High Lift Devices Table | | | | | | | | | |
| # | High Lift Device | η_i % | η_o % | $\Delta C_{L_{W_0}}$ | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 0.0000 | | | | | |

Fig. 16 Horizontal stabilizer downwash angle

| Horizontal Tail Lift Coefficient at Zero Horizontal Tail Angle of Attack: Flight Condition 1 | | | | | | | | | |
|--|--------------------------|------------------------------|--------------------------|----------------------------------|--------------------------|----------------------------------|--------------------------|------------------------------|---------|
| Input Parameters | | | | | | | | | |
| Altitude | 30000 ft | S_{th} | 190.00 ft ² | $\Lambda_{c_{\text{th}}}$ | 0.0 deg | $C_{l_{\alpha_{\text{th}}@M=0}}$ | 6.2504 rad ⁻¹ | δ_{th} | 0.0 deg |
| ΔT | 0.0 deg F | AR_{th} | 7.00 | $C_{l_{\alpha_{\text{th}}}}$ | 5.7070 rad ⁻¹ | $\alpha_{\text{th}M=0}$ | 0.0 deg | $(l/c)_{\text{th}}$ | 12.0 % |
| U_i | 350.00 kts | i_{th} | 1.00 | $C_{l_{\alpha_{\text{th}}@M=0}}$ | 6.2504 rad ⁻¹ | $\alpha_{\text{th}M=0}$ | 0.0 deg | $(l/c)_{\text{th}}$ | 12.0 % |
| Output Parameters | | | | | | | | | |
| M_i | 0.594 | $C_{l_{\alpha_{\text{th}}}}$ | 7.7681 rad ⁻¹ | α_{th} | 0.0 deg | α_{th} | -0.4 | $C_{l_{\alpha_{\text{th}}}}$ | 0.0000 |
| $C_{l_{\text{th}}}$ | 7.7681 rad ⁻¹ | α_{th} | 0.0 deg | δ_{th} | 0.0 deg | α_{th} | 0.0 deg | | |

Fig. 17 Horizontal stabilizer lift coefficient at zero angle of attack

| Vertical Tail Sidewash Gradient: Flight Condition 1 | | | | | | | |
|---|------------------------|-----------------------------|---------|-----------------------|---------|-------|------------------------|
| Input Parameters | | | | | | | |
| S_w | 837.00 ft ² | $\Lambda_{c_{\text{th}}@w}$ | 0.0 deg | $Z_{c_{\text{th}}@w}$ | 2.50 ft | l | 55.00 ft |
| AR_w | 8.00 | $Z_{c_{\text{th}}@w}$ | 2.00 ft | h_{th} | 2.50 ft | S_v | 137.00 ft ² |
| Output Parameter | | | | | | | |
| $(d\sigma/d\beta)_v$ | -0.1264 | | | | | | |

Fig. 18 Vertical stabilizer sidewash gradient

| Vertical Tail Downwash Gradient: Flight Condition 1 | | | | | | | | | | | |
|---|------------------------|-----------------|------------|-----------------------------|--------------------------|-------------------------------|--------------------------|-----------------------------|---------|---------------------|----------|
| Input Parameters | | | | | | | | | | | |
| S_w | 837.00 ft ² | $\Lambda_{w,t}$ | 0.0 deg | $Z_{w,t}$ | 2.00 ft | $C_{l_{w_0}} @ M=0_{clean}$ | 4.5851 rad ⁻¹ | AR_w | 3.00 | Γ_v | 90.0 deg |
| AR_w | 8.00 | X_{trim_w} | 23.00 ft | ι_w | -1.0 deg | $C_{l_{w_0}}$ | 5.3706 rad ⁻¹ | λ_w | 0.60 | X_{trim_v} | 60.00 ft |
| λ_w | 0.60 | Y_{down_w} | 0.00 ft | $C_{l_{w_0,clean}}$ | 5.3706 rad ⁻¹ | S_w | 137.00 ft ² | $\Lambda_{w,t}$ | 5.0 deg | Z_{trim_v} | 15.00 ft |
| Output Parameters | | | | | | | | | | | |
| $Z_{w,v}$ | 24.76 ft | L | 36.53 ft | $(d\epsilon/d\alpha)_{M=0}$ | 0.2379 | $(d\epsilon/d\alpha)_{w,off}$ | 0.2787 | $d\epsilon/d\alpha_{clean}$ | 0.2787 | $d\epsilon/d\alpha$ | 0.2787 |
| High Lift Devices Table | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | | | | | | | | |

Fig. 19 Vertical stabilizer downwash gradient

| Vertical Tail Downwash Angle: Flight Condition 1 | | | | | | | | | |
|--|--------------------------|-----------------------------|------------|----------------------|------------------------|-----------|---------|-----------|----------|
| Input Parameters | | | | | | | | | |
| $C_{l_{w_0,clean}}$ | 5.3706 rad ⁻¹ | $(d\epsilon/d\alpha)_{M=0}$ | 0.2379 | ι_w | -1.0 deg | AR_w | 8.00 | $Z_{w,v}$ | 24.76 ft |
| $C_{l_{w_0}} @ M=0_{clean}$ | 4.5851 rad ⁻¹ | $\alpha_{w_0,clean}$ | -3.0 deg | S_w | 837.00 ft ² | $Z_{w,t}$ | 2.00 ft | | |
| Output Parameters | | | | | | | | | |
| $\Delta\epsilon_{w,v}$ | 0.0 deg | $\epsilon_{w_0,M=0}$ | 0.5 deg | ϵ_{w_0} | 0.6 deg | | | | |
| High Lift Devices Table | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | $\Delta C_{L_{w_0}}$ | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 0.0000 | | | | | |

Fig. 20 Vertical stabilizer downwash angle

| Wing Lift Coefficient for Given Angle of Attack: Linear Range: Flight Condition 1 | | | | | | | | | |
|---|----------|-------------------|----------|-----------------------------|--------------------------|----------------------------|--------|----------------------------|--------------------------|
| Input Parameters | | | | | | | | | |
| α | 0.00 deg | α_{w_0} | -3.0 deg | $C_{l_{w_0,clean}}$ | 5.3706 rad ⁻¹ | $C_{l_{w_0,no emp,clean}}$ | 0.1875 | $C_{l_{w_0,no emp,clean}}$ | 5.3724 rad ⁻¹ |
| $\alpha_{w_0,clean}$ | -3.0 deg | ι_w | -1.0 deg | $C_{l_{w_0}}$ | 5.3706 rad ⁻¹ | $C_{l_{w_0,no emp}}$ | 0.1875 | $C_{l_{w_0,no emp}}$ | 5.3724 rad ⁻¹ |
| Output Parameters | | | | | | | | | |
| $\alpha_{p,off}$ | -1.0 deg | $C_{l_{w,clean}}$ | 0.1875 | $C_{l_{w,off clean,p,off}}$ | 0.1875 | $C_{l_{w,off}}$ | 0.1875 | $\Delta C_{l_{w,off}}$ | 0.0000 |
| $C_{l_{w,off,p,off}}$ | 0.1875 | $C_{l_{w}}$ | 0.1875 | $C_{l_{w,clean}}$ | 0.1875 | $\Delta C_{l_{w,off}}$ | 0.0000 | | |

Fig. 21 Wing lift coefficient

| Subsonic Wing Drag Coefficient Prediction: Flight Condition 1 | | | | | | | | | | | |
|---|----------------------|------------------|------------------------|------------------|-----------------------------|----------------------|------------------------|---------------------|-------------------------|-------------------|---------|
| Input Parameters | | | | | | | | | | | |
| Altitude | 30000 ft | S_w | 837.00 ft ² | Λ_{LE_w} | 1.8 deg | $(R_{LE}/C)_{LE_w}$ | 1.000 % | L_{LE_w} | 1.2 | ϵ_{LE_w} | 0.0 deg |
| ΔT | 0.0 deg F | AR_w | 8.00 | $(V/C)_{LE_w}$ | 12.00 % | S_{max_w} | 837.00 ft ² | $(R_{tr}/C)_{LE_w}$ | 15.0 % | $C_{D_{gap_w}}$ | 0.00020 |
| U_1 | 350.00 kts | h_w | 0.60 | κ_{root} | 0.01333 $\times 10^{-1}$ ft | Z_{top} | 10.20 ft | ϵ_{tr_w} | 7.9041 rad ¹ | | |
| C_{L_w} | 0.1875 | Λ_{LE_w} | 0.0 deg | \bar{E}_w | 10.44 ft | h | 55.00 ft | $C_{D_{tr_w}}$ | 5.3706 rad ¹ | | |
| Output Parameters | | | | | | | | | | | |
| M_1 | 0.594 | Re_{LE_w} | 0.2590 $\times 10^6$ | C_{L_w} | 0.0024 | $C_{D_{gap_{ref}}}$ | 0.00020 | $C_{D_{tr_w}}$ | 0.0015 | | |
| Re_{LE_w} | 1.4677 $\times 10^6$ | Re_{root} | 5.3833 $\times 10^6$ | ϵ_w | 0.9514 | $\bar{C}_{D_{tr_w}}$ | 0.0037 | | | | |
| High Lift Devices Table | | | | | | | | | | | |
| # | High Lift Device | $C_{D_{gap}}$ | | | | | | | | | |
| 1 | Single Slotted Flap | 0.00020 | | | | | | | | | |

Fig. 22 Wing drag coefficients

| Wing Aerodynamic Center: Flight Condition 1 | | | | | | | | | | | |
|---|--------------------------|------------------|------------------------|--------------|----------|------------------|----------|------------------|---------|------------|---------|
| Input Parameters | | | | | | | | | | | |
| Altitude | 30000 ft | U_1 | 350.00 kts | AR_w | 8.00 | Λ_{LE_w} | 0.0 deg | Y_{dist_w} | 0.00 ft | Γ_w | 5.0 deg |
| ΔT | 0.0 deg F | S_w | 837.00 ft ² | h_w | 0.60 | X_{top_w} | 23.00 ft | Z_{LE_w} | 2.00 ft | | |
| Output Parameters | | | | | | | | | | | |
| M_1 | 0.594 | \bar{C}_w | 10.44 ft | Y_{ref_w} | 18.75 ft | X_{ac_w} | 26.20 ft | \bar{X}_{ac_w} | 0.2500 | | |
| \bar{q}_1 | 155.41 $\frac{lb}{ft^2}$ | κ_{top_w} | 0.59 ft | X_{ac_w}/C | 0.2500 | Z_{ac_w} | 3.64 ft | | | | |

Fig. 23 Wing aerodynamic center

| Horizontal Tail Aerodynamic Center: Flight Condition 1 | | | | | | | | | | | |
|--|-----------|-------------|--------------------------|------------------|---------|------------------|----------|--------------|---------|------------|----------|
| Input Parameters | | | | | | | | | | | |
| Altitude | 30000 ft | U_1 | 350.00 kts | AR_h | 7.00 | Λ_{LE_h} | 0.0 deg | Y_{dist_h} | 0.00 ft | Γ_h | 0.0 deg |
| ΔT | 0.0 deg F | S_h | 190.00 ft ² | Λ_{LE_h} | 1.00 | κ_{top_h} | 60.00 ft | Z_{LE_h} | 6.00 ft | | |
| Output Parameters | | | | | | | | | | | |
| M_1 | 0.594 | \bar{q}_1 | 155.41 $\frac{lb}{ft^2}$ | \bar{C}_h | 5.21 ft | κ_{top_h} | 0.00 ft | Y_{ref_h} | 9.12 ft | X_{ac_h} | 61.30 ft |
| | | | | | | | | | | Z_{ac_h} | 6.00 ft |

Fig. 24 Horizontal stabilizer aerodynamic center

| Vertical Tail Aerodynamic Center: Flight Condition 1 | | | | | | | | | | | |
|--|-----------|-------------|--------------------------|------------------|---------|------------------|----------|-------------|----------|------------|----------|
| Input Parameters | | | | | | | | | | | |
| Altitude | 30000 ft | U_1 | 350.00 kts | AR_v | 3.00 | Λ_{LE_v} | 5.0 deg | Z_{top_v} | 15.00 ft | | |
| ΔT | 0.0 deg F | S_v | 137.00 ft ² | Λ_{LE_v} | 0.80 | κ_{top_v} | 60.00 ft | | | | |
| Output Parameters | | | | | | | | | | | |
| M_1 | 0.594 | \bar{q}_1 | 155.41 $\frac{lb}{ft^2}$ | \bar{C}_v | 6.79 ft | κ_{top_v} | 1.03 ft | Z_{ref_v} | 9.76 ft | X_{ac_v} | 62.73 ft |
| | | | | | | | | | | Z_{ac_v} | 24.76 ft |

Fig. 25 Vertical stabilizer aerodynamic center

| Calculation of the Aerodynamic Center Shift due to Fuselage: Flight Condition 1 | | | | | | | |
|---|------------------------|-----------------|----------|----------------|----------|---------------------|-------------------------|
| Input Parameters | | | | | | | |
| S_w | 837.00 ft ² | h_w | 0.60 | $X_{AC_{fus}}$ | 23.00 ft | $C_{m_{fus}}^{(0)}$ | 4.5851 rad ³ |
| AR_w | 0.00 | Λ_{fus} | 0.0 deg | V_{fus} | 0.00 ft | $C_{m_{fus}}^{(1)}$ | 5.3786 rad ³ |
| | | | | | | $X_{AC_{fus}}$ | 0.00 ft |
| | | | | | | h_w | 6.83 ft |
| Output Parameters | | | | | | | |
| $X_{AC_{fus}}$ | 0.59 ft | $C_{m_{fus}}$ | 10.44 ft | $C_{m_{fus}}$ | 12.36 ft | h_w | 23.11 ft |
| | | | | | | h_w | 19.53 ft |
| | | | | | | ΔX_{AC} | -0.0451 |

| Fuselage Table | | |
|----------------|--------------|----------------------------------|
| Section | X_{fus} ft | Λ_{fus} rad ² |
| 1 | 0.0000 | 0.00 |
| 2 | 4.5000 | 19.60 |
| 3 | 15.0000 | 36.30 |
| 4 | 47.0000 | 36.30 |
| 5 | 55.0000 | 9.10 |
| 6 | 60.0000 | 2.14 |
| 7 | 66.0000 | 2.14 |
| 8 | 66.1000 | 0.00 |

Fig. 26 Aerodynamic center shift due to fuselage effects

| Power-off Dynamic Pressure Ratio: Flight Condition 1 | | | | | | | |
|--|----------|-----------------------------|------------------------|---------------------|----------|-------------------|----------|
| Input Parameters | | | | | | | |
| α | 0.00 deg | δ_w | 0.6 deg | AR_w | 0.00 | δ_w | -1.0 deg |
| δ_w | 0.8 deg | $(d\delta_w/d\alpha)_{off}$ | 0.2787 | h_w | 0.60 | Z_{fus} | 2.00 ft |
| $(d\delta_w/d\alpha)_{off}$ | 0.3931 | S_w | 837.00 ft ² | $X_{AC_{fus}}$ | 23.00 ft | Z_{fus} | 6.00 ft |
| | | | | $C_{m_{fus}}^{(0)}$ | 0.0037 | $X_{AC_{fus}}$ | 62.73 ft |
| | | | | | | α_{trim} | -5.0 deg |
| Output Parameters | | | | | | | |
| δ_w | 10.44 ft | ΔZ_{trim} | 0.70 ft | δ_w | 1.000 | ΔZ_{trim} | 0.71 ft |
| δ_w | 4.18 ft | δ_w | 1.000 | Z_{trim} | 22.85 ft | δ_w | 1.000 |

Fig. 27 Power-off dynamic pressure ratio

| Elevator Related Derivatives: Flight Condition 1 | | | | | | | |
|--|-------------------------|---------------------|-------------------------|---------------------|-------------------------|---------------------|-------------------------|
| Input Parameters | | | | | | | |
| Altitude | 30000 ft | $C_{m_{fus}}^{(0)}$ | 6.2504 rad ³ | h_w | 1.00 | δ_w | 12.0 % |
| δ_T | 0.0 deg F | $C_{m_{fus}}^{(1)}$ | 6.2504 rad ³ | Λ_{fus} | 0.0 deg | δ_w | 95.0 % |
| h | 350.00 ft | S_w | 190.00 ft ² | δ_w | 1.000 | δ_w | -0.04 deg |
| S_w | 837.00 ft ² | AR_w | 7.00 | δ_w | 12.0 % | δ_w | 5.0 % |
| | | | | δ_w | 5.0 % | Balance | 0.05 |
| | | | | δ_w | 12.0 % | $C_{m_{fus}}$ | 0.5482 rad ³ |
| Output Parameters | | | | | | | |
| M_1 | 0.594 | $C_{m_{fus}}^{(0)}$ | 7.7681 rad ³ | h_w | 1.0000 | $C_{m_{fus}}^{(1)}$ | 0.4231 |
| $C_{m_{fus}}^{(0)}$ | 7.7681 rad ³ | $C_{m_{fus}}^{(1)}$ | 1.2955 rad ³ | h_w | 1.00 | $C_{m_{fus}}^{(2)}$ | 0.5482 rad ³ |
| | | | | $C_{m_{fus}}^{(2)}$ | 2.4149 rad ³ | $C_{m_{fus}}^{(3)}$ | 0.4231 |
| | | | | $C_{m_{fus}}^{(3)}$ | 0.4231 | $C_{m_{fus}}^{(4)}$ | -0.0003 |

Fig. 28 Elevator related derivatives

| Horizontal Tail Lift Coefficient for Given Angle of Attack: Linear Range: Flight Condition 1 | | | | | | | |
|--|----------|-----------------------------|----------|---------------------|-------------------------|---------------------|-------------------------|
| Input Parameters | | | | | | | |
| α | 0.00 deg | $(d\delta_w/d\alpha)_{off}$ | 0.3931 | δ_w | 0.0 deg | $C_{m_{fus}}^{(0)}$ | 2.4149 rad ³ |
| δ_w | 0.8 deg | h | 0.0 deg | $C_{m_{fus}}^{(1)}$ | 5.7070 rad ³ | δ_w | -0.04 deg |
| | | | | $C_{m_{fus}}^{(2)}$ | 28.5 % | δ_w | 1.000 |
| | | | | $C_{m_{fus}}^{(3)}$ | 2.4149 rad ³ | δ_w | 1.000 |
| | | | | $C_{m_{fus}}^{(4)}$ | 0.4231 | δ_w | 1.000 |
| | | | | $C_{m_{fus}}^{(5)}$ | -0.0003 | δ_w | 1.000 |
| Output Parameters | | | | | | | |
| K_{δ} | 1.0000 | δ_w | 0.79 deg | $d\delta_w/d\alpha$ | -0.8 deg | $C_{m_{fus}}$ | -0.0798 |

Fig. 29 Horizontal tail lift coefficient

| Steady State Coefficients: Lift: Flight Condition 1 | | | | | | | | | | | | | | | |
|---|---------------|-------|--------------|---------|-------|-----------------|--------|-------|----------------------|---------|-------|----------------------|--------|------------------|--------|
| Input Parameters | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | V_{crust} | 37689.0 | b | S_w | 837.00 | sq | δ_{c_1} | -3.0 | deg | z_{c_1} | 2.00 | ft | |
| δT | 0.0 | deg F | η | 1.00 | o | γ | 0.0 | deg | AR_w | 8.00 | | δ_{c_2} | 0.0 | deg | |
| U_1 | 350.00 | kts | α | 0.00 | deg | δ_{c_3} | -1.0 | deg | Y_{cruise} | 0.00 | ft | X_{cruise} | 23.00 | ft | |
| | | | | | | | | | $C_{D_{0_{cruise}}}$ | | | $C_{D_{0_{cruise}}}$ | 4.5851 | rad ² | |
| Output Parameters | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $SHIP_{tot}$ | 3109 | hp | $DC_{L_{prop}}$ | | | $\delta_{c_{11}}$ | 7.0 | deg | C_{L_1} | 0.1076 | | |
| δ_1 | 155.41 | deg | DP_{tot} | 2492 | hp | CT_{tot} | 2320 | b | $C_{T_{c_1}}$ | -0.0022 | | | | | |
| Propeller Table | | | | | | | | | | | | | | | |
| # | Type | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Output | Output |
| 1 | Propeller: On | 22.00 | 9.01 | 4.00 | 9.25 | 7.0 | | 5 | | | | | 1555 | 0.850 | 5.7 |
| 2 | Propeller: On | 22.00 | 9.01 | 4.00 | 9.25 | 7.0 | | 5 | | | | | 0 | 0.850 | 5.7 |

Fig. 30 Steady state lift coefficients

| Angle of Attack Related Derivatives: Lift: Flight Condition 1 | | | | | | | | | | | | | | |
|---|---------------------|------------------|------------------|-------------------|------------------|-------------------|--------|------------------|---------------------|--------|------------------|-----------------------|--------|------------------|
| Input Parameters | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | δ_{c_1} | 0.93 | | δ_{c_2} | -1.0 | deg | z_{c_1} | 2.00 | ft | X_{cruise} | 60.00 | ft |
| δT | 0.0 | deg F | X_{cruise} | 23.00 | ft | S_w | 190.00 | sq | Y_{cruise} | 0.00 | ft | η_{prop} | 1.0000 | |
| U_1 | 350.00 | kts | AR_w | 8.00 | | Y_{cruise} | 0.00 | ft | AR_c | 7.00 | | $DC_{L_{cruise}}$ | 12.0 | % |
| $C_{D_{0_{cruise}}}$ | 6.3598 | rad ² | δ_{c_3} | 0.60 | | $DC_{L_{cruise}}$ | 12.00 | % | δ_{c_4} | 1.00 | | $DC_{D_{0_{cruise}}}$ | 6.2504 | rad ² |
| $C_{D_{0_{cruise}}}$ | 6.3598 | rad ² | δ_{c_4} | 0.0 | deg | $DC_{L_{cruise}}$ | 12.00 | % | δ_{c_5} | 0.0 | deg | z_{c_2} | 6.00 | ft |
| | | | | | | | | | δ_{c_6} | 1.00 | | δ_{c_7} | 1.00 | |
| Output Parameters | | | | | | | | | | | | | | |
| M_1 | 0.594 | | δ_{c_8} | 7.9041 | rad ² | $C_{D_{prop}}$ | 5.3724 | rad ² | $C_{D_{cruise}}$ | 7.7681 | rad ² | $\delta_{D_{prop}}$ | 0.3931 | |
| δ_1 | 155.41 | deg | $C_{D_{cruise}}$ | 5.3706 | rad ² | K_w | 1.0003 | | z_{c_2} | 6.00 | ft | $C_{D_{cruise}}$ | 5.7070 | rad ² |
| $C_{D_{cruise}}$ | 7.9041 | rad ² | $C_{D_{prop}}$ | 5.3724 | rad ² | $C_{D_{cruise}}$ | 7.7681 | rad ² | $\delta_{D_{prop}}$ | 0.3931 | | $C_{D_{cruise}}$ | 0.7862 | rad ² |
| $C_{D_{cruise}}$ | 7.9041 | rad ² | $C_{D_{prop}}$ | 5.3706 | rad ² | $C_{D_{cruise}}$ | 7.7681 | rad ² | $\delta_{D_{prop}}$ | 0.3931 | | $C_{D_{cruise}}$ | 5.3724 | rad ² |
| | | | | | | | | | $C_{D_{cruise}}$ | | | $C_{D_{cruise}}$ | 6.1586 | rad ² |
| High Lift Devices Table | | | | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | $q/C_{L_{max}}$ % | δ deg | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | |

Fig. 31 Angle of attack related derivatives

| Airplane Aerodynamic Center: Flight Condition 1 | | | | | | | | | | | | | | |
|---|--------|-------|----------------|-------|-----|----------------|--------|------------------|---------------------|--------|------------------|----------------|---------|----|
| Input Parameters | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | AR_w | 8.00 | | X_{cruise} | 23.00 | ft | X_{cruise} | 61.30 | ft | S_w | 190.00 | sq |
| δT | 0.0 | deg F | δ_{c_1} | 0.60 | | X_{cruise} | 26.20 | ft | $C_{D_{cruise}}$ | 5.7070 | rad ² | X_{cruise} | 60.00 | ft |
| U_1 | 350.00 | kts | δ_{c_2} | 0.0 | deg | $C_{D_{prop}}$ | 5.3724 | rad ² | $\delta_{D_{prop}}$ | 0.3931 | | δ_{c_3} | -0.0451 | |
| S_w | 837.00 | sq | δ_{c_3} | -1.0 | deg | $C_{D_{prop}}$ | 6.1586 | rad ² | δ_{c_4} | 1.0000 | | X_{cruise} | 24.80 | ft |
| | | | | | | | | | δ_{c_5} | | | X_{cruise} | | ft |
| Output Parameters | | | | | | | | | | | | | | |
| M_1 | 0.594 | | X_{cruise} | 10.44 | ft | X_{cruise} | 0.2500 | | X_{cruise} | 0.2049 | | X_{cruise} | 25.73 | ft |
| δ_1 | 155.41 | deg | X_{cruise} | 0.59 | ft | X_{cruise} | 0.2049 | | X_{cruise} | 25.73 | ft | X_{cruise} | 3.6121 | |
| | | | | | | | | | X_{cruise} | | | X_{cruise} | 0.6399 | |
| | | | | | | | | | X_{cruise} | | | X_{cruise} | 0.6399 | |
| | | | | | | | | | X_{cruise} | | | X_{cruise} | 38.27 | ft |

Fig. 32 Aircraft aerodynamic center

| Steady State Coefficients: Lift: Flight Condition 1 | | | | | | | | | | | | | | | | | | |
|---|--------------------------|--------------------|---------------|-----------------------|------------------------|-------------------|---------------------------|----------------|-----------------------|-----------------------|-------------------------|-----------------------|---------------|--------------|----------------|--------------|-------------------|----------------|
| Input Parameters | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 ft | W_{gross} | 37689.0 lb | S_w | 837.00 ft ² | δ_{tw} | -3.0 deg | λ_w | 0.60 | Z_{prop} | 2.00 ft | | | | | | | |
| ΔT | 0.0 deg F | η | 1.00 | γ | 0.0 deg | AR_w | 8.00 | λ_{tw} | 0.0 deg | $C_{D_{paras}}$ | 5.3706 rad ¹ | | | | | | | |
| U_1 | 350.00 kts | α | 0.00 deg | λ_w | -1.0 deg | Y_{gross} | 0.00 ft | X_{gross} | 23.00 ft | $C_{D_{Q_{gross}}}$ | 4.5851 rad ¹ | | | | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | ΣSHP_{set} | 3109 hp | $\Delta C_{D_{prop}}$ | | ϕ_{CT} | 7.0 deg | C_{T_1} | 0.1076 | | | | | | | | | |
| \dot{q}_1 | 155.41 $\frac{lb}{ft^2}$ | ΣP_{avail} | 2492 hp | ΣT_{avail} | 2320 lb | $C_{T_{X_1}}$ | 0.0022 | | | | | | | | | | | |
| Propeller Table | | | | | | | | | | | | | | | | | | |
| # | Type | X_{prop} ft | Y_{prop} ft | Z_{prop} ft | D_{prop} ft | ψ_{prop} deg | $\beta_{0.75_{prop}}$ deg | N_{blades_p} | $(W/R)_{0.3R_{prop}}$ | $(W/R)_{0.5R_{prop}}$ | $(W/R)_{0.9R_{prop}}$ | $\phi_{SHP_{set}}$ hp | η_{prop} | K_{loss} % | P_{avail} hp | $T_{c/prop}$ | d_{tip}/d_{hub} | $C_{N_{prop}}$ |
| 1 | Propeller: On | 22.00 | 9.01 | 4.00 | 9.25 | 7.0 | | 5 | | | | 1555 | 0.850 | 5.7 | 1246 | 0.0089 | 0.0000 | 0.0000 |
| 2 | Propeller: On | 22.00 | 9.01 | 4.00 | 9.25 | 7.0 | | 5 | | | | 0 | 0.850 | 5.7 | 0 | 0.0000 | 0.0000 | 0.0000 |

Fig. 33 Steady state lift coefficient

| Steady State Coefficients: Drag: Flight Condition 1 | | | | | | | | | | | |
|---|--------|------------|------|---------------|--|---------------|--|---------------|--|---------------|--|
| Input Parameters | | | | | | | | | | | |
| C_{D_1} | 0.1076 | C_{D_2} | | $B_{C_{D_2}}$ | | $B_{C_{D_3}}$ | | $B_{C_{D_4}}$ | | $B_{C_{D_5}}$ | |
| Output Parameters | | | | | | | | | | | |
| C_{D_1} | 0.0177 | ΔD | 6.08 | | | | | | | | |

Fig. 34 Steady state flight coefficients

| Class I Current Flight Condition Drag Polar: Flight Condition 1 | | | | | | | | | | | |
|---|-------------------------|-----------------|-----------------------|--------------|---------|--------------|---------|------------------|--------|-----------------|--------|
| Input Parameters | | | | | | | | | | | |
| W_{TO} | 37689.0 lb | AR_w | 8.00 | a | -2.3010 | c | -0.0866 | ΔC_{D_0} | 0.0005 | $C_{D_{paras}}$ | 3.0000 |
| S_w | 837.00 ft ² | λ_w | 0.60 | b | 1.0000 | d | 0.8099 | $C_{D_{paras}}$ | 0.0000 | | |
| Output Parameters | | | | | | | | | | | |
| e | 0.8560 | f | 20.83 ft ² | $C_{D_{in}}$ | 0.0254 | $B_{D_{CP}}$ | 0.0465 | $C_{D_{paras}}$ | 0.0000 | | |
| S_{wet} | 4165.58 ft ² | $C_{D_{paras}}$ | 0.0249 | A_{CP} | 0.0000 | $C_{D_{in}}$ | 0.0254 | | | | |

Fig. 35 Steady state drag polar calculations

| Steady State Coefficient due to Thrust in X-direction: Flight Condition 1 | | | | | | | | | | |
|---|--------------------------|--------------------|---------------|--------------------|-------------------|---------------|----------------|----------------|------------------------|---------------|
| Input Parameters | | | | | | | | | | |
| Altitude | 30000 ft | ΔT | 0.0 deg F | U_1 | 350.00 kts | α | 0.00 deg | S_w | 837.00 ft ² | |
| Output Parameters | | | | | | | | | | |
| M_1 | 0.594 | $\phi_{T_{prop}}$ | 7.0 deg | ΣP_{avail} | 2492 hp | ϕ_{CT} | 7.0 deg | | | |
| \dot{q}_1 | 155.41 $\frac{lb}{ft^2}$ | ΣSHP_{set} | 3109 hp | ΣT_{avail} | 2320 lb | $C_{T_{X_1}}$ | 0.0177 | | | |
| Propeller Table | | | | | | | | | | |
| # | Type | SHP_{set} hp | η_{prop} | i_{prop} deg | ψ_{prop} deg | K_{loss} % | P_{avail} hp | T_{avail} lb | $T_{c/prop}$ | $C_{T_{X_1}}$ |
| 1 | Propeller: On | 1555 | 0.850 | 7.0 | 0.0 | 5.7 | 1246 | 1160 | 0.0089 | 0.0089 |
| 2 | Propeller: On | 0 | 0.850 | 7.0 | 0.0 | 5.7 | 0 | 0 | 0.0000 | 0.0089 |

Fig. 36 Steady state thrust

| Steady State Pitching Moment Coefficient due to Thrust: Flight Condition 1 | | | | | | | | | | | | | | | | | | |
|--|---------------|-----------------|------------------|---------------|----------------|---|----------------------------------|---|-----------------|------------|----------------|---------------------|-----------------------|--------------|----------|--------------|---------------|--------------|
| Input Parameters | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | U_1 | 350.00 | fts | Z_{prop} | 2.95 | ft | AR_{prop} | 0.00 | α | 0.00 | deg | α_w | -1.0 | deg | | |
| ΔT | 0.0 | deg F | X_{cp} | 24.32 | ft | S_w | 837.00 | ft ² | L_w | 0.60 | α_{tw} | -3.0 | deg | | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | E_w | 10.44 | ft | P_{prop} | 2492 | hp | $\frac{\partial C_{m_{prop}}}{\partial \alpha}$ | -0.0013 | d_{T1} | 0.76 | ft | θ_{T1} | 7.0 | deg | $C_{m_{T1}}$ | -0.0013 | |
| \bar{g}_1 | 155.41 | $\frac{g}{g_0}$ | $P_{SHP_{prop}}$ | 3109 | hp | $\frac{\partial C_{m_{SHP_{prop}}}}{\partial \alpha}$ | 0.0000 | ET_{prop} | 2320 | lb | d_{N1} | 2.43 | ft | $C_{m_{N1}}$ | 0.0000 | | | |
| Propeller Table | | | | | | | | | | | | | | | | | | |
| # | Type | X_{prop} ft | Z_{prop} ft | D_{prop} ft | i_{prop} deg | β_{prop} deg | $C_{N_{prop}}$ rad ⁻¹ | Inflow | d_{T1}/d_{N1} | SHP set hp | β_{prop} | $C_{D_{prop_{wm}}}$ | $C_{D_{prop_{stop}}}$ | K_{loss} % | d_T ft | d_N ft | P_{eval} hp | T_{cdprop} |
| 1 | Propeller: On | 22.00 | 4.00 | 3.25 | 7.0 | 0.0 | 0.0000 | 1.0402 | 0.0000 | 1555 | 0.850 | 0.0000 | 0.0000 | 5.7 | 0.76 | 2.43 | 1246 | 0.0089 |
| 2 | Propeller: On | 22.00 | 4.00 | 3.25 | 7.0 | 0.0 | 0.0000 | 1.0402 | 0.0000 | 0 | 0.850 | 0.0000 | 0.0000 | 5.7 | 0.76 | 2.43 | 0 | 0.0000 |

Fig. 37 Steady state pitching moment

State Coefficients: Pitching Moment: Flight Condition 1

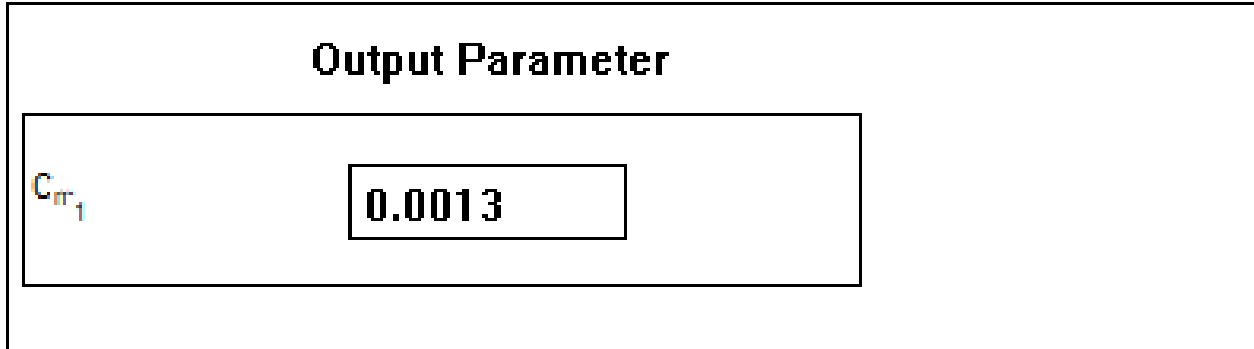


Fig. 38 Steady state pitching moment

| Speed Related Derivatives: Drag: Flight Condition 1 | | | | | | | | | | |
|---|-------|------------------|------------|-----|-------|-------|--------|-----|---|-------|
| Input Parameters | | | | | | | | | | |
| Altitude | 30000 | ft | ΔT | 0.0 | deg F | U_1 | 350.00 | fts | $\frac{\partial C_{D1}}{\partial \alpha}$ | 0.000 |
| Output Parameters | | | | | | | | | | |
| M_1 | 0.594 | $C_{D_{\alpha}}$ | 0.0000 | | | | | | | |

Fig. 39 Speed related derivatives

| Speed Related Derivatives: Lift: Flight Condition 1 | | | | | | | | | | | | | |
|---|-------|-------------|------------|-----------------|------------------|--------|--------|-----|----------|--------|-------------------|-----|-----|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 | ft | ΔT | 0.0 | deg F | U_1 | 350.00 | fts | C_{L1} | 0.1076 | Λ_{out_w} | 0.0 | deg |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | \bar{g}_1 | 155.41 | $\frac{g}{g_0}$ | $C_{L_{\alpha}}$ | 0.0586 | | | | | | | |

Fig. 40 Speed related derivatives

| Speed Related Derivatives: Pitching Moment: Flight Condition 1 | | | | | | | | | | | | | |
|--|--------------------------|------------------------------|--------------------------|------------------------------|--------------|------------------------------|--------------------------|------------------------------|--------------------------|------------------------------|-------------------------------------|------------------------------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | $C_{m_{\dot{\alpha}}}$ | 6.3598 rad ⁻¹ | Λ_{tip} | 0.0 deg | $\beta(C)_{\text{tip}}$ | 12.00 % | $X_{\text{cm}_{\text{tip}}}$ | 60.00 ft | τ_{tip} | 0.0 deg | ξ_{tip} | 1.00 |
| αT | 0.0 deg F | ξ_{tip} | 0.93 | $X_{\text{cm}_{\text{tip}}}$ | 23.00 ft | S_{tip} | 190.00 in ² | $Y_{\text{cm}_{\text{tip}}}$ | 0.00 ft | η_{tip} | 1.000 | W_{tip} | 2.00 ft |
| U_1 | 350.00 ft/s | S_{tip} | 837.00 in ² | $Y_{\text{cm}_{\text{tip}}}$ | 0.00 ft | AR_{tip} | 7.00 | $\beta(C)_{\text{tip}}$ | 12.0 % | η_{tip} | 1.000 | $D_{\text{cm}_{\text{tip}}}$ | 6.83 ft |
| C_{L_1} | 0.1976 | AR_{tip} | 8.00 | $Z_{\text{cm}_{\text{tip}}}$ | 2.00 ft | ξ_{tip} | 1.00 | $\beta(C)_{\text{tip}}$ | 12.0 % | $C_{m_{\dot{\alpha}}}$ | 6.2504 rad ⁻¹ | $\dot{C}_{m_{\dot{\alpha}}}$ | -0.0451 |
| $C_{m_{\dot{\alpha}}}$ | 6.3598 rad ⁻¹ | ξ_{tip} | 0.60 | $\beta(C)_{\text{tip}}$ | 12.00 % | Λ_{tip} | 0.0 deg | $Z_{\text{cm}_{\text{tip}}}$ | 6.00 ft | $C_{m_{\dot{\alpha}}}$ | 6.2504 rad ⁻¹ | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | $C_{m_{\dot{\omega}}}$ | 5.2621 rad ⁻¹ | $\dot{C}_{m_{\dot{\omega}}}$ | -0.1666 | $\dot{C}_{m_{\dot{\omega}}}$ | 7.7681 rad ⁻¹ | $C_{m_{\dot{\omega}}}$ | 5.7070 rad ⁻¹ | $\dot{C}_{m_{\dot{\omega}}}$ | 0.6399 | | |
| $C_{m_{\dot{\omega}}}$ | 7.9041 rad ⁻¹ | $C_{m_{\dot{\omega}}}$ | 5.3706 rad ⁻¹ | $X_{\text{cm}_{\text{tip}}}$ | 26.20 ft | $C_{m_{\dot{\omega}}}$ | 7.7681 rad ⁻¹ | $C_{m_{\dot{\omega}}}$ | 0.7862 rad ⁻¹ | $\dot{C}_{m_{\dot{\omega}}}$ | 155.41 $\frac{\text{ft}}{\text{s}}$ | | |
| $C_{m_{\dot{\omega}}}$ | 7.9041 rad ⁻¹ | $C_{m_{\dot{\omega}}}$ | 5.3724 rad ⁻¹ | $Z_{\text{cm}_{\text{tip}}}$ | 0.2500 | $C_{m_{\dot{\omega}}}$ | 7.7681 rad ⁻¹ | $X_{\text{cm}_{\text{tip}}}$ | 61.30 ft | $C_{m_{\dot{\omega}}}$ | 10.44 ft | | |
| $C_{m_{\dot{\omega}}}$ | 7.9041 rad ⁻¹ | $X_{\text{cm}_{\text{tip}}}$ | 0.59 ft | $Z_{\text{cm}_{\text{tip}}}$ | 0.2049 | $C_{m_{\dot{\omega}}}$ | 5.3897 rad ⁻¹ | $\dot{C}_{m_{\dot{\omega}}}$ | 3.6121 | $C_{m_{\dot{\omega}}}$ | 0.0106 | | |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_j % | τ_j % | q/C_{L_j} % | τ_j deg | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | |

Fig. 41 Speed related derivatives

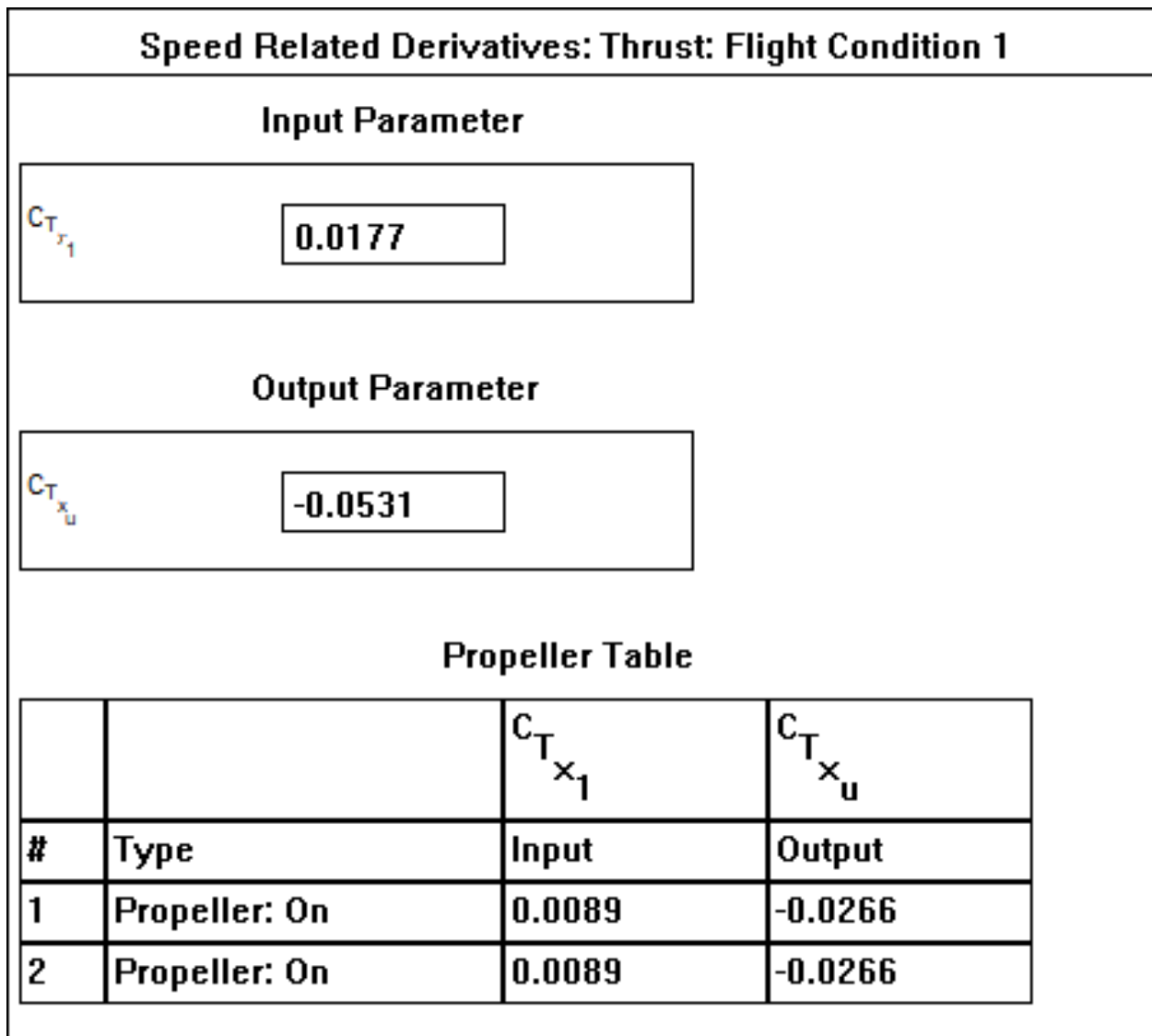


Fig. 42 Speed related derivatives

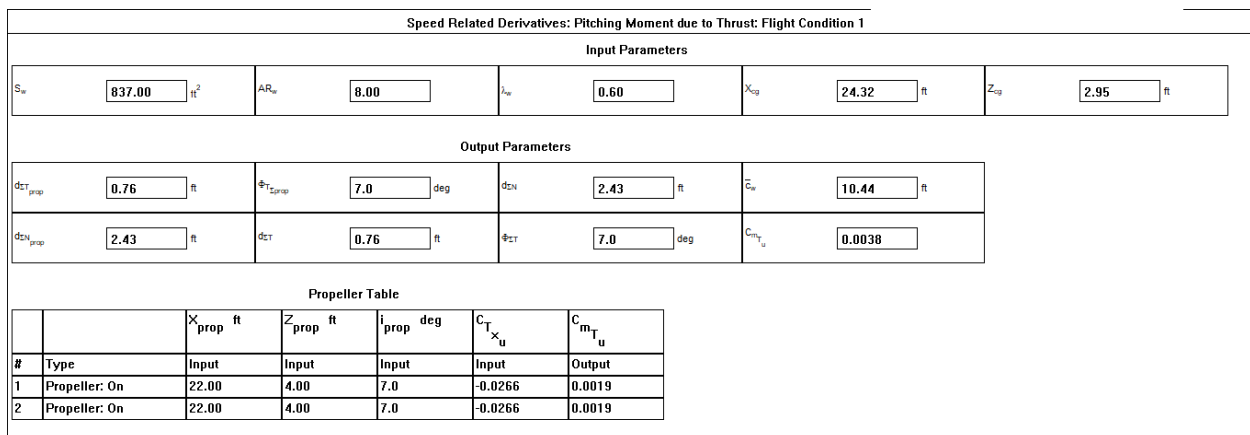


Fig. 43 Speed related derivatives

| Angle of Attack Related Derivatives: Drag: Flight Condition 1 | | | | | |
|---|--------------------------|--------------|----------|------------------|--------------------------|
| Input Parameters | | | | | |
| Altitude | 30000 ft | M_1 | 0.594 | \bar{C}_{D_0} | 0.0254 |
| B_{DP} | 0.0465 | $C_{D_{DP}}$ | 0.1698 | $C_{D_{DP,off}}$ | 6.1586 rad ⁻¹ |
| ΔT | 0.0 deg F | α | 0.00 deg | A_{DP} | 0.0000 |
| Output Parameter | | | | | |
| $C_{D_{\alpha}}$ | 0.0972 rad ⁻¹ | | | | |

Fig. 44 Angle of attack related derivatives

| Angle of Attack Related Derivatives: Lift: Flight Condition 1 | | | | | | | | | | | | | |
|---|--------------------------|----------------------|--------------------------|------------------|--------------------------|---------------------|--------------------------|---------------------------|--------------------------|-----------------------|--------------------------|------------------|--------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | t_{max} | 0.93 | t_w | -1.0 deg | $Z_{c/w}$ | 2.00 ft | X_{cm} | 50.00 ft | Γ_s | 0.0 deg | W_{ts} | 2.00 ft |
| ΔT | 0.0 deg F | S_w | 837.00 ft ² | $X_{cm,w}$ | 23.00 ft | S_w | 190.00 ft ² | $Y_{cm,w}$ | 0.00 ft | η_{flap} | 1.000 | $D_{cm,w}$ | 6.83 ft |
| U_1 | 350.00 kts | AR_w | 8.00 | $Y_{cm,w}$ | 0.00 ft | AR_w | 7.00 | $(\beta C_L)_w$ | 12.0 % | $C_{D_{w,off=0}}$ | 6.2504 rad ⁻¹ | | |
| $C_{D_{w,off=0}}$ | 6.3598 rad ⁻¹ | t_w | 0.50 | $(\beta C_L)_w$ | 12.00 % | L_w | 1.00 | $(\beta C_L)_w$ | 12.0 % | $C_{D_{w,off=0}}$ | 6.2504 rad ⁻¹ | | |
| $C_{D_{w,off=0}}$ | 6.3598 rad ⁻¹ | $\Delta t_{c/w}$ | 0.0 deg | $(\beta C_L)_w$ | 12.00 % | $\Delta t_{c/w}$ | 0.0 deg | $Z_{c/w}$ | 6.00 ft | t_{flap} | 1.00 | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $C_{D_{w,off}}$ | 5.3724 rad ⁻¹ | E_{cm} | 7.7681 rad ⁻¹ | $dU/d\alpha$ | 0.3931 | $C_{D_{w,off,mean}}$ | 5.3724 rad ⁻¹ | $C_{D_{\alpha}}$ | 6.1586 rad ⁻¹ |
| \bar{c}_i | 155.41 ft ² | $C_{D_{w,off,mean}}$ | 5.3706 rad ⁻¹ | K_{flap} | 1.0003 | Z_{cm} | 6.00 ft | $C_{D_{\alpha}}$ | 5.7070 rad ⁻¹ | $C_{D_{w,off,DP}}$ | 6.1586 rad ⁻¹ | | |
| $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $C_{D_{w,off,mean}}$ | 5.3724 rad ⁻¹ | $C_{D_{\alpha}}$ | 7.7681 rad ⁻¹ | $dU/d\alpha_{mean}$ | 0.3931 | $C_{D_{\alpha}}$ | 0.7862 rad ⁻¹ | $C_{D_{w,off}}$ | 6.1586 rad ⁻¹ | | |
| $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $C_{D_{\alpha}}$ | 5.3706 rad ⁻¹ | $C_{D_{\alpha}}$ | 7.7681 rad ⁻¹ | $(dU/d\alpha)_{DP}$ | 0.3931 | $C_{D_{\alpha,emp,mean}}$ | 5.3724 rad ⁻¹ | $C_{D_{\alpha,mean}}$ | 6.1586 rad ⁻¹ | | |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | c/c_w % | δ deg | | | | | | | | |
| 1 | Single Slotted Flap | 8.0 | 55.5 | 30.0 | 0.0 | | | | | | | | |

Fig. 45 Angle of attack related derivatives

| Angle of Attack Related Derivatives: Pitching Moment: Flight Condition 1 | | | | | | | | | | | | | |
|--|--------------------------|----------------------|--------------------------|-----------------|--------------------------|------------------|--------------------------|---------------------|--------------------------|-------------------|--------------------------|-------------------|---------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | t_{max} | 0.93 | $X_{cm,w}$ | 23.00 ft | S_w | 190.00 ft ² | $Y_{cm,w}$ | 0.00 ft | η_{flap} | 1.000 | $D_{cm,w}$ | 6.83 ft |
| ΔT | 0.0 deg F | S_w | 837.00 ft ² | $Y_{cm,w}$ | 0.00 ft | AR_w | 7.00 | $(\beta C_L)_w$ | 12.0 % | $C_{D_{w,off=0}}$ | 6.2504 rad ⁻¹ | $\bar{c}k_{flap}$ | -0.0451 |
| U_1 | 350.00 kts | AR_w | 8.00 | $(\beta C_L)_w$ | 12.00 % | L_w | 1.00 | $(\beta C_L)_w$ | 12.0 % | $C_{D_{w,off=0}}$ | 6.2504 rad ⁻¹ | X_{flap} | 24.32 ft |
| $C_{D_{w,off=0}}$ | 6.3598 rad ⁻¹ | t_w | 0.50 | $(\beta C_L)_w$ | 12.00 % | $\Delta t_{c/w}$ | 0.0 deg | $Z_{c/w}$ | 6.00 ft | t_{flap} | 1.00 | | |
| $C_{D_{w,off=0}}$ | 6.3598 rad ⁻¹ | $\Delta t_{c/w}$ | 0.0 deg | $Z_{c/w}$ | 2.00 ft | X_{cm} | 50.00 ft | Γ_s | 0.0 deg | W_{ts} | 2.00 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $C_{D_{w,off}}$ | 5.3706 rad ⁻¹ | $K_{flap,DP}$ | 0.2049 | K_{flap} | 3.6121 | $dU/d\alpha$ | 0.3931 | SM | 56.96 % |
| \bar{c}_i | 155.41 ft ² | $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $C_{D_{w,off}}$ | 5.3724 rad ⁻¹ | E_{cm} | 7.7681 rad ⁻¹ | $C_{D_{\alpha}}$ | 5.7070 rad ⁻¹ | \bar{V}_1 | 0.8040 | $C_{D_{w,off}}$ | 6.1586 rad ⁻¹ |
| \bar{c}_{flap} | 0.0702 | $C_{D_{\alpha}}$ | 7.9041 rad ⁻¹ | $X_{cm,DP}$ | 26.20 ft | E_{cm} | 7.7681 rad ⁻¹ | $C_{D_{\alpha}}$ | 0.7862 rad ⁻¹ | X_{flap} | 30.27 ft | $C_{D_{\alpha}}$ | 6.1586 rad ⁻¹ |
| E_L | 10.44 ft | $C_{D_{w,off,mean}}$ | 5.3706 rad ⁻¹ | X_{cm} | 0.2500 | $C_{D_{\alpha}}$ | 7.7681 rad ⁻¹ | $Z_{c/w}$ | 6.00 ft | $\bar{c}k_{flap}$ | 0.6399 | $C_{D_{w,off}}$ | -3.5082 rad ⁻¹ |
| K_{flap} | 0.59 | $C_{D_{w,off,mean}}$ | 5.3724 rad ⁻¹ | $K_{flap,DP}$ | 25.73 ft | X_{cm} | 61.30 ft | $(dU/d\alpha)_{DP}$ | 0.3931 | $\bar{c}k_{flap}$ | 0.6399 | $C_{D_{\alpha}}$ | -3.5082 rad ⁻¹ |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | c/c_w % | δ deg | | | | | | | | |
| 1 | Single Slotted Flap | 8.0 | 55.5 | 30.0 | 0.0 | | | | | | | | |

Fig. 46 Angle of attack related derivatives

| Angle of Attack Related Derivatives: Pitching Moment due to Thrust: Flight Condition 1 | | | | | | | | | | | | | | | | | | | |
|--|---------------|---------------|---------------|---------------|----------------|---|----------------------------------|---|--|------------------|--|-------------------|-----------------|---------------|-------|----|-----------|--------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | U_1 | 350.00 | fts | C_{L_1} | 0.1076 | Z_{TP} | 2.95 | ft | S_w | 837.00 | ft ² | $X_{CG_{TP}}$ | 23.00 | ft | C_{L_2} | 6.1586 | rad ⁻¹ |
| αT | 0.0 | deg F | W_{gross} | 37689.0 | lb | X_{CG} | 24.32 | ft | $X_{CG_{TP}}$ | 26.20 | ft | AR_w | 8.00 | $Z_{CG_{TP}}$ | 2.00 | ft | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | |
| E_1 | 10.44 | ft | E_2 | 155.41 | ft | EP_{max} | 2492 | hp | $(\partial C_{L_1} / \partial \alpha)_T$ | -0.0041 | $(\partial C_{L_2} / \partial \alpha)_T$ | -0.0041 | | | | | | | |
| M_1 | 0.594 | | $MSHP_{max}$ | 3109 | hp | $(\partial C_{L_1} / \partial \alpha)_{prop}$ | 0.0000 | $(\partial C_{L_2} / \partial \alpha)_{prop}$ | 0.0000 | $C_{L_{\alpha}}$ | -0.0251 | rad ⁻¹ | | | | | | | |
| Propeller Table | | | | | | | | | | | | | | | | | | | |
| # | Type | X_{prop} ft | Z_{prop} ft | D_{prop} ft | i_{prop} deg | β_{prop} deg | $C_{N_{prop}}$ rad ⁻¹ | Inflow | d_t/d^n | SHP set hp | η_{prop} | K_{loss} % | P_{avail} hp | | | | | | |
| 1 | Propeller: On | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Output | | | | | | |
| 2 | Propeller: On | 22.00 | 4.00 | 3.25 | 7.0 | 0.0 | 0.0000 | 1.0402 | 0.0000 | 1555 | 0.850 | 5.7 | 1246 | | | | | | |
| | | 22.00 | 4.00 | 3.25 | 7.0 | 0.0 | 0.0000 | 1.0402 | 0.0000 | 0 | 0.850 | 5.7 | 0 | | | | | | |

Fig. 47 Angle of attack related derivatives

| Rate of Angle of Attack Related Derivatives: Drag: Flight Condition 1 | |
|---|--------------------------|
| Output Parameter | |
| $C_{D_{\alpha}}$ | 0.0000 rad ⁻¹ |

Fig. 48 Angle of attack rate related derivatives

| Rate of Angle of Attack Related Derivatives: Lift: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | | |
|---|---------------------|-------------------|-----------------------|-----------|-------------------|------------------------------------|--------|-------------------|-----------------------|--------|-------------------|------------------------------|--------|-------------------|------------------------------|--------|-------------------|----------|-------|----|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | t_{max} | 0.93 | | X_{trim} | 23.00 | ft | S_w | 190.00 | ft ² | Y_{trim} | 0.00 | ft | η_1 | 1.000 | | X_{cg} | 24.32 | ft | |
| δT | 0.0 | deg F | S_w | 837.00 | ft ² | Y_{trim} | 0.00 | ft | AR_w | 7.00 | | $(PCL)_w$ | 12.0 | % | $C_{L_{\alpha, \delta T=0}}$ | 6.2504 | rad ⁻¹ | | | | |
| U_1 | 350.00 | ft/s | AR_w | 8.00 | | $(PCL)_w$ | 12.00 | % | L_w | 1.00 | | $(PCL)_w$ | 12.0 | % | $C_{L_{\alpha, \delta T=0}}$ | 6.2504 | rad ⁻¹ | | | | |
| $C_{L_{\alpha, \delta T=0}}$ | 6.3598 | rad ⁻¹ | L_w | 0.60 | | $(PCL)_w$ | 12.00 | % | $\Delta_{L_{\alpha}}$ | 0.0 | deg | $Z_{L_{\alpha}}$ | 6.00 | ft | t_{trim} | 1.00 | | | | | |
| $C_{L_{\alpha, \delta T=0}}$ | 6.3598 | rad ⁻¹ | $\Delta_{L_{\alpha}}$ | 0.0 | deg | $Z_{L_{\alpha}}$ | 2.00 | ft | X_{trim} | 60.00 | ft | Γ_1 | 0.0 | deg | W_1 | 2.00 | ft | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | C_L | 10.44 | | $C_{L_{\alpha, \delta T=0, trim}}$ | 4.5851 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | \bar{z}_{cg} | 3.6121 | | $\delta U_{\delta T}$ | 0.3931 | | | | | |
| X_{cg} | 26.20 | ft | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{D_{trim}}$ | 5.3706 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | Z_{cg} | 6.00 | ft | \bar{U}_1 | 0.8040 | | | | | |
| \bar{z}_{cg} | 0.2500 | | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{L_{\alpha, \delta T=0}}$ | 4.5851 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | $C_{D_{trim}}$ | 5.7070 | rad ⁻¹ | $C_{D_{\alpha}}$ | 3.6077 | rad ⁻¹ | | | | |
| \bar{z}_{cg} | 0.0702 | | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{D_{trim}}$ | 5.3706 | rad ⁻¹ | X_{trim} | 61.30 | ft | $(\delta U_{\delta T})_{up}$ | 0.3931 | | $C_{D_{\alpha}}$ | 3.6077 | rad ⁻¹ | | | | |
| High Lift Devices Table | | | | | | | | | | | | | | | | | | | | | |
| # | High Lift Device | δ_i % | δ_o % | q/C_w % | δ deg | | | | | | | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | | | | | | | | |

Fig. 49 Angle of attack rate related derivatives

| Rate of Angle of Attack Related Derivatives: Pitching Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | | |
|--|---------------------|-------------------|-----------------------|-----------|-------------------|------------------------------------|--------|-------------------|-----------------------|--------|-------------------|------------------------------|--------|-------------------|------------------------------|----------|-------------------|----------|-------|----|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | t_{max} | 0.93 | | X_{trim} | 23.00 | ft | S_w | 190.00 | ft ² | Y_{trim} | 0.00 | ft | η_1 | 1.000 | | X_{cg} | 24.32 | ft | |
| δT | 0.0 | deg F | S_w | 837.00 | ft ² | Y_{trim} | 0.00 | ft | AR_w | 7.00 | | $(PCL)_w$ | 12.0 | % | $C_{L_{\alpha, \delta T=0}}$ | 6.2504 | rad ⁻¹ | | | | |
| U_1 | 350.00 | ft/s | AR_w | 8.00 | | $(PCL)_w$ | 12.00 | % | L_w | 1.00 | | $(PCL)_w$ | 12.0 | % | $C_{L_{\alpha, \delta T=0}}$ | 6.2504 | rad ⁻¹ | | | | |
| $C_{L_{\alpha, \delta T=0}}$ | 6.3598 | rad ⁻¹ | L_w | 0.60 | | $(PCL)_w$ | 12.00 | % | $\Delta_{L_{\alpha}}$ | 0.0 | deg | $Z_{L_{\alpha}}$ | 6.00 | ft | t_{trim} | 1.00 | | | | | |
| $C_{L_{\alpha, \delta T=0}}$ | 6.3598 | rad ⁻¹ | $\Delta_{L_{\alpha}}$ | 0.0 | deg | $Z_{L_{\alpha}}$ | 2.00 | ft | X_{trim} | 60.00 | ft | Γ_1 | 0.0 | deg | W_1 | 2.00 | ft | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | C_L | 10.44 | | $C_{L_{\alpha, \delta T=0, trim}}$ | 4.5851 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | \bar{z}_{cg} | 3.6121 | | $\delta U_{\delta T}$ | 0.3931 | | | | | |
| X_{cg} | 26.20 | ft | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{D_{trim}}$ | 5.3706 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | Z_{cg} | 6.00 | ft | \bar{U}_1 | 0.8040 | | | | | |
| \bar{z}_{cg} | 0.2500 | | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{L_{\alpha, \delta T=0}}$ | 4.5851 | rad ⁻¹ | $C_{D_{trim}}$ | 7.7681 | rad ⁻¹ | $C_{D_{trim}}$ | 5.7070 | rad ⁻¹ | $C_{D_{\alpha}}$ | -12.7779 | rad ⁻¹ | | | | |
| \bar{z}_{cg} | 0.0702 | | $C_{D_{trim}}$ | 7.9041 | rad ⁻¹ | $C_{D_{trim}}$ | 5.3706 | rad ⁻¹ | X_{trim} | 61.30 | ft | $(\delta U_{\delta T})_{up}$ | 0.3931 | | $C_{D_{\alpha}}$ | -12.7779 | rad ⁻¹ | | | | |
| High Lift Devices Table | | | | | | | | | | | | | | | | | | | | | |
| # | High Lift Device | δ_i % | δ_o % | q/C_w % | δ deg | | | | | | | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | | | | | | | | |

Fig. 50 Angle of attack rate related derivatives

Pitch Rate Related Derivatives: Drag: Flight Condition 1

Output Parameter

C_{D_q}

0.0000

rad⁻¹

Fig. 51 Pitch rate related derivatives

| Pitch Rate Related Derivatives: Lift: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|---------------------|------------|-------------------------------|----------------|-----------------|--------------------------------------|--------|-------|------------------------------|--------|-----------------|------------------------------|---------|-------|-------------------------------|---------|-----------------|--------------------|-------|-----------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 0.0 | deg | S_w | 190.00 | ft ² | Y_{pitch} | 0.00 | ft | η_1 | 1.000 | X_{cm} | 0.00 | ft | |
| ΔT | 0.0 | deg F | ϵ_{pitch} | 0.93 | | X_{cm} | 23.00 | ft | AR_0 | 7.00 | | $(PCL)_0$ | 12.0 | % | $\dot{\alpha}_{\text{pitch}}$ | 6.2504 | rad/s | l | 55.00 | ft |
| U_1 | 350.00 | kts | S_w | 837.00 | ft ² | Y_{pitch} | 0.00 | ft | l_w | 1.00 | | $(PCL)_0$ | 12.0 | % | $\dot{\alpha}_{\text{pitch}}$ | 6.2504 | rad/s | D_{pitch} | 6.83 | ft |
| K_{α} | 24.32 | ft | AR_0 | 8.00 | | $(PCL)_0$ | 12.00 | % | $\dot{\alpha}_{\text{roll}}$ | 0.0 | deg | Z_{pitch} | 6.00 | ft | f_{pitch} | 1.00 | | W_{pitch} | 6.83 | ft |
| $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | l_w | 0.60 | | $(PCL)_0$ | 12.00 | % | X_{cm} | 60.00 | ft | Γ_1 | 0.0 | deg | W_{pitch} | 2.00 | ft | S_0 | 20.49 | ft ² |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | C_{pitch} | 5.2621 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 0.2500 | | $\dot{\alpha}_{\text{roll}}$ | 3.6121 | rad/s | C_{pitch} | 9.1769 | rad/s | | | |
| $\dot{\alpha}_{\text{roll}}$ | 0.0702 | | $\dot{\alpha}_{\text{pitch}}$ | 7.9041 | rad/s | $\alpha_0 - \alpha_1$ | 0.913 | | C_{pitch} | 7.7681 | rad/s | C_{pitch} | 5.7070 | rad/s | C_{pitch} | 4.6958 | rad/s | | | |
| $\dot{\alpha}_{\text{roll}}$ | 10.44 | ft | S_{pitch} | 751.13 | ft ² | C_{pitch} | 0.0447 | rad/s | C_{pitch} | 7.7681 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 0.8040 | | C_{pitch} | 0.2628 | rad/s | | | |
| $\dot{\alpha}_{\text{roll}}$ | 7.9041 | rad/s | S_{pitch} | 10.20 | ft | $K_{\text{pitch}} + K_{\text{roll}}$ | 1.18 | | C_{pitch} | 7.7681 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 5.21 | ft | C_{pitch} | 4.9586 | rad/s | | | |
| $\dot{\alpha}_{\text{roll}}$ | 7.9041 | rad/s | $\dot{\alpha}_{\text{pitch}}$ | 4.5851 | rad/s | X_{cm} | 26.20 | ft | X_{cm} | 61.30 | ft | C_{pitch} | 81.0235 | rad/s | C_{pitch} | 14.1354 | rad/s | | | |
| High Lift Devices Table | | | | | | | | | | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | c_l/c_{l0} % | δ deg | | | | | | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | | | | | | | |

Fig. 52 Pitch rate related derivatives

| Pitch Rate Related Derivatives: Pitching Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|---|--------|-------|-------------------------------|--------|-----------------|--------------------------------------|--------|-------|------------------------------|--------|-----------------|-------------------------------|--------|-------|-------------------------------|-----------|-------|--------------------|----------|-----------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | ϵ_{pitch} | 0.91 | | X_{cm} | 23.00 | ft | S_w | 190.00 | ft ² | $(PCL)_0$ | 12.0 | % | $\dot{\alpha}_{\text{pitch}}$ | 6.2504 | rad/s | X_T | | ft |
| ΔT | 0.0 | deg F | ϵ_{pitch} | 0.93 | | Y_{pitch} | 0.00 | ft | AR_0 | 7.00 | | $(PCL)_0$ | 12.0 | % | f_{pitch} | 1.00 | | S_0 | | ft ² |
| U_1 | 350.00 | kts | S_w | 837.00 | ft ² | $(PCL)_0$ | 12.00 | % | l_w | 1.00 | | Z_{pitch} | 6.00 | ft | W_{pitch} | 2.00 | ft | V_1 | | ft ³ |
| K_{α} | 24.32 | ft | AR_0 | 8.00 | | $(PCL)_0$ | 12.00 | % | $\dot{\alpha}_{\text{roll}}$ | 0.0 | deg | Γ_1 | 0.0 | deg | X_{cm} | 0.00 | ft | | | |
| $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | l_w | 0.60 | | W_{pitch} | 6.83 | ft | X_{cm} | 60.00 | ft | η_1 | 1.000 | | l | 55.00 | ft | | | |
| $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 0.0 | deg | C_{pitch} | 5.3724 | rad/s | Y_{pitch} | 0.00 | ft | $\dot{\alpha}_{\text{pitch}}$ | 6.2504 | rad/s | $\dot{\alpha}_{\text{roll}}$ | -0.0451 | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $\dot{\alpha}_{\text{pitch}}$ | 7.9041 | rad/s | S_{pitch} | 10.20 | ft | $\dot{\alpha}_{\text{roll}}$ | 0.2500 | | X_{cm} | 61.30 | ft | $\dot{\alpha}_{\text{roll}}$ | 5.21 | ft | C_{pitch} | | rad/s |
| $\dot{\alpha}_{\text{roll}}$ | 0.0702 | | $\dot{\alpha}_{\text{pitch}}$ | 6.3598 | rad/s | C_{pitch} | 0.2422 | rad/s | C_{pitch} | 7.7681 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 3.6121 | | C_{pitch} | -143.1950 | rad/s | C_{pitch} | | rad/s |
| $\dot{\alpha}_{\text{roll}}$ | 10.44 | ft | $\dot{\alpha}_{\text{pitch}}$ | 7.9041 | rad/s | $K_{\text{pitch}} + K_{\text{roll}}$ | 1.18 | | C_{pitch} | 7.7681 | rad/s | C_{pitch} | 5.7070 | rad/s | C_{pitch} | -32.5032 | rad/s | C_{pitch} | -32.5032 | rad/s |
| $\dot{\alpha}_{\text{roll}}$ | 7.9041 | rad/s | S_{pitch} | 751.13 | ft ² | X_{cm} | 26.20 | ft | C_{pitch} | 7.7681 | rad/s | $\dot{\alpha}_{\text{roll}}$ | 0.8040 | | C_{pitch} | -1.3600 | rad/s | | | |

Fig. 53 Pitch rate related derivatives

| Fuselage Geometry: Flight Condition 1 | | | | | | | | | | | | | | |
|---|----------------|----------------|------------------------|----------------|-----------------------|----------------|----------------|-------------------|-------------------|-----------------------|-------------------|-------------------|-----------------------------|--------------|
| Input Parameters | | | | | | | | | | | | | | |
| X_{fus_1} | 0.00 ft | Z_{fus_1} | 2.00 ft | X_{fus_2} | 23.00 ft | X_{fus_3} | 60.00 ft | X_{fus_4} | 60.00 ft | XZ_{fus} | 8 | | | |
| Y_{fus_1} | 0.00 ft | t | 0.00 deg | C_{sw} | 12.79 ft | E_{sw} | 5.21 ft | C_{sw} | 7.51 ft | X,Y,Z_{fus} | | | | |
| Output Parameters | | | | | | | | | | | | | | |
| l | 55.00 ft | S_{fus} | | X_{L1} | | X_{L2} | | D_{fus} | 2.50 ft | D_{L1} | 2.00 ft | | | |
| h_{fus} | 2.00 ft | S_{L1} | 383.07 ft ² | X_{L2} | 49.72 ft | D_{L2} | 6.78 ft | D_{fus} | 6.83 ft | Z_{L1} | 5.00 ft | | | |
| W_{fus} | 6.78 ft | S_{L2} | | S_{L2} | 20.49 ft ² | D_{L3} | 5.00 ft | Z_{L2} | 5.00 ft | D_{L4} | 2.00 ft | | | |
| S_{L1} | | S_{fus} | | V_1 | | Z_{L3} | 2.50 ft | D_{L5} | | Coordinates Undefined | | | | |
| Fuselage Table: double click for Cross-Section Dialog | | | | | | | | | | | | | | |
| Fuselage | X_{fus_1} ft | Y_{fus_1} ft | Z_{fus_1} ft | X_{fus_2} ft | Z_{fus_2} ft | Y_{fus_3} ft | Z_{fus_3} ft | $Y_{fus_{12}}$ ft | $Z_{fus_{12}}$ ft | $Y_{fus_{12}}$ ft | $Z_{fus_{23}}$ ft | $Z_{fus_{23}}$ ft | A_{fus_1} ft ² | S_{fus} ft |
| Section | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Input | Output | Output |
| 1 | 0.0000 | | | | | | | | | | | | 0.00 | |
| 2 | 4.5000 | | | | | | | | | | | | 19.60 | |
| 3 | 15.0000 | | | | | | | | | | | | 36.30 | |
| 4 | 47.0000 | | | | | | | | | | | | 36.30 | |
| 5 | 55.0000 | | | | | | | | | | | | 9.10 | |
| 6 | 60.0000 | | | | | | | | | | | | 3.14 | |
| 7 | 66.0000 | | | | | | | | | | | | 3.14 | |
| 8 | 66.1000 | | | | | | | | | | | | 0.00 | |

Fig. 54 Fuselage geometry

| Sideslip Related Derivatives: Sideslope: Flight Condition 1 | | | | | | | | | | | | | |
|---|------------------------|---------------------|--------------------------|---------------|---------------------------|---------------------|---------------------------|-----------------|---------------------------|-----------|----------|-----------|-----------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | $\lambda_{L_{fus}}$ | 0.0 deg | F_w | 5.0 deg | S_w | 137.00 ft ² | $C_{L_{fus_0}}$ | 6.2800 rad ⁻¹ | X_{fus} | 60.00 ft | D_{fus} | 2.00 ft |
| ΔT | 0.0 deg F | Z_{fus} | 2.50 ft | S_w | 190.00 ft ² | AR_L | 3.00 | f_{fus} | 1.00 | Z_{fus} | 15.00 ft | S_w | 20.49 ft ² |
| U_1 | 350.00 kts | Z_{fus} | 2.00 ft | X_{fus} | 61.30 ft | L | 0.80 | $(DCL)_{fus}$ | 12.0 % | D_{fus} | 6.83 ft | | |
| S_w | 837.00 ft ² | W_w | 6.83 ft | Z_{fus} | 6.00 ft | $\lambda_{L_{fus}}$ | 5.0 deg | $(DCL)_{fus}$ | 12.0 % | l | 55.00 ft | | |
| AR_w | 8.00 | C_w | 5.0 deg | Z_{fus} | 5.00 ft | $C_{L_{fus_0}}$ | 6.2800 rad ⁻¹ | D_{fus} | 1.000 | D_{fus} | 2.50 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| Z_w | 0.80 ft | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | $C_{L_{fus}}$ | -4.5029 rad ⁻¹ | $U_1 - U_2$ | 0.913 | $C_{L_{fus}}$ | -0.0590 rad ⁻¹ | | | | |
| M_1 | 0.594 | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | K/C_L | 0.2760 | $C_{L_{fus}}$ | 0.0447 rad ⁻¹ | $C_{L_{fus}}$ | -0.8302 rad ⁻¹ | | | | |
| AR_{fus} | 4.32 | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | $(DCL)_{fus}$ | -0.1264 | $C_{L_{fus}}$ | -0.0287 rad ⁻¹ | $C_{L_{fus}}$ | -0.9179 rad ⁻¹ | | | | |

Fig. 55 Sideslip related derivatives

| Sideslip Related Derivatives: Rolling Moment: Flight Condition 1 | | | | | | | | | | | | | |
|--|--------------------------|---------------------|--------------------------|-----------------|--------------------------|---------------------|--------------------------|---------------------|---------------------------|-----------------|---------------------------|-----------|---------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | $\lambda_{L_{fus}}$ | 0.60 deg | $C_{L_{fus_0}}$ | 6.3598 rad ⁻¹ | $\lambda_{L_{fus}}$ | 0.0 deg | X_{fus} | 60.00 ft | $C_{L_{fus_0}}$ | 6.2800 rad ⁻¹ | D_{fus} | 6.83 ft |
| ΔT | 0.0 deg F | $\lambda_{L_{fus}}$ | 0.0 deg | $C_{L_{fus_0}}$ | 6.3598 rad ⁻¹ | Γ_w | 0.0 deg | D_{L1} | 2.00 ft | $C_{L_{fus_0}}$ | 6.2800 rad ⁻¹ | X_{fus} | 24.32 ft |
| U_1 | 350.00 kts | C_w | 5.0 deg | X_{fus} | 0.00 ft | S_w | 0.0 deg | S_w | 137.00 ft ² | f_{fus} | 1.00 | Z_{fus} | 2.95 ft |
| θ | 0.00 deg | F_w | 5.0 deg | Z_{fus} | 2.50 ft | Z_{fus} | 6.00 ft | AR_L | 3.00 | $(DCL)_{fus}$ | 12.0 % | | |
| $C_{w_{roll}}$ | 0.1875 | D_{fus} | 0.0 deg | $C_{L_{fus}}$ | -0.0790 | Z_{fus} | 5.00 ft | L | 0.80 | $(DCL)_{fus}$ | 12.0 % | | |
| ΔC_{fus} | 0.0000 | Z_{fus} | 2.00 ft | S_w | 190.00 ft ² | X_{fus} | 61.30 ft | $\lambda_{L_{fus}}$ | 5.0 deg | D_{fus} | 1.000 | | |
| S_w | 837.00 ft ² | X_{fus} | 23.00 ft | AR_L | 7.00 | Z_{fus} | 6.00 ft | X_{fus} | 60.00 ft | D_{fus} | 2.50 ft | | |
| AR_w | 8.00 | Γ_{fus} | 0.0 % | D_{fus} | 1.00 | Z_{fus} | 5.00 ft | Z_{fus} | 15.00 ft | D_{fus} | 2.00 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | $C_{L_{fus}}$ | 7.9041 rad ⁻¹ | AR_{fus} | 4.32 | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | $C_{L_{fus}}$ | -4.5029 rad ⁻¹ | $C_{L_{fus}}$ | -0.0888 rad ⁻¹ | C_D | -0.3025 rad ⁻¹ |
| $C_{L_{fus}}$ | 7.9041 rad ⁻¹ | X_{fus} | 62.73 ft | K/C_L | 0.2760 | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | $C_{L_{fus}}$ | -0.8302 rad ⁻¹ | $C_{L_{fus}}$ | -0.0084 rad ⁻¹ | | |
| $C_{L_{fus}}$ | 7.9041 rad ⁻¹ | Z_{fus} | 24.76 ft | $(DCL)_{fus}$ | -0.1264 | $C_{L_{fus}}$ | 7.8049 rad ⁻¹ | $C_{L_{fus}}$ | -0.0790 rad ⁻¹ | $C_{L_{fus}}$ | -0.2213 rad ⁻¹ | | |

Fig. 56 Sideslip related derivatives

| Sideslip Related Derivatives: Yawing Moment: Flight Condition 1 | | | | | | | | | | | | | |
|---|------------------------|-------------------|--------------------------|-------------------|--------------------------|----------------------------------|---------------------------|---------------|--------------------------|-------------------------|--------------------------|-----------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | α_w | 0.60 | Z_{w_0} | 6.00 ft | X_{w_0} | 60.00 ft | $(BC)_w$ | 12.0 % | Z_{w_1} | 2.95 ft | X_{w_1} | 0.00 ft |
| βT | 0.0 deg F | $\Delta \alpha_w$ | 0.0 deg | Z_{w_2} | 5.00 ft | Z_{w_3} | 15.00 ft | τ_w | 1.000 | S_{w_1} | 383.07 ft ² | | |
| U_1 | 350.00 ft/s | Z_{w_4} | 2.00 ft | S_w | 137.00 ft ² | $C_{L_{\text{prop}=\text{off}}}$ | 6.2800 rad ⁻¹ | h | 55.00 ft | $\tau_{w_{\text{rot}}}$ | 6.78 ft | | |
| α | 0.00 deg | Z_{w_5} | 2.50 ft | ARL | 3.00 | $C_{L_{\text{prop}=\text{on}}}$ | 6.2800 rad ⁻¹ | τ_{w_1} | 2.50 ft | $\tau_{w_{\text{rot}}}$ | 5.00 ft | | |
| S_w | 837.00 ft ² | S_w | 190.00 ft ² | L_w | 0.80 | f_{w_1} | 1.00 | τ_{w_2} | 2.00 ft | $\tau_{w_{\text{rot}}}$ | 2.00 ft | | |
| ARL | 8.00 | X_{w_0} | 61.30 ft | $\Delta \alpha_w$ | 5.0 deg | $(BC)_w$ | 12.0 % | X_{w_1} | 24.32 ft | $W_{w_{\text{rot}}}$ | 6.78 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| h | 0.594 | Z_{w_0} | 24.76 ft | $C_{L_{w_0}}$ | 7.8049 rad ⁻¹ | ARL | 0.2760 | $K_{L_{w_0}}$ | -0.00029 | $C_{D_{w_0}}$ | 0.3897 rad ⁻¹ | | |
| Re | 93.1248 $\times 10^3$ | ARL | 4.32 | $C_{L_{w_1}}$ | 7.8049 rad ⁻¹ | (g_{rot}/g) | -0.1264 | $K_{L_{w_1}}$ | 1.92878 | $C_{D_{w_1}}$ | 0.3995 rad ⁻¹ | | |
| $K_{L_{w_0}}$ | 62.73 | $C_{L_{w_0}}$ | 7.8049 rad ⁻¹ | $C_{D_{w_0}}$ | 4.5029 rad ⁻¹ | $C_{D_{w_1}}$ | -0.8302 rad ⁻¹ | $C_{D_{w_2}}$ | 0.0098 rad ⁻¹ | | | | |

Fig. 57 Sideslip related derivatives

| Sideslip Related Derivatives: Sideforce due to Thrust: Flight Condition 1 | | | | |
|---|---------------|----------------------|---------------------|--|
| Input Parameter | | | | |
| S_w | 837.00 | | | ft ² |
| Output Parameter | | | | |
| $C_{Y\beta}$ | 0.0000 | | | rad ⁻¹ |
| Propeller Table | | | | |
| # | Type | D _{prop} ft | f _{Inflow} | $C_{N_{\alpha_{\text{prop}}}}$ rad ⁻¹ |
| 1 | Propeller: On | 9.25 | 1.0402 | 0.0000 |
| 2 | Propeller: On | 9.25 | 1.0402 | 0.0000 |

Fig. 58 Sideslip related derivatives

| Sideslip Related Derivatives: Yawing Moment due to Thrust: Flight Condition 1 | | | | | | | | |
|---|--------------------------|---------------|---------------|----------------|-------------------|---------------|--------------|--|
| Input Parameters | | | | | | | | |
| X_{cg} | 24.32 ft | Y_{cg} | -0.11 ft | | | | | |
| S_w | 837.00 ft ² | AR_w | 8.00 | | | | | |
| Output Parameter | | | | | | | | |
| $C_{N_{\dot{\beta}}}$ | 0.0000 rad ⁻¹ | | | | | | | |
| Propeller Table | | | | | | | | |
| # | Type | X_{prop} ft | Y_{prop} ft | i_{prop} deg | ψ_{prop} deg | D_{prop} ft | f_{inflow} | $C_{N_{\dot{\beta}}}$ prop rad ⁻¹ |
| 1 | Propeller: On | 22.00 | 9.01 | 7.0 | 0.0 | 9.25 | 1.0402 | 0.0000 |
| 2 | Propeller: On | 22.00 | -9.01 | 7.0 | 0.0 | 9.25 | 1.0402 | 0.0000 |

Fig. 59 Sideslip related derivatives

| Subsonic Horizontal Tail Drag Coefficient Prediction: Flight Condition 1 | | | | | | | |
|--|------------|-------------|------------------------|------------------|-----------------------------|---------------|--------------------------|
| Input Parameters | | | | | | | |
| Altitude | 30000 ft | S_w | 837.00 ft ² | $\lambda_{w,h}$ | 0.0 deg | C_h | 5.21 ft |
| ΔT | 0.0 deg F | S_h | 190.00 ft ² | $\lambda_{t,h}$ | 0.0 deg | $(R_{w/C}_h)$ | 1.000 % |
| U_1 | 350.00 kts | AR_h | 7.00 | (θ_{C}_h) | 12.00 % | $S_{w,h}$ | 369.94 ft ² |
| $C_{N_{\dot{\beta}}}$ | -0.0798 | λ_h | 1.00 | k_{yaw} | 0.01333 10 ⁻³ ft | $C_{D_{w,h}}$ | 7.7681 rad ⁻¹ |
| | | | | | | $C_{D_{w,h}}$ | 5.7070 rad ⁻¹ |
| Output Parameters | | | | | | | |
| M_1 | 0.594 | C_h | 0.0028 | e_h | 0.9956 | $C_{D_{w,h}}$ | 0.0017 |
| | | | | | | $C_{D_{w,h}}$ | 0.0001 |

Fig. 60 Horizontal stabilizer drag coefficient

| Rate of Sideslip Related Derivatives: Sideforce: Flight Condition 1 | | | | | | | | | | | |
|---|------------------------|-----------------|----------|-----------------------|--------------------------|-----------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
| Input Parameters | | | | | | | | | | | |
| Altitude | 30000 ft | AR_w | 8.00 | $Z_{w,w}$ | 2.00 ft | $X_{w,w}$ | 61.30 ft | b_w | 0.80 | $C_{N_{\dot{\beta}}=0}$ | 6.2800 rad ⁻¹ |
| ΔT | 0.0 deg F | λ_w | 0.60 | $Z_{w,w}$ | 2.50 ft | $Z_{w,w}$ | 6.00 ft | $\lambda_{w,w}$ | 5.0 deg | f_{sw} | 1.00 |
| U_1 | 350.00 kts | $\lambda_{w,w}$ | 0.0 deg | $X_{w,w}$ | 26.20 ft | $Z_{w,w}$ | 5.00 ft | k_{sw} | 60.00 ft | (θ_{C}_w) | 12.0 % |
| α | 0.00 deg | τ_w | 5.0 deg | $Z_{w,w}$ | 3.64 ft | S_w | 137.00 ft ² | $Z_{w,w}$ | 15.00 ft | (θ_{C}_w) | 12.0 % |
| S_w | 837.00 ft ² | λ_w | 0.0 deg | S_h | 190.00 ft ² | AR_h | 3.00 | $C_{N_{\dot{\beta}}=0}$ | 6.2800 rad ⁻¹ | $D_{w,w}$ | 6.83 ft |
| Output Parameters | | | | | | | | | | | |
| M_1 | 0.594 | $Z_{w,w}$ | 24.76 ft | $C_{N_{\dot{\beta}}}$ | 7.8049 rad ⁻¹ | $C_{N_{\dot{\beta}}}$ | 7.8049 rad ⁻¹ | $\delta_{N_{\dot{\beta}}}$ | -0.0012 deg ⁻¹ | $\delta_{N_{\dot{\beta}}}$ | -0.0012 deg ⁻¹ |
| k_{sw} | 62.73 ft | $AR_{w,w}$ | 4.32 | $C_{N_{\dot{\beta}}}$ | 7.8049 rad ⁻¹ | $C_{D_{\dot{\beta}}}$ | -4.5029 rad ⁻¹ | $\delta_{D_{\dot{\beta}}}$ | -0.2389 deg ⁻¹ | $\delta_{D_{\dot{\beta}}}$ | 0.0109 |
| | | | | | | | | | | $C_{\dot{\beta}}$ | -0.0066 rad ⁻¹ |

Fig. 61 Sideslip rate related derivatives

| Rate of Sideslip Related Derivatives: Rolling Moment: Flight Condition 1 | | | | | | | | | | | | | |
|--|------------------------|-----------------|--------------------------|----------------------|---------------------------|------------|---------------------------|-----------------------------|---------------------------|---------------------------|--------------------------|-------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | AR_{w_0} | 8.00 | $Z_{w_0}^*$ | 2.00 ft | X_{w_0} | 61.30 ft | z_0 | 0.80 | $C_{w_0, \dot{\omega}_w}$ | 6.2800 rad ⁻¹ | h_0 | 2.00 ft |
| ΔT | 0.0 deg F | L_w | 0.60 | Z_{w_0} | 2.50 ft | Z_{w_0} | 6.00 ft | λ_{w_0} | 5.0 deg | f_{w_0} | 1.00 | | |
| U_1 | 350.00 kts | λ_{w_0} | 0.0 deg | X_{w_0} | 26.20 ft | Z_{w_0} | 5.00 ft | X_{w_0} | 60.00 ft | $(DC)_{w_0}$ | 12.0 % | | |
| α | 0.00 deg | τ_w | 5.0 deg | Z_{w_0} | 3.64 ft | S_w | 137.00 ft ² | Z_{w_0} | 15.00 ft | $(DC)_{w_0}$ | 12.0 % | | |
| S_w | 837.00 ft ² | τ_w | 0.0 deg | S_w | 190.00 ft ² | AR_w | 3.00 | $C_{w_0, \dot{\omega}_w}$ | 6.2800 rad ⁻¹ | D_{w_0} | 6.83 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| $M_{\dot{\omega}_w}$ | 0.594 | AR_{w_0} | 4.32 | C_{w_0} | 7.8049 rad ⁻¹ | Pl_{w_0} | -0.2389 deg ⁻¹ | $g_{roll}^{\dot{\omega}_w}$ | -0.0100 | | | | |
| X_{w_0} | 62.73 ft | C_{w_0} | 7.8049 rad ⁻¹ | $C_{\dot{\omega}_w}$ | -4.5029 rad ⁻¹ | Pl_{w_0} | -0.0012 deg ⁻¹ | $C_{\dot{\omega}_w}$ | -0.0066 rad ⁻¹ | | | | |
| Z_{w_0} | 24.76 ft | C_{w_0} | 7.8049 rad ⁻¹ | Pl_{w_0} | -0.0012 deg ⁻¹ | Pl_{w_0} | 0.0109 | $C_{\dot{\omega}_w}$ | -0.0017 rad ⁻¹ | | | | |

Fig. 62 Sideslip rate related derivatives

| Rate of Sideslip Related Derivatives: Yawing Moment: Flight Condition 1 | | | | | | | | | | | | | |
|---|------------------------|-----------------|--------------------------|----------------------|---------------------------|------------|---------------------------|-----------------------------|---------------------------|---------------------------|--------------------------|-------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | AR_{w_0} | 8.00 | $Z_{w_0}^*$ | 2.00 ft | X_{w_0} | 61.30 ft | z_0 | 0.80 | $C_{w_0, \dot{\omega}_w}$ | 6.2800 rad ⁻¹ | h_0 | 2.00 ft |
| ΔT | 0.0 deg F | L_w | 0.60 | Z_{w_0} | 2.50 ft | Z_{w_0} | 6.00 ft | λ_{w_0} | 5.0 deg | f_{w_0} | 1.00 | | |
| U_1 | 350.00 kts | λ_{w_0} | 0.0 deg | X_{w_0} | 26.20 ft | Z_{w_0} | 5.00 ft | X_{w_0} | 60.00 ft | $(DC)_{w_0}$ | 12.0 % | | |
| α | 0.00 deg | τ_w | 5.0 deg | Z_{w_0} | 3.64 ft | S_w | 137.00 ft ² | Z_{w_0} | 15.00 ft | $(DC)_{w_0}$ | 12.0 % | | |
| S_w | 837.00 ft ² | τ_w | 0.0 deg | S_w | 190.00 ft ² | AR_w | 3.00 | $C_{w_0, \dot{\omega}_w}$ | 6.2800 rad ⁻¹ | D_{w_0} | 6.83 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| $M_{\dot{\omega}_w}$ | 0.594 | AR_{w_0} | 4.32 | C_{w_0} | 7.8049 rad ⁻¹ | Pl_{w_0} | -0.2389 deg ⁻¹ | $g_{roll}^{\dot{\omega}_w}$ | -0.0100 | | | | |
| X_{w_0} | 62.73 ft | C_{w_0} | 7.8049 rad ⁻¹ | $C_{\dot{\omega}_w}$ | -4.5029 rad ⁻¹ | Pl_{w_0} | -0.0012 deg ⁻¹ | $C_{\dot{\omega}_w}$ | -0.0066 rad ⁻¹ | | | | |
| Z_{w_0} | 24.76 ft | C_{w_0} | 7.8049 rad ⁻¹ | Pl_{w_0} | -0.0012 deg ⁻¹ | Pl_{w_0} | 0.0109 | $C_{\dot{\omega}_w}$ | -0.0029 rad ⁻¹ | | | | |

Fig. 63 Sideslip rate related derivatives

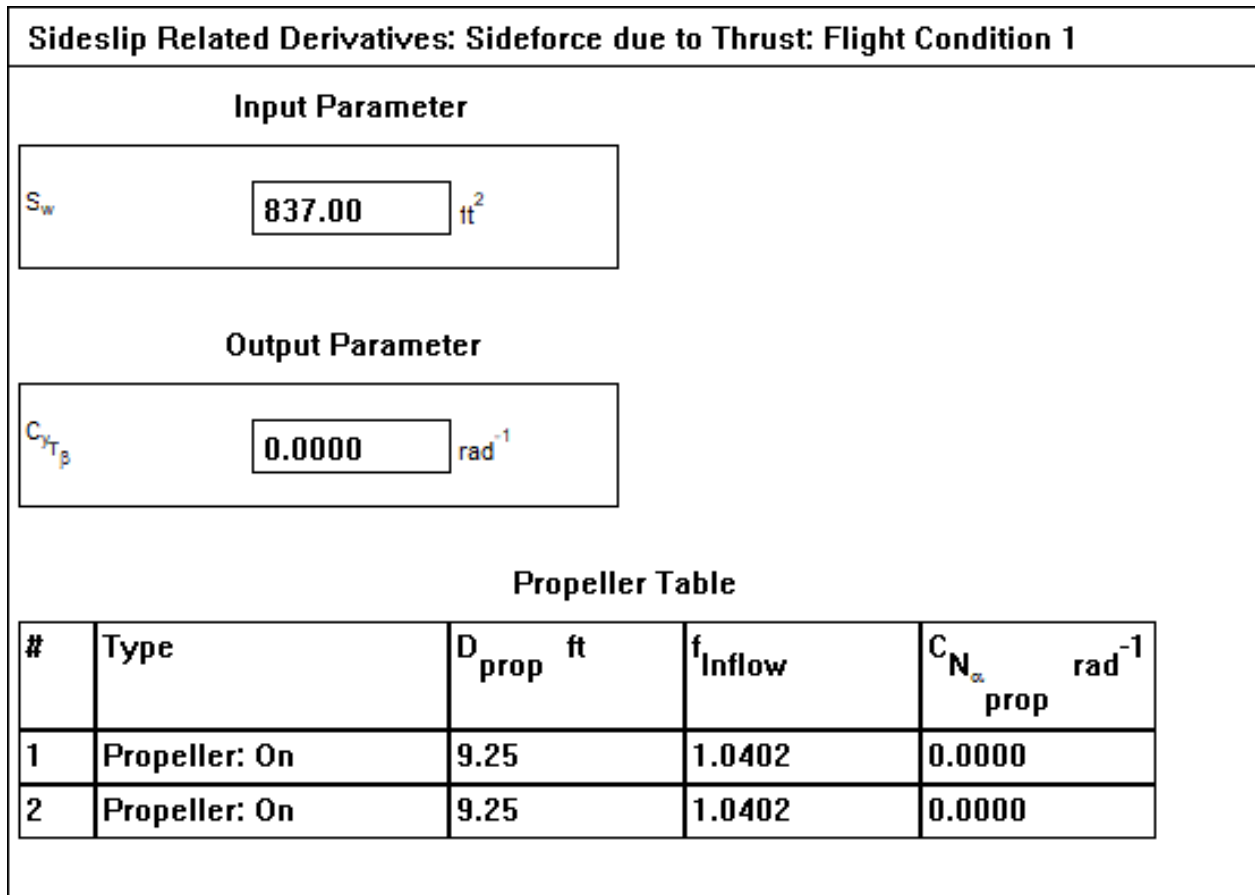


Fig. 64 Sideslip related derivatives

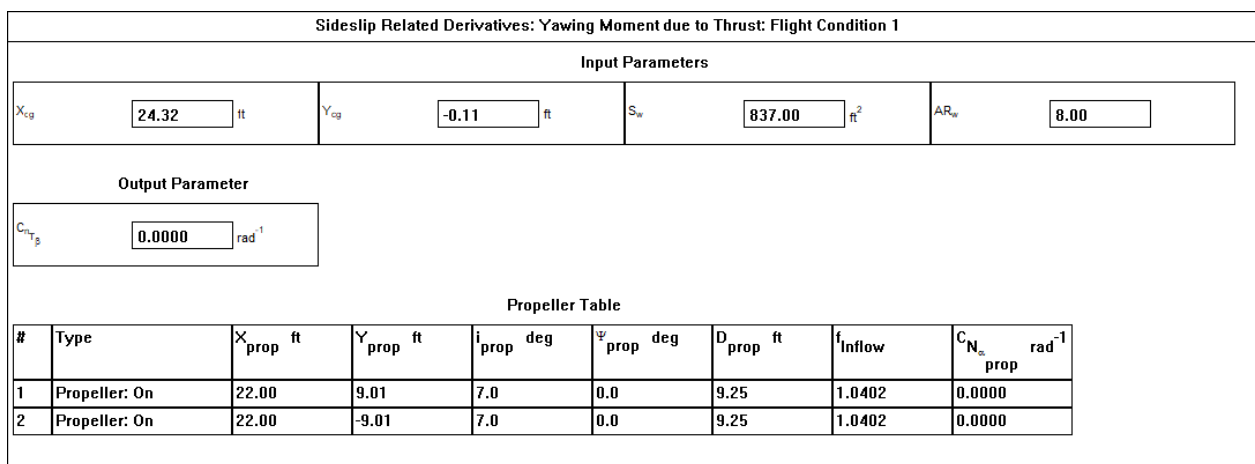


Fig. 65 Sideslip related derivatives

| Roll Rate Related Derivatives: Sideforce: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|--------|-------------------|----------------------------|--------|-------------------|--|--------|-------------------|--------------------------|---------|-------------------|-------------------------------------|---------|-------------------|--|--------|-------------------|--------------------------|-------|----|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | α | 0.00 | deg | $Z_{\dot{\omega}_r}$ | 2.50 | ft | $f_{\dot{\omega}_r}$ | 0.91 | | S_x | 137.00 | ft ² | $Z_{\dot{\omega}_r}$ | 15.00 | ft | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % |
| δT | 0.0 | deg F | S_w | 837.00 | ft ² | l_w | 0.60 | | S_w | 190.00 | ft ² | ARL | 3.00 | | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2800 | rad ⁻¹ | l_w | 1.000 | |
| U_1 | 350.00 | kts | ARL | 8.00 | | Γ_w | 5.0 | deg | $X_{\dot{\omega}_r}$ | 61.30 | ft | l_w | 0.80 | | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2800 | rad ⁻¹ | l_w | 2.50 | ft |
| $X_{\dot{\omega}_r}$ | 24.32 | ft | $\lambda_{\dot{\omega}_r}$ | 0.0 | deg | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.3598 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 6.00 | ft | $\lambda_{\dot{\omega}_r}$ | 5.0 | deg | $f_{\dot{\omega}_r}$ | 1.00 | | l_w | 2.00 | ft |
| $Z_{\dot{\omega}_r}$ | 2.95 | ft | $Z_{\dot{\omega}_r}$ | 2.00 | ft | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.3598 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 5.00 | ft | $X_{\dot{\omega}_r}$ | 60.00 | ft | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| $M_{\dot{\omega}_r}$ | 0.594 | | $C_{\dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | ARL _{dot} | 4.32 | | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $(\dot{\omega}_r)_{\dot{\omega}_r}$ | -0.1264 | | | | | | | |
| $C_{\dot{\omega}_r, \dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | $X_{\dot{\omega}_r}$ | 62.73 | ft | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -4.5029 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -0.8302 | rad ⁻¹ | | | | | | |
| $C_{\dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 24.76 | ft | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $(DCL)_{\dot{\omega}_r}$ | 0.2760 | | $C_{\dot{\omega}_r}$ | -0.1342 | rad ⁻¹ | | | | | | |

Fig. 66 Roll rate related derivatives

| Roll Rate Related Derivatives: Rolling Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|---|--------|-------------------|--|--------|-------------------|--|---------|-------------------|--|--------|-------------------|-------------------------------------|---------|-------------------|--|---------|-------------------|----------------------|---------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | ARL | 8.00 | | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.3598 | rad ⁻¹ | l_w | 1.00 | | $f_{\dot{\omega}_r}$ | 1.00 | | $\lambda_{\dot{\omega}_r}$ | 5.0 | deg | l_w | 2.50 | ft |
| δT | 0.0 | deg F | l_w | 0.60 | | $f_{\dot{\omega}_r}$ | 0.91 | | $\lambda_{\dot{\omega}_r}$ | 0.0 | deg | $f_{\dot{\omega}_r}$ | 1.00 | | $X_{\dot{\omega}_r}$ | 60.00 | ft | l_w | 2.00 | ft |
| U_1 | 350.00 | kts | $\lambda_{\dot{\omega}_r}$ | 0.0 | deg | $f_{\dot{\omega}_r}$ | 0.93 | | Γ_w | 0.0 | deg | $C_{\dot{\omega}_r}$ | 5.7070 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 15.00 | ft | $X_{\dot{\omega}_r}$ | 24.32 | ft |
| α | 0.00 | deg | Γ_w | 5.0 | deg | $C_{\dot{\omega}_r}$ | 5.3706 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 6.00 | ft | $X_{\dot{\omega}_r}$ | 61.30 | ft | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2800 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 2.95 | ft |
| $C_{\dot{\omega}_r, \dot{\omega}_r}$ | -3.0 | deg | $Z_{\dot{\omega}_r}$ | 2.00 | ft | $C_{\dot{\omega}_r}$ | 0.0037 | | l_w | 2.00 | ft | $Z_{\dot{\omega}_r}$ | 6.00 | ft | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2800 | rad ⁻¹ | | | |
| l_w | -1.0 | deg | $(DCL)_{\dot{\omega}_r}$ | 12.00 | % | $C_{\dot{\omega}_r, \dot{\omega}_r}$ | 0.0000 | | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % | $C_{\dot{\omega}_r}$ | 0.0017 | | $f_{\dot{\omega}_r}$ | 1.00 | | | | |
| $C_{\dot{\omega}_r, \dot{\omega}_r}$ | 5.3706 | rad ⁻¹ | $(DCL)_{\dot{\omega}_r}$ | 12.00 | % | $C_{\dot{\omega}_r}$ | -0.0790 | | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % | S_x | 137.00 | ft ² | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % | | | |
| $\delta C_{\dot{\omega}_r}$ | 0.0000 | | $Z_{\dot{\omega}_r}$ | 2.50 | ft | S_w | 190.00 | ft ² | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2504 | rad ⁻¹ | ARL | 3.00 | | $(DCL)_{\dot{\omega}_r}$ | 12.0 | % | | | |
| S_w | 837.00 | ft ² | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.3598 | rad ⁻¹ | ARL | 7.00 | | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2504 | rad ⁻¹ | l_w | 0.80 | | l_w | 1.000 | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| $M_{\dot{\omega}_r}$ | 0.594 | | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.3598 | rad ⁻¹ | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2504 | rad ⁻¹ | ARL _{dot} | 4.32 | | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -0.8302 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -0.5259 | rad ⁻¹ |
| $C_{\dot{\omega}_r, \dot{\omega}_r}$ | 0.1875 | | $C_{\dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | 7.7681 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -4.5029 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | -0.5141 | rad ⁻¹ | | | |
| $C_{\dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | 7.7681 | rad ⁻¹ | $X_{\dot{\omega}_r}$ | 62.73 | ft | $C_{\dot{\omega}_r}$ | 7.8049 | rad ⁻¹ | $(DCL)_{\dot{\omega}_r}$ | 0.2760 | | $C_{\dot{\omega}_r}$ | -0.0118 | rad ⁻¹ | | | |
| $C_{\dot{\omega}_r}$ | 7.9041 | rad ⁻¹ | $C_{\dot{\omega}_r}$ | 7.7681 | rad ⁻¹ | $Z_{\dot{\omega}_r}$ | 24.76 | ft | $C_{\dot{\omega}_r, \dot{\omega}_r=0}$ | 6.2000 | rad ⁻¹ | $(\dot{\omega}_r)_{\dot{\omega}_r}$ | -0.1264 | | $C_{\dot{\omega}_r}$ | 0.0000 | rad ⁻¹ | | | |

| High Lift Devices Table | | | |
|-------------------------|---------------------|----------------------------|----------------------------|
| # | High Lift Device | $c_{l_{\dot{\omega}_r}}$ % | $S_{\dot{\omega}_r} / S_w$ |
| 1 | Single Slotted Flap | 30.0 | 0.506 |

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Fig. 67 Roll rate related derivatives

| Roll Rate Related Derivatives: Yaw Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | | | |
|---|---------------------|-------------------|---------------------------|-----------|-------------------|---------------------------|--------|-------------------|---------------------------|---------|-------------------|---------------------------|---------|-------------------|-------------------------|---------|-------------------|--------------------|---------|-------------------|--|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | $C_{L_{\alpha_{down}}}$ | 5.3706 | rad ⁻¹ | $Z_{\alpha_{up}}$ | 2.00 | ft | $Z_{\alpha_{down}}$ | 6.00 | ft | $X_{\alpha_{down}}$ | 60.00 | ft | $(b/c)_{\alpha}$ | 12.0 | % | SM | 56.96 | % | | |
| ΔT | 0.0 | deg F | S_w | 837.00 | ft ² | $Z_{\alpha_{up}}$ | 2.50 | ft | $Z_{\alpha_{down}}$ | 5.00 | ft | $Z_{\alpha_{down}}$ | 15.00 | ft | τ_{α} | 1.000 | | | | | | |
| U_1 | 350.00 | kts | AR_w | 8.00 | | $C_{L_{\alpha_{down=0}}}$ | 6.3598 | rad ⁻¹ | S_w | 137.00 | ft ² | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | h_{α} | 2.50 | ft | | | | | |
| α | 0.00 | deg | λ_w | 0.60 | | $C_{L_{\alpha_{down=0}}}$ | 6.3598 | rad ⁻¹ | AR_c | 3.00 | | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | h_{α} | 2.00 | ft | | | | | |
| α_{down} | -3.0 | deg | $\lambda_{\alpha_{down}}$ | 0.0 | deg | S_w | 190.00 | ft ² | L_w | 0.80 | | f_{spw} | 1.00 | | X_{α} | 24.32 | ft | | | | | |
| λ | -1.0 | deg | λ_{α} | 0.0 | deg | $X_{\alpha_{up}}$ | 61.30 | ft | $\lambda_{\alpha_{down}}$ | 5.0 | deg | $(b/c)_{\alpha}$ | 12.0 | % | Z_{α} | 2.95 | ft | | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $Z_{\alpha_{up}}$ | 24.76 | ft | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | x/c_c | 0.2760 | | $C_{L_{\alpha_{down}}}$ | 0.0000 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -0.0193 | rad ⁻¹ | | |
| $C_{L_{\alpha_{down=0}}}$ | 0.1875 | | $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $AR_{w_{eff}}$ | 4.32 | | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $(goldB)$ | -0.1264 | | $C_{L_{\alpha_{down}}}$ | -0.0193 | rad ⁻¹ | | | | | |
| $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $X_{\alpha_{up}}$ | 62.73 | ft | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -4.5029 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -0.8302 | rad ⁻¹ | $C_{\dot{\alpha}}$ | 0.0000 | rad ⁻¹ | | | | | |
| High Lift Devices Table | | | | | | | | | | | | | | | | | | | | | | |
| # | High Lift Device | h_i % | h_o % | c/c_w % | δ deg | | | | | | | | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | | | | | | | | | |

Fig. 68 Roll rate related derivatives

| Yaw Rate Related Derivatives: Sideforce: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | | |
|---|--------|-------|---------------------------|--------|-----------------|-------------------------|--------|-------------------|---------------------------|---------|-------------------|---------------------------|---------|-------------------|--------------------|---------|-------------------|--|--|--|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | α | 0.00 | deg | $Z_{\alpha_{up}}$ | 2.50 | ft | S_w | 137.00 | ft ² | $Z_{\alpha_{down}}$ | 15.00 | ft | $(b/c)_{\alpha}$ | 12.0 | % | | | | |
| ΔT | 0.0 | deg F | S_w | 837.00 | ft ² | S_w | 190.00 | ft ² | AR_w | 3.00 | | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | τ_{α} | 1.000 | | | | | |
| U_1 | 350.00 | kts | AR_w | 8.00 | | $X_{\alpha_{up}}$ | 61.30 | ft | L_w | 0.80 | | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | h_{α} | 2.50 | ft | | | | |
| X_{α} | 24.32 | ft | $\lambda_{\alpha_{down}}$ | 0.0 | deg | $Z_{\alpha_{up}}$ | 6.00 | ft | $\lambda_{\alpha_{down}}$ | 5.0 | deg | f_{spw} | 1.00 | | h_{α} | 2.00 | ft | | | | |
| Z_{α} | 2.95 | ft | $Z_{\alpha_{up}}$ | 2.00 | ft | $Z_{\alpha_{down}}$ | 5.00 | ft | $X_{\alpha_{down}}$ | 60.00 | ft | $(b/c)_{\alpha}$ | 12.0 | % | | | | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $Z_{\alpha_{up}}$ | 24.76 | ft | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | x/c_c | 0.2760 | | $C_{\dot{\alpha}}$ | -0.8302 | rad ⁻¹ | | | | |
| $X_{\alpha_{down}}$ | 62.73 | ft | $AR_{w_{eff}}$ | 4.32 | | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -4.5029 | rad ⁻¹ | $(goldB)$ | -0.1264 | | $C_{\dot{\alpha}}$ | 0.7794 | rad ⁻¹ | | | | |

Fig. 69 Yaw rate related derivatives

| Yaw Rate Related Derivatives: Rolling Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | | | |
|--|---------------------|-------------------|---------------------------|-----------|-------------------|---------------------------|--------|-------------------|-------------------------|---------|-------------------|---------------------------|---------|-------------------|-------------------------|--------|-------------------|--------------------|--------|-------------------|--|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | $C_{L_{\alpha_{down}}}$ | 5.3706 | rad ⁻¹ | λ_w | 0.0 | deg | $X_{\alpha_{up}}$ | 61.30 | ft | $\lambda_{\alpha_{down}}$ | 5.0 | deg | $(b/c)_{\alpha}$ | 12.0 | % | Z_{α} | 2.95 | ft | | |
| ΔT | 0.0 | deg F | S_w | 837.00 | ft ² | $Z_{\alpha_{up}}$ | 2.00 | ft | $Z_{\alpha_{down}}$ | 6.00 | ft | $X_{\alpha_{down}}$ | 60.00 | ft | $(b/c)_{\alpha}$ | 12.0 | % | | | | | |
| U_1 | 350.00 | kts | AR_w | 8.00 | | $Z_{\alpha_{down}}$ | 2.50 | ft | $Z_{\alpha_{down}}$ | 5.00 | ft | $Z_{\alpha_{down}}$ | 15.00 | ft | τ_{α} | 1.000 | | | | | | |
| α | 0.00 | deg | λ_w | 0.60 | | $C_{L_{\alpha_{down=0}}}$ | 6.3598 | rad ⁻¹ | S_w | 137.00 | ft ² | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | h_{α} | 2.50 | ft | | | | | |
| α_{down} | -3.0 | deg | $\lambda_{\alpha_{down}}$ | 0.0 | deg | $C_{L_{\alpha_{down=0}}}$ | 6.3598 | rad ⁻¹ | AR_c | 3.00 | | $C_{L_{\alpha_{down=0}}}$ | 6.2800 | rad ⁻¹ | h_{α} | 2.00 | ft | | | | | |
| λ | -1.0 | deg | C_{λ} | 5.0 | deg | S_w | 190.00 | ft ² | L_w | 0.80 | | f_{spw} | 1.00 | | X_{α} | 24.32 | ft | | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $Z_{\alpha_{up}}$ | 24.76 | ft | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | x/c_c | 0.2760 | | $C_{L_{\alpha_{down}}}$ | 0.0000 | rad ⁻¹ | $C_{\dot{\alpha}}$ | 0.2663 | rad ⁻¹ | | |
| $C_{L_{\alpha_{down=0}}}$ | 0.1875 | | $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $AR_{w_{eff}}$ | 4.32 | | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $(goldB)$ | -0.1264 | | $C_{L_{\alpha_{down}}}$ | 0.0586 | rad ⁻¹ | | | | | |
| $C_{L_{\alpha_{down}}}$ | 7.9041 | rad ⁻¹ | $X_{\alpha_{up}}$ | 62.73 | ft | $C_{L_{\alpha_{down}}}$ | 7.8049 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -4.5029 | rad ⁻¹ | $C_{\dot{\alpha}}$ | -0.8302 | rad ⁻¹ | $C_{\dot{\alpha}}$ | 0.2077 | rad ⁻¹ | | | | | |
| High Lift Devices Table | | | | | | | | | | | | | | | | | | | | | | |
| # | High Lift Device | h_i % | h_o % | c/c_w % | δ deg | | | | | | | | | | | | | | | | | |
| 1 | Single Slotted Flap | 9.0 | 55.5 | 30.0 | 0.0 | | | | | | | | | | | | | | | | | |

Fig. 70 Yaw rate related derivatives

| Yaw Rate Related Derivatives: Yawing Moment: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|---|--------|-------|----------------|--------|-------------------|----------------------|---------|-------------------|--------------------|---------|-------------------|----------------|---------|-------------------|----------------|--------|-------------------|-----------|-------|----|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | α_w | -1.0 | deg | $\alpha_{w,0}$ | 0.0 | deg | $X_{w,0}$ | 61.30 | ft | z_w | 0.80 | ft | $C_{y_w,0}$ | 6.2800 | rad ⁻¹ | η_w | 2.50 | ft |
| ΔT | 0.0 | deg F | $C_{y_w,down}$ | 5.3706 | rad ⁻¹ | Z_{y_w} | 2.00 | ft | $Z_{w,0}$ | 6.00 | ft | $\alpha_{w,0}$ | 5.0 | deg | $\beta_{w,0}$ | 1.00 | ft | η_w | 2.00 | ft |
| U_1 | 350.00 | fts | S_w | 837.00 | ft ² | $Z_{w,0}$ | 2.50 | ft | $Z_{w,0}$ | 5.00 | ft | $X_{w,0}$ | 60.00 | ft | $\beta(C/L)_w$ | 12.0 | % | $X_{w,0}$ | 24.32 | ft |
| α | 0.00 | deg | AR_w | 8.00 | | $C_{y_w,0}$ | 0.0037 | | S_w | 137.00 | ft ² | $Z_{w,0}$ | 15.00 | ft | $\beta(C/L)_w$ | 12.0 | % | $Z_{w,0}$ | 2.95 | ft |
| $\alpha_{w,down}$ | -3.0 | deg | α_w | 0.60 | | S_w | 190.00 | ft ² | AR_w | 3.00 | | $C_{y_w,0}$ | 6.2800 | rad ⁻¹ | η_w | 1.000 | | SM | 56.96 | % |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $Z_{w,0}$ | 24.76 | ft | $\dot{\alpha}_{w,0}$ | 7.8049 | rad ⁻¹ | K/C_L | 0.2760 | | C_{y_w} | -0.0019 | rad ⁻¹ | | | | | | |
| $C_{y_w,output}$ | 0.1875 | | AR_w | 4.32 | | $\dot{\alpha}_{w,0}$ | 7.8049 | rad ⁻¹ | $(\partial C/L)_w$ | -0.1264 | | C_{y_w} | -0.3659 | rad ⁻¹ | | | | | | |
| $X_{w,0}$ | 62.73 | ft | $C_{y_w,0}$ | 7.8049 | rad ⁻¹ | C_{y_w} | -4.5029 | rad ⁻¹ | C_{y_w} | -0.8302 | rad ⁻¹ | C_{y_w} | -0.3678 | rad ⁻¹ | | | | | | |

Fig. 71 Yaw rate related derivatives

| Airplane Lift Coefficient and Downwash at Alpha = 0: Flight Condition 1 | | | | | | | | | | | | | | | | | |
|---|--------|-----------------|---------------------|--------|--|----------------|---------|-------------------|------------------|--------|-----|-----------------------|--------|-----|----------------|--------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | |
| S_w | 837.00 | ft ² | $C_{y_w,0}$ | 0.1875 | | S_h | 190.00 | ft ² | $\beta_{w,down}$ | 1.000 | | $\beta_{w,0}$ | 0.8 | deg | $C_{y_w,down}$ | 6.1586 | rad ⁻¹ |
| $C_{y_w,down}$ | 0.1875 | | $\Delta C_{y_w,hd}$ | 0.0000 | | C_{y_w} | 5.7070 | rad ⁻¹ | $\alpha_{w,0}$ | 0.0 | deg | $\Delta \beta_{w,hd}$ | 0.0 | deg | C_{y_w} | 6.1586 | rad ⁻¹ |
| Output Parameters | | | | | | | | | | | | | | | | | |
| $\alpha_{w,down}$ | -1.6 | deg | $\Delta C_{y_w,hd}$ | 0.0000 | | C_{y_w} | -0.0178 | | $C_{y_w,down}$ | 0.1875 | | $C_{y_w,down}$ | 0.1698 | | C_{y_w} | 0.1698 | |
| α_w | -1.6 | deg | $\Delta C_{y_w,hd}$ | 0.0000 | | $C_{y_w,down}$ | 0.1875 | | $C_{y_w,down}$ | 0.1698 | | $C_{y_w,down}$ | 0.1698 | | | | |

Fig. 72 Angle of attack related derivatives

| Elevator Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|--------|-----------------|-----------|--------|-------------------|----------------------|--------|-------------------|-----------|--------|-------------------|------------------|--------|-----|----------------|--------|-------------------|------------|--------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | C_{y_0} | 0.1698 | | α_w | 0.60 | | S_h | 190.00 | ft ² | $\alpha_{w,0}$ | 0.0 | deg | $\beta(C/L)_w$ | 12.0 | % | η_w | 5.0 | % |
| ΔT | 0.0 | deg F | S_w | 837.00 | ft ² | $C_{y_w,0}$ | 6.2504 | rad ⁻¹ | AR_h | 7.00 | | $\beta_{w,down}$ | 1.000 | | C_{y_w} | 5.7070 | rad ⁻¹ | η_w | 95.0 | % |
| U_1 | 350.00 | fts | AR_w | 8.00 | | $C_{y_w,0}$ | 6.2504 | rad ⁻¹ | z_w | 1.00 | ft | $\beta(C/L)_w$ | 12.0 | % | C_L/C_D | 28.5 | % | α_w | -0.04 | deg |
| S_w | 837.00 | ft ² | AR_h | 7.00 | | $\beta(C/L)_w$ | 12.0 | % | β_w | 5.0 | % | Balance | 0.05 | | $(C_L/C_D)_w$ | | % | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | C_{y_w} | 7.7681 | rad ⁻¹ | $\dot{\alpha}_{w,0}$ | 7.7681 | rad ⁻¹ | C_{y_0} | 1.2955 | rad ⁻¹ | β_w | 0.4231 | | C_{y_0} | 0.0204 | rad ⁻¹ | C_{y_0} | 0.0087 | rad ⁻¹ |

Fig. 73 Elevator related derivatives

| Elevator Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|--------|-------------------|----------------------|--------|-------------------|------------------|--------|-----|------------------|--------|-------------------|--------------------|--------|-------------------|------------------|---------|-------------------|---------------|---|---|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | $C_{y_w,0}$ | 6.2504 | rad ⁻¹ | z_w | 1.00 | ft | $\beta(C/L)_w$ | 12.0 | % | β_w | 95.0 | % | $\beta_{w,down}$ | | deg | $(C_L/C_D)_w$ | | % |
| ΔT | 0.0 | deg F | $C_{y_w,0}$ | 6.2504 | rad ⁻¹ | $\alpha_{w,0}$ | 0.0 | deg | C_{y_w} | 5.7070 | rad ⁻¹ | α_w | -0.04 | deg | $\beta_{w,down}$ | | deg | Number C/C | 2 | |
| U_1 | 350.00 | fts | S_w | 190.00 | ft ² | $\beta_{w,down}$ | 1.000 | | C_L/C_D | 28.5 | % | $(\partial C/L)_w$ | 0.00 | % | Number S_w | 2 | | | | |
| S_w | 837.00 | ft ² | AR_h | 7.00 | | $\beta(C/L)_w$ | 12.0 | % | β_w | 5.0 | % | Balance | 0.05 | | $(C_L/C_D)_w$ | | % | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | $\dot{\alpha}_{w,0}$ | 7.7681 | rad ⁻¹ | K/C_L | 1.0000 | | $\beta_{w,down}$ | 0.4231 | | C_{y_w} | 0.5482 | rad ⁻¹ | C_{y_w} | 0.5482 | rad ⁻¹ | | | |
| $\dot{\alpha}_{w,0}$ | 7.7681 | rad ⁻¹ | C_{y_0} | 1.2955 | rad ⁻¹ | $\beta_{w,down}$ | 1.00 | | C_{y_w} | 2.4149 | rad ⁻¹ | β_w | 0.4231 | | C_{y_w} | -0.0003 | | | | |

Fig. 74 Elevator related derivatives

| Elevator Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | |
|--|--------------------------|-------------------|--------------------------|-----------------------|---------------------------|-------------------|--------------------------|-----------------------|---------------------------|--------------------------|---------------------------|----------------|--------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | δ_w | 0.60 | C_{δ_w} | 6.2504 rad ⁻¹ | $(D/C)_w$ | 12.0 % | δ_{min} | 5.0 deg | δ_{max} | | Number c/c | 2 |
| ΔT | 0.0 deg F | $\Delta \delta_w$ | 0.0 deg | C_{δ_w} | 190.00 rad ⁻¹ | $(D/C)_w$ | 12.0 % | δ_{min} | 95.0 deg | δ_{max} | | | |
| U ₁ | 350.00 kts | X_{cm_w} | 23.00 ft | AR _w | 7.00 | C_{δ_w} | 5.7070 rad ⁻¹ | δ_w | -0.04 deg | Number δ_w | 2 | | |
| S_w | 837.00 m ² | X_{cp} | 24.32 ft | S_w | 1.00 | X_{cm_w} | 61.30 ft | $(g\delta/C)_w$ | 0.00 % | $(C_u/C_w)_{\text{min}}$ | | | |
| AR _w | 8.00 | C_{δ_w} | 6.2504 rad ⁻¹ | δ_{min} | 1.0000 | C_u/C_w | 28.5 % | Balance _w | 0.05 | $(C_u/C_w)_{\text{max}}$ | | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | C_{δ_w} | 7.7681 rad ⁻¹ | δ_w | 0.0040 | C_w | 1.0000 | δ_{min} | 0.4231 | δ_{max} | 0.4231 | C_{δ_w} | 0.0012 |
| C_{δ_w} | 7.7681 rad ⁻¹ | δ_w | 0.0702 | δ_{min} | -4.5884 rad ⁻¹ | S_w | 1.00 | C_{δ_w} | -1.9416 rad ⁻¹ | C_{δ_w} | -1.9416 rad ⁻¹ | | |

Fig. 75 Elevator related derivatives

Aileron Related Derivatives: Flight Condition 1

Output Parameter

C_{δ_a}

0.0000

 rad^{-1}

Fig. 76 Aileron related derivatives

| Aileron Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | |
|---|--------------------------|-------------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|--------------------------|--------------------------|--|--|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | δ_w | 0.60 | C_{δ_w} | 6.3598 rad ⁻¹ | δ_{min} | 98.0 deg | δ_{max} | 0.0 deg | $(C_u/C_w)_{\text{min}}$ | | | |
| ΔT | 0.0 deg F | $\Delta \delta_w$ | 0.0 deg | C_{δ_w} | 6.3598 rad ⁻¹ | $(g\delta/C)_w$ | 2.00 % | Number δ_w | 3 | $(C_u/C_w)_{\text{max}}$ | | | |
| U ₁ | 350.00 kts | $(D/C)_w$ | 12.00 % | C_u/C_w | 23.8 % | Balance _w | 0.05 | δ_{min} | | Number c/c | 2 | | |
| AR _w | 8.00 | $(D/C)_w$ | 12.00 % | δ_{min} | 60.0 % | δ_{max} | 1.0000 | δ_{min} | | δ_{max} | | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | C_{δ_w} | 7.9041 rad ⁻¹ | δ_w | 0.85 | C_w | 0.0000 | C_w | 1.0000 | C_{δ_w} | 0.1629 rad ⁻¹ | | |
| R_1 | 155.41 deg | δ_w | 0.0 deg | C_{δ_w} | 0.0000 | C_w | 1.0000 | C_{δ_w} | 0.0814 rad ⁻¹ | | | | |
| C_{δ_w} | 7.9041 rad ⁻¹ | δ_w | 0.00 deg | C_w | 0.0000 | C_{δ_w} | 0.0814 rad ⁻¹ | C_{δ_w} | 0.1629 rad ⁻¹ | | | | |

Fig. 77 Aileron related derivatives

| Aileron Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|---|--------|-------------------|------------------|--------|-------------------|---------------------|--------|---------------------|---------------|-------------------|-------------------|----------------------|--------|----------------|-------------------|--------|------------------|---------------|---------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | $\delta_{a,max}$ | -3.0 | deg | AR _a | 8.00 | $\beta C_{L_{a,0}}$ | 12.00 | % | $\beta_{a,0}$ | 60.0 | % | $\delta_{a,0}$ | 1.0000 | deg | $\delta_{a,max}$ | | deg | |
| δT | 0.0 | deg F | $\delta_{a,0}$ | -1.0 | deg | $\delta_{a,0}$ | 0.60 | $C_{L_{a,0}}$ | 6.3598 | rad ⁻¹ | $\beta_{a,0}$ | 98.0 | % | $\delta_{a,0}$ | 0.0 | deg | $\delta_{a,max}$ | | deg | |
| U ₁ | 350.00 | ft/s | $C_{L_{a,0}}$ | 5.3706 | rad ⁻¹ | $\delta_{a,0}$ | 0.0 | deg | $C_{L_{a,0}}$ | 6.3598 | rad ⁻¹ | $\beta_{a,0}$ | 2.00 | % | $K_{a,0}$ | 1.0 | | | | |
| α | 0.00 | deg | S_a | 837.00 | ft ² | $\beta C_{L_{a,0}}$ | 12.00 | % | $C_{L_{a,0}}$ | 23.8 | % | Balance _a | 0.05 | | Number δ_a | 3 | | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M ₁ | 0.594 | | $C_{L_{a,0}}$ | 7.9041 | rad ⁻¹ | $\delta_{a,0}$ | 0.00 | deg | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | -0.0044 | rad ⁻¹ |
| β | 155.41 | deg | $C_{L_{a,0}}$ | 0.1875 | | $\delta_{a,0}$ | 0.05 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | -0.0044 | rad ⁻¹ |
| $C_{L_{a,0}}$ | 7.9041 | rad ⁻¹ | $\delta_{a,0}$ | 0.0 | deg | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | | $C_{L_{a,0}}$ | 0.0000 | rad ⁻¹ |

Fig. 78 Aileron related derivatives

| Rudder Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|--------|-----------------|---------------|--------|-------------------|-----------------|---------|-------------------|---------------------|---------|-------------------|---------------|---------|-------------------|----------------------|------|------------------|--|-----|--|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| Altitude | 30000 | ft | S_r | 190.00 | ft ² | AR _r | 3.00 | $\delta_{r,max}$ | 1.00 | deg | $\beta_{r,0}$ | 2.00 | % | $\delta_{r,0}$ | 0.82 | deg | $\delta_{r,max}$ | | deg | |
| δT | 0.0 | deg F | $X_{r,0}$ | 61.30 | ft | $\delta_{r,0}$ | 0.80 | deg | $\beta C_{L_{r,0}}$ | 12.0 | % | $\beta_{r,0}$ | 1.000 | | $\beta_{r,0}$ | 2.00 | % | | | |
| U ₁ | 350.00 | ft/s | $Z_{r,0}$ | 6.00 | ft | $\delta_{r,0}$ | 5.0 | deg | $\beta C_{L_{r,0}}$ | 12.0 | % | $C_{L_{r,0}}$ | 28.5 | % | Balance _r | 0.05 | | | | |
| S_r | 837.00 | ft ² | $Z_{r,0}$ | 5.00 | ft | $C_{L_{r,0}}$ | 6.2800 | rad ⁻¹ | $X_{r,0}$ | 60.00 | ft | $\beta_{r,0}$ | 5.0 | % | Number δ_r | 2 | | | | |
| AR _r | 8.00 | | S_r | 137.00 | ft ² | $C_{L_{r,0}}$ | 6.2800 | rad ⁻¹ | $Z_{r,0}$ | 15.00 | ft | $\beta_{r,0}$ | 95.0 | % | $\delta_{r,0}$ | | deg | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M ₁ | 0.594 | | $C_{L_{r,0}}$ | 7.8049 | rad ⁻¹ | $C_{L_{r,0}}$ | -4.5029 | rad ⁻¹ | $\delta_{r,0}$ | 0.85 | | $\beta_{r,0}$ | -0.4356 | | | | | | | |
| β | 155.41 | deg | $C_{L_{r,0}}$ | 7.8049 | rad ⁻¹ | $K_{L_{r,0}}$ | 0.2760 | | $\beta_{r,0}$ | -0.4356 | | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | | | | | | |
| AR _{r,0}} | 4.32 | | $C_{L_{r,0}}$ | 7.8049 | rad ⁻¹ | $K_{L_{r,0}}$ | 1.0000 | | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | $C_{L_{r,0}}$ | 0.0000 | | | | | | | |

Fig. 79 Rudder related derivatives

| Rudder Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|--------|-------------------|---------------|--------|-------------------|-----------------|--------|-----------------|----------------|-----|---------------|---------------|------|----------------------|----------------|------|-------------------|------------------|-----|-----|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| α | 0.00 | deg | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | AR _r | 8.00 | L_r | 0.80 | | $Z_{r,0}$ | 15.00 | ft | $\beta_{r,0}$ | 95.0 | % | Number δ_r | 2 | | |
| $X_{r,0}$ | 24.32 | ft | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | S_r | 137.00 | ft ² | $\delta_{r,0}$ | 5.0 | deg | $C_{L_{r,0}}$ | 28.5 | % | $\delta_{r,0}$ | 0.82 | deg | $\delta_{r,max}$ | | deg |
| $Z_{r,0}$ | 2.95 | ft | S_r | 837.00 | ft ² | AR _r | 3.00 | $X_{r,0}$ | 60.00 | ft | $\beta_{r,0}$ | 5.0 | % | Balance _r | 0.05 | | $\delta_{r,max}$ | | deg | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| $C_{L_{r,0}}$ | 0.0726 | rad ⁻¹ | $C_{L_{r,0}}$ | 0.0726 | rad ⁻¹ | $C_{L_{r,0}}$ | 0.0000 | | | | | | | | | | | | | |

Fig. 80 Rudder related derivatives

| Rudder Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|---------|-------------------|---------------|---------|-------------------|-----------------|--------|-----------------|----------------|-----|---------------|---------------|------|----------------------|----------------|------|-------------------|------------------|-----|-----|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| α | 0.00 | deg | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | AR _r | 8.00 | L_r | 0.80 | | $Z_{r,0}$ | 15.00 | ft | $\beta_{r,0}$ | 95.0 | % | Number δ_r | 2 | | |
| $X_{r,0}$ | 24.32 | ft | $C_{L_{r,0}}$ | 0.2717 | rad ⁻¹ | S_r | 137.00 | ft ² | $\delta_{r,0}$ | 5.0 | deg | $C_{L_{r,0}}$ | 28.5 | % | $\delta_{r,0}$ | 0.82 | deg | $\delta_{r,max}$ | | deg |
| $Z_{r,0}$ | 2.95 | ft | S_r | 837.00 | ft ² | AR _r | 3.00 | $X_{r,0}$ | 60.00 | ft | $\beta_{r,0}$ | 5.0 | % | Balance _r | 0.05 | | $\delta_{r,max}$ | | deg | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| $C_{L_{r,0}}$ | -0.1380 | rad ⁻¹ | $C_{L_{r,0}}$ | -0.1380 | rad ⁻¹ | $C_{L_{r,0}}$ | 0.0000 | | | | | | | | | | | | | |

Fig. 81 Rudder related derivatives

B. AAA: Static Stability and One Engine Inoperative Analyses

| Angle of Attack Related Derivatives: Pitching Moment: Flight Condition 1 | | | | | | | | | | | | | |
|--|-------------------------|-------------------|-------------------------|--------------|-------------------------|-------------------|-------------------------|------------------|-------------------------|--------------------|-------------------------|-----------------|--------------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | α_{trim} | 0.93 | X_{trim} | 23.00 ft | S_w | 190.00 ft ² | Y_{trim} | 0.00 ft | η_{trim} | 1.000 | D_{trim} | 6.83 ft |
| ΔT | 0.0 deg F | S_w | 837.00 ft ² | Y_{trim} | 0.00 ft | ARL | 7.00 | $(PCL)_w$ | 12.0 % | $\delta_{sw,trim}$ | 6.2504 rad ¹ | ΔC_{Lw} | -0.0451 |
| U_1 | 350.00 kts | ARL | 8.00 | $(PCL)_w$ | 12.00 % | l_w | 1.00 | $(PCL)_w$ | 12.0 % | $\delta_{sw,trim}$ | 6.2504 rad ¹ | X_{ref} | 24.32 ft |
| $\delta_{sw,trim}$ | 6.3598 rad ¹ | l_w | 0.60 | $(PCL)_w$ | 12.00 % | $\Delta \alpha_w$ | 0.0 deg | Z_{ref} | 6.00 ft | f_{trim} | 1.00 | | |
| $\delta_{sw,trim}$ | 6.3598 rad ¹ | $\Delta \alpha_w$ | 0.0 deg | Z_{ref} | 2.00 ft | X_{trim} | 60.00 ft | Γ_w | 0.0 deg | W_1 | 2.00 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | $C_{m,w}$ | 7.9041 rad ¹ | $C_{m,w}$ | 5.3706 rad ¹ | $X_{ref,up}$ | 0.2049 | Z_{ref} | 3.6121 | $\delta_{sw,up}$ | 0.3931 | SM | 56.96 % |
| \dot{w}_1 | 155.41 ft/s | $C_{m,w}$ | 7.9041 rad ¹ | $C_{m,w}$ | 5.3724 rad ¹ | $C_{m,w}$ | 7.7681 rad ¹ | $C_{m,w}$ | 5.7070 rad ¹ | \dot{w}_1 | 0.8040 | $C_{m,up}$ | 6.1586 rad ¹ |
| \dot{w}_w | 0.0702 | $C_{m,w}$ | 7.9041 rad ¹ | Z_{ref} | 26.20 ft | $C_{m,w}$ | 7.7681 rad ¹ | $C_{m,w}$ | 0.7862 rad ¹ | X_{ref} | 30.27 ft | $C_{m,w}$ | 6.1586 rad ¹ |
| \dot{w}_w | 10.44 | $C_{m,w,down}$ | 5.3706 rad ¹ | Z_{ref} | 0.2500 | $C_{m,w}$ | 7.7681 rad ¹ | Z_{ref} | 6.00 ft | $Z_{ref,up}$ | 0.6399 | $C_{m,up}$ | -3.5082 rad ¹ |
| X_{trim} | 0.59 | $C_{m,w,down}$ | 5.3724 rad ¹ | $Z_{ref,up}$ | 25.73 ft | X_{trim} | 61.30 ft | $\delta_{sw,up}$ | 0.3931 | Z_{ref} | 0.6399 | $C_{m,w}$ | -3.5082 rad ¹ |
| High Lift Devices Table | | | | | | | | | | | | | |
| # | High Lift Device | η_1 % | η_0 % | c/l_c % | deg | | | | | | | | |
| 1 | Single Slotted Flap | 0.0 | 55.5 | 30.0 | 0.0 | | | | | | | | |

Fig. 82 Angle of attack related derivatives

| Sideslip Related Derivatives: Yawing Moment: Flight Condition 1 | | | | | | | | | | | | | |
|---|---------------------------|--------------------|-------------------------|-------------------|--------------------------|------------------------|--------------------------|-----------|-------------------------|---------------|-------------------------|------------|---------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | l_w | 0.60 | Z_{ref} | 6.00 ft | X_{trim} | 60.00 ft | $(PCL)_w$ | 12.0 % | Z_{ref} | 2.95 ft | X_{trim} | 0.00 ft |
| ΔT | 0.0 deg F | $\Delta \alpha_w$ | 0.0 deg | Z_{ref} | 5.00 ft | Z_{trim} | 15.00 ft | η_w | 1.000 | R_{sw} | 383.07 ft ² | | |
| U_1 | 350.00 kts | $Z_{ref,w}$ | 2.00 ft | S_w | 137.00 ft ² | $C_{m,trim}$ | 6.2800 rad ¹ | h | 55.00 ft | η_{sw} | 6.78 ft | | |
| α | 0.0 deg | $Z_{ref,w}$ | 2.50 ft | ARL | 3.00 | $C_{m,trim}$ | 6.2800 rad ¹ | η_w | 2.50 ft | η_{sw} | 5.00 ft | | |
| S_w | 837.00 ft ² | S_w | 190.00 ft ² | l_w | 0.60 | f_{trim} | 1.00 | η_w | 2.00 ft | η_{trim} | 2.00 ft | | |
| ARL | 8.00 | X_{trim} | 61.30 ft | $\Delta \alpha_w$ | 5.0 deg | $(PCL)_w$ | 12.0 % | X_{ref} | 24.32 ft | W_{trim} | 6.78 ft | | |
| Output Parameters | | | | | | | | | | | | | |
| M_1 | 0.594 | Z_{ref} | 24.76 ft | $C_{m,w}$ | 7.8049 rad ¹ | ARL | 0.2760 | $K_{m,w}$ | -0.00029 | $C_{m,w}$ | 0.3897 rad ¹ | | |
| R_{sw} | 93.1248 x 10 ³ | ARL _{ref} | 4.32 | $C_{m,w}$ | 7.8049 rad ¹ | $(\partial C_{m,w})_w$ | -0.1264 | $K_{m,w}$ | 1.92878 | $C_{m,w}$ | 0.3995 rad ¹ | | |
| X_{trim} | 62.73 ft | $C_{m,w}$ | 7.8049 rad ¹ | $C_{m,w}$ | -4.5029 rad ¹ | $C_{m,w}$ | -0.8302 rad ¹ | $C_{m,w}$ | 0.0098 rad ¹ | | | | |

Fig. 83 Sideslip related derivatives

| Rudder Related Derivatives: Flight Condition 1 | | | | | | | | | | | | | |
|--|--------------------------|-----------|--------------------------|----------------|------------------------|-------------------|----------|------------|----------|----------|----------|-----------------|-----|
| Input Parameters | | | | | | | | | | | | | |
| δ | 0.00 deg | $C_{m,w}$ | 0.2717 rad ¹ | ARL | 8.00 | l_w | 0.60 | Z_{trim} | 15.00 ft | η_w | 95.0 % | Number of | 2 |
| X_{ref} | 24.32 ft | $C_{m,w}$ | 0.2717 rad ¹ | S_w | 137.00 ft ² | $\Delta \alpha_w$ | 5.0 deg | c/l_c | 28.5 % | δ | 0.82 deg | δ_{trim} | deg |
| Z_{ref} | 2.95 ft | S_w | 837.00 ft ² | ARL | 3.00 | X_{trim} | 60.00 ft | η_w | 5.0 % | Balance | 0.05 | δ_{trim} | deg |
| Output Parameters | | | | | | | | | | | | | |
| $C_{m,w}$ | -0.1380 rad ¹ | $C_{m,w}$ | -0.1380 rad ¹ | $C_{m,rudder}$ | 0.0000 | | | | | | | | |

Fig. 84 Rudder related derivatives

| Engine Out Control: Flight Condition 1 | | | | | | | | | | | | | |
|--|---------------|-----------------------|----------------------|----------------------|------------------------|-----------------------|-------------------------------|------------------------|---------------------|-------------------------|---------------------------|-----------------------|-----------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | ΔT | 0.0 deg F | S_w | 837.00 ft ² | AR_w | 8.00 | V_{is} | 350.00 kts | C_{D_0} | -0.1380 rad ⁻¹ | | |
| Output Parameters | | | | | | | | | | | | | |
| V_{ic} | 420.00 kts | δ_c | 0.28 deg | | | | | | | | | | |
| Propeller Table | | | | | | | | | | | | | |
| # | Type | SHP _{set} hp | X _{prop} ft | Y _{prop} ft | Z _{prop} ft | i _{prop} deg | φ _{prop} deg | η _{prop} | K _{loss} % | C _{D prop w/m} | C _{D prop stop} | P _{avail} hp | T _{avail} lb |
| 1 | Propeller: On | 1555 | 22.00 | 9.01 | 4.00 | 7.0 | 0.0 | 0.850 | 5.7 | 0.0000 | 0.0000 | 1246 | 1160 |
| 2 | Propeller: On | 0 | 22.00 | -9.01 | 4.00 | 7.0 | 0.0 | 0.850 | 5.7 | 0.0000 | 0.0000 | 0 | 0 |

Fig. 85 One engine out at cruise altitude and speed

| Engine Out Control: Flight Condition 1 | | | | | | | | | | | | | |
|--|---------------|-----------------------|----------------------|----------------------|------------------------|-----------------------|-------------------------------|------------------------|---------------------|-------------------------|---------------------------|-----------------------|-----------------------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 7000 ft | ΔT | 0.0 deg F | S_w | 837.00 ft ² | AR_w | 8.00 | V_{is} | 140.00 kts | C_{D_0} | -0.1380 rad ⁻¹ | | |
| Output Parameters | | | | | | | | | | | | | |
| V_{ic} | 168.00 kts | δ_c | 0.82 deg | | | | | | | | | | |
| Propeller Table | | | | | | | | | | | | | |
| # | Type | SHP _{set} hp | X _{prop} ft | Y _{prop} ft | Z _{prop} ft | i _{prop} deg | φ _{prop} deg | η _{prop} | K _{loss} % | C _{D prop w/m} | C _{D prop stop} | P _{avail} hp | T _{avail} lb |
| 1 | Propeller: On | 1555 | 22.00 | 9.01 | 4.00 | 7.0 | 0.0 | 0.850 | 5.7 | 0.0000 | 0.0000 | 1246 | 1160 |
| 2 | Propeller: On | 0 | 22.00 | -9.01 | 4.00 | 7.0 | 0.0 | 0.850 | 5.7 | 0.0000 | 0.0000 | 0 | 0 |

Fig. 86 One engine out at takeoff altitude and speed

C. AAA: Transfer Function and Flying Quality Analyses

| Computation of Longitudinal Transfer Functions: Flight Condition 1 | | | | | | | | | | | | |
|--|-------------------------|------------------------|------------------------------|-------------------------|----------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|--|
| Input Parameters | | | | | | | | | | | | |
| Altitude | 30000 ft | α | 0.00 deg | C_{m_0} | 0.0106 | $C_{m_{\dot{\alpha}}}$ | 0.0038 | $C_{m_{\ddot{\alpha}}}$ | 3.6077 rad ⁻¹ | $C_{m_{\dot{\omega}_y}}$ | 0.0177 | |
| ΔT | 0.0 deg F | γ | 0.0 deg | $C_{m_{\dot{\gamma}}}$ | -3.5082 rad ⁻¹ | $C_{m_{\ddot{\gamma}}}$ | -0.0251 rad ⁻¹ | $C_{m_{\dot{\omega}_z}}$ | 14.1354 rad ⁻¹ | $C_{m_{\ddot{\omega}_z}}$ | -0.0531 | |
| V_{is} | 350.00 kts | C_{L_0} | 10.44 | $C_{L_{\dot{\alpha}}}$ | -12.7779 rad ⁻¹ | $C_{L_{\ddot{\alpha}}}$ | 0.1076 | $C_{L_{\dot{\omega}_y}}$ | 0.0177 | $C_{L_{\ddot{\omega}_y}}$ | 0.5482 rad ⁻¹ | |
| W_{curves} | 37689.0 lb | η_{sp} | 51880.2 skip-ft ² | $C_{L_{\dot{\gamma}}}$ | -32.5032 rad ⁻¹ | $C_{L_{\ddot{\gamma}}}$ | 0.0586 | $C_{L_{\dot{\omega}_z}}$ | 0.0972 rad ⁻¹ | $C_{L_{\ddot{\omega}_z}}$ | 0.0087 rad ⁻¹ | |
| S_w | 837.00 ft ² | $C_{m_{\dot{\alpha}}}$ | 0.0013 | $C_{m_{\ddot{\alpha}}}$ | -0.0013 | $C_{m_{\dot{\omega}_y}}$ | 6.1506 rad ⁻¹ | $C_{m_{\ddot{\omega}_y}}$ | 0.0000 | $C_{m_{\dot{\omega}_z}}$ | -1.9416 rad ⁻¹ | |
| Output Parameters | | | | | | | | | | | | |
| M ₀ | 0.594 | K_a | 1.1436 s ⁻¹ | M _z | 0.0001 s ⁻¹ | B_{amp} | 6860.1 | C_{sp} | 0.501 | TC_{amp_2} | s | |
| δ_1 | 155.41 s ⁻¹ | Z ₁ | -0.0510 s ⁻¹ | M _w | -91.8437 s ⁻² | C_{amp} | 58549.8 | δ_{amp} | 0.0530 s ⁻¹ | TC_{amp_3} | s | |
| W _D | 45.03 s ⁻¹ | Z ₂ | -679.4278 s ⁻¹ | M _u | -0.6576 s ⁻² | D_{amp} | 595.4 | $C_{\text{f amp}}$ | 0.093 | TC_{amp_4} | s | |
| θ | 0.0 deg | Z ₃ | -3.5074 s ⁻¹ | M _v | -2.9565 s ⁻¹ | E_{amp} | 164.2 | δ_{sp} | s ⁻¹ | $N_{\dot{\alpha}}$ | -0.9516 s ⁻¹ | |
| $K_{\dot{\alpha}}$ | -0.0066 s ⁻¹ | Z ₄ | -13.7427 s ⁻¹ | M _z | -7.5205 s ⁻¹ | R_{amp} | 23122011400.2 | ζ_{sp} | | Z ₅ | -60.3020 s ⁻¹ | |
| $K_{\ddot{\alpha}}$ | -0.0033 s ⁻¹ | M _z | 0.0006 s ⁻¹ | A_{amp} | 594.2 | δ_{amp} | 9.9203 s ⁻¹ | TC_{amp_5} | s | M _v | -50.8298 s ⁻² | |

Fig. 87 Longitudinal transfer functions, frequencies, and damping

| Lateral-Directional Transfer Functions: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|----------|---------------------|---------------------|-----------|-----------------|--------------------|----------|---------------------|----------------------|------------|-------------------|----------------------|---------|-------------------|---------------------------|---------|-------------------|---------------|---------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| W_{inert} | 37689.0 | b | S_w | 837.00 | m ² | h_{cg} | 200121.1 | skip-m ² | $C_{y\delta}$ | -0.5259 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.0193 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | -0.1342 | rad ⁻¹ | $C_{y\delta}$ | -0.0044 | rad ⁻¹ |
| Altitude | 30000 | ft | θ | 0.0 | deg | h_{cg} | 245693.0 | skip-m ² | $C_{y\delta}$ | 0.2663 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.3678 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.7794 | rad ⁻¹ | | | |
| ΔT | 0.0 | deg F | α | 0.00 | deg | h_{cg} | 4375.6 | skip-m ² | $C_{y\delta}$ | 0.3995 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.9179 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.0000 | rad ⁻¹ | | | |
| U_1 | 350.00 | fts | S_w | 81.83 | ft | $C_{y\delta}$ | -0.3025 | rad ⁻¹ | $C_{y\dot{\delta}}$ | 0.0000 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.0000 | rad ⁻¹ | $C_{y\delta}$ | 0.1629 | rad ⁻¹ | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | Y_{δ} | -100.9699 | $\frac{1}{s^2}$ | L_{δ} | 0.9809 | s ⁻¹ | $B_{e,\delta}$ | 1887.7 | | G_{δ} | 0.138 | | $TC_{conv,\delta}$ | | s | | | |
| ξ_1 | 155.41 | $\frac{1}{s}$ | $Y_{\dot{\delta}}$ | 0.0000 | $\frac{1}{s}$ | N_{δ} | 17.3067 | s ⁻² | $C_{e,\delta}$ | 11539.0 | | $B_{e,\dot{\delta}}$ | | $\frac{1}{s}$ | $TC_{conv,\dot{\delta}}$ | | s | | | |
| WS | 45.03 | $\frac{1}{s}$ | $Y_{\ddot{\delta}}$ | -1.0227 | $\frac{1}{s}$ | $N_{\dot{\delta}}$ | 0.0000 | s ⁻² | $D_{e,\delta}$ | 20872.2 | | $C_{f,conv,\delta}$ | | | $TC_{conv,\ddot{\delta}}$ | | s | | | |
| h_{cg} | 200121.1 | skip-m ² | Y_{δ} | 5.9385 | $\frac{1}{s^2}$ | N_{δ} | -0.0578 | s ⁻¹ | $E_{e,\delta}$ | 24.8 | | T_{δ} | 839.642 | s | $Y_{\dot{\delta}}$ | 0.0000 | $\frac{1}{s}$ | | | |
| h_{cg} | 245693.0 | skip-m ² | L_{δ} | -16.0899 | s ⁻² | $N_{\dot{\delta}}$ | -1.1036 | s ⁻¹ | $R_{e,\delta}$ | 1972936812 | 6.6 | T_{δ} | 0.487 | s | $L_{\dot{\delta}}$ | 8.6636 | s ⁻² | | | |
| h_{cg} | 4375.6 | skip-m ² | L_{δ} | -1.9372 | s ⁻¹ | $A_{e,\delta}$ | 590.5 | | $B_{e,\dot{\delta}}$ | 4.1464 | $\frac{1}{s}$ | $TC_{conv,\delta}$ | | s | $N_{\dot{\delta}}$ | -0.1923 | s ⁻² | | | |

Fig. 88 Lateral-directional transfer functions, frequencies, and damping response to ailerons

| Lateral-Directional Transfer Functions: Flight Condition 1 | | | | | | | | | | | | | | | | | | | | |
|--|----------|---------------------|---------------------|-----------|-----------------|--------------------|----------|---------------------|----------------------|------------|-------------------|----------------------|---------|-------------------|---------------------------|---------|-------------------|---------------|---------|-------------------|
| Input Parameters | | | | | | | | | | | | | | | | | | | | |
| W_{inert} | 37689.0 | b | S_w | 837.00 | m ² | h_{cg} | 200121.1 | skip-m ² | $C_{y\delta}$ | -0.5259 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.0193 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | -0.1342 | rad ⁻¹ | $C_{y\delta}$ | -0.1380 | rad ⁻¹ |
| Altitude | 30000 | ft | θ | 0.0 | deg | h_{cg} | 245693.0 | skip-m ² | $C_{y\delta}$ | 0.2663 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.3678 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.7794 | rad ⁻¹ | | | |
| ΔT | 0.0 | deg F | α | 0.00 | deg | h_{cg} | 4375.6 | skip-m ² | $C_{y\delta}$ | 0.3995 | rad ⁻¹ | $C_{y\dot{\delta}}$ | -0.9179 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.2717 | rad ⁻¹ | | | |
| U_1 | 350.00 | fts | S_w | 81.83 | ft | $C_{y\delta}$ | -0.3025 | rad ⁻¹ | $C_{y\dot{\delta}}$ | 0.0000 | rad ⁻¹ | $C_{y\ddot{\delta}}$ | 0.0000 | rad ⁻¹ | $C_{y\delta}$ | 0.0726 | rad ⁻¹ | | | |
| Output Parameters | | | | | | | | | | | | | | | | | | | | |
| M_1 | 0.594 | | Y_{δ} | -100.9699 | $\frac{1}{s^2}$ | L_{δ} | 0.9809 | s ⁻¹ | $B_{e,\delta}$ | 1887.7 | | G_{δ} | 0.138 | | $TC_{conv,\delta}$ | | s | | | |
| ξ_1 | 155.41 | $\frac{1}{s}$ | $Y_{\dot{\delta}}$ | 0.0000 | $\frac{1}{s}$ | N_{δ} | 17.3067 | s ⁻² | $C_{e,\delta}$ | 11539.0 | | $B_{e,\dot{\delta}}$ | | $\frac{1}{s}$ | $TC_{conv,\dot{\delta}}$ | | s | | | |
| WS | 45.03 | $\frac{1}{s}$ | $Y_{\ddot{\delta}}$ | -1.0227 | $\frac{1}{s}$ | $N_{\dot{\delta}}$ | 0.0000 | s ⁻² | $D_{e,\delta}$ | 20872.2 | | $C_{f,conv,\delta}$ | | | $TC_{conv,\ddot{\delta}}$ | | s | | | |
| h_{cg} | 200121.1 | skip-m ² | Y_{δ} | 5.9385 | $\frac{1}{s^2}$ | N_{δ} | -0.0578 | s ⁻¹ | $E_{e,\delta}$ | 24.8 | | T_{δ} | 839.642 | s | $Y_{\dot{\delta}}$ | 29.8864 | $\frac{1}{s}$ | | | |
| h_{cg} | 245693.0 | skip-m ² | L_{δ} | -16.0899 | s ⁻² | $N_{\dot{\delta}}$ | -1.1036 | s ⁻¹ | $R_{e,\delta}$ | 1972936812 | 6.6 | T_{δ} | 0.407 | s | $L_{\dot{\delta}}$ | 3.8637 | s ⁻² | | | |
| h_{cg} | 4375.6 | skip-m ² | L_{δ} | -1.9372 | s ⁻¹ | $A_{e,\delta}$ | 590.5 | | $B_{e,\dot{\delta}}$ | 4.1464 | $\frac{1}{s}$ | $TC_{conv,\delta}$ | | s | $N_{\dot{\delta}}$ | -5.9794 | s ⁻² | | | |

Fig. 89 Lateral-directional transfer functions, frequencies, and damping response to rudder

| Longitudinal Mode Checking Flight Phase Category B: Flight Condition 1 | | | | | | | | |
|--|-----------|---------------|----------------|-------|---|--------------------------|---------|----|
| Input Parameters | | | | | | | | |
| ω_{SP} | 9.9203 | $\frac{1}{s}$ | ζ_{SP} | 0.581 | | Altitude | 30000 | ft |
| ω_{Phug} | 0.0530 | $\frac{1}{s}$ | ζ_{Phug} | 0.093 | | | | |
| Z_{ω} | -679.4278 | $\frac{1}{s}$ | | | | | | |
| Output Parameters | | | | | | | | |
| n_{IX} | 21.316 | $\frac{1}{s}$ | T_{SP} | | s | T_{Phug} | 140.700 | s |
| | | | | | | Level ζ_{SP} = 1 | | |
| | | | | | | Level ζ_{Phug} = 1 | | |
| | | | | | | Level ω_{SP} = 2 | | |

Fig. 90 Longitudinal mode frequencies, phugoid and short period flying quality levels

| Roll Mode Performance Checking Flight Phase Category B, Cruise: Flight Condition 1 | | | | | | | | | | | | | |
|--|-----------|----------------------|-----------------------|-----------------|------------------------------|---------------|--------------------------|--------------------|----------|------------------|----------|------------------|-------|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | U_1 | 350.00 kts | b_w | 81.83 ft | C_{Dp} | -0.5259 rad ¹ | $C_{D/C_{D0}}$ | 23.8 % | $\delta_{1,max}$ | 25.0 deg | $\delta_{1,min}$ | 1.9 s |
| δT | 0.0 deg F | S_w | 837.00 m ² | h_{10} | 200121.1 slug-m ² | $C_{D_{ref}}$ | 0.1429 rad ¹ | $\delta_{1,max}^2$ | 25.0 deg | T_{10} | 0.487 s | | |
| Output Parameters | | | | | | | | | | | | | |
| Level $T_{10} = 1$ | | Level $\delta_1 = 1$ | | θ_{roll} | 115.3 deg | | | | | | | | |

Fig. 91 Roll mode performance and flying quality level

| Spiral and Dutch Roll Mode Checking Flight Phase Category B, Cruise: Flight Condition 1 | | | | | | | | | | | | | |
|---|------------|----------|------------------------------|----------|------------------------------|--------------------------|--------------------------|---------------------|--------------------------|-------------------------|-----------|-------------------------|--|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | S_w | 837.00 m ² | h_{10} | 245693.0 slug-m ² | C_{Dp} | -0.0193 rad ¹ | C_{Dp} | -0.5259 rad ¹ | ζ_D | 0.138 | | |
| δT | 0.0 deg F | b_w | 81.83 ft | h_{10} | 4375.6 slug-m ² | C_{Dp} | -0.3678 rad ¹ | C_{Dp} | 0.2663 rad ¹ | T_{10} | 839.642 s | | |
| U_1 | 350.00 kts | h_{10} | 200121.1 slug-m ² | C_{Dp} | 0.3995 rad ¹ | C_{Dp} | -0.3025 rad ¹ | θ_{D0} | 4.1464 deg | | | | |
| Output Parameters | | | | | | | | | | | | | |
| θ_{D0} | 0.8797 | T_{10} | | T_{10} | 581.996 s | Level $\zeta_D =$ Stable | | Level $\zeta_D = 1$ | | Level $\theta_{D0} = 1$ | | Level $\theta_{D0} = 1$ | |

Fig. 92 Spiral and dutch roll fling quality levels

| Spiral and Dutch Roll Mode Checking Flight Phase Category B, Cruise: Flight Condition 1 | | | | | | | | | | | | | |
|---|------------|----------|------------------------------|----------|------------------------------|--------------------------|--------------------------|---------------------|--------------------------|-------------------------|-----------|-------------------------|--|
| Input Parameters | | | | | | | | | | | | | |
| Altitude | 30000 ft | S_w | 837.00 m ² | h_{10} | 245693.0 slug-m ² | C_{Dp} | -0.0193 rad ¹ | C_{Dp} | -0.5259 rad ¹ | ζ_D | 0.138 | | |
| δT | 0.0 deg F | b_w | 81.83 ft | h_{10} | 4375.6 slug-m ² | C_{Dp} | -0.3678 rad ¹ | C_{Dp} | 0.2663 rad ¹ | T_{10} | 839.642 s | | |
| U_1 | 350.00 kts | h_{10} | 200121.1 slug-m ² | C_{Dp} | 0.3995 rad ¹ | C_{Dp} | -0.3025 rad ¹ | θ_{D0} | 4.1464 deg | | | | |
| Output Parameters | | | | | | | | | | | | | |
| θ_{D0} | 0.8797 | T_{10} | | T_{10} | 581.996 s | Level $\zeta_D =$ Stable | | Level $\zeta_D = 1$ | | Level $\theta_{D0} = 1$ | | Level $\theta_{D0} = 1$ | |

Fig. 93 Spiral and dutch roll fling quality levels