HYBRID LTA VEHICLE CONTROLLABILITY AS AFFECTED BY THRUSTER MAGNITUDE AND SPACING

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Donald N. Meyers

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PREPARED FOR

NAVAL AIR DEVELOPMENT CENTER
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Hybrid LTA Vehicle Controllability as Affected by Thruster Magnitude and Spacing

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                                     Lighter-than-air (LTA)
                                     Maneuverability |
| 20. ABSTRACT (CONTINUE ON REVERSE SIDE IF NECESSARY AND IDENTIFY BY BLOCK NUMBER) | Results of an analytical investigation are presented which show the effects on low speed maneuverability of several geometric and dynamic parameters of a hybrid lighter-than-air (LTA) vehicle. Important of these parameters are: ratio of static lift to gross weight; relative spacing of vertical thrusters; relative amount and direction of available horizontal thrust. The analysis, which is based on nine "point designs" representation of real
vehicles, takes into account the increased moment of inertia associated with increased spacing of the dynamic thrusters.
PIASECKI HELI-STAT, HEAVY VERTICAL AIR LIFTER
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1. **SUMMARY**

An investigation has been conducted on the effect of geometric and dynamic parameters on the maneuverability of a hybrid lighter-than-air (LTA) vehicle, notably the ratio of longitudinal rotor spacing to overall length, and the ratio of static-lift to gross-weight. Other parameters considered were airspeed, angle of sideslip, and amount of horizontal thrust.

The study was conducted on 4 variations of 9 different vehicle designs forming a matrix with 36 variations in the geometric and dynamic parameters.

A qualitative summary of the effects of these parameters is shown in the chart, Fig. 1. More detailed discussion of these separate effects is given in Section 5, together with graphs showing the various functional relationships.
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<td>SLIGHT DECREASE</td>
<td>NOT INVESTIGATED</td>
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<td>DECREASES</td>
<td>NO INFLUENCE</td>
<td>DECREASES</td>
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<td>NO INFLUENCE</td>
<td>DECREASES</td>
<td>NO INFLUENCE</td>
<td>DECREASES</td>
<td>NOT INVESTIGATED</td>
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<td>DECREASES</td>
<td>DECREASES</td>
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3. **INTRODUCTION**

The ability of Lighter-Than-Air-Vehicles utilizing large fractions of rotor lift to perform precision hovering maneuvers depends on the relative magnitudes of the dynamic thrust forces and their moments, the overall moment of inertia, and the aerodynamic hull moments. Design studies show the desirability to keep the overall length of the vehicle to a minimum for a given payload capability, in order to reduce surface wetted area, structural weight, cost, and mooring space requirements.

Hovering maneuverability is directly related to the ratio of static to rotor lift.

The study effort herein is directed toward reduction of weight empty and construction costs by reduction of rotor-spacing/overall-length ratio, and increasing the static/rotor lift ratio.

Calculations of the controllability for various hybrid configurations with reduced ratio of rotor spacing to overall length are presented.
4. METHODOLOGY

The objective of this investigation was to determine the effects on controllability of hybrid LTA vehicles of buoyancy ratio and longitudinal rotor spacing ratio. These two quantities are both dimensionless ratios, and hence a knowledge of their influence can be applied to a wide variety of designs. However, consideration of other design aspects has shown that several other design variables can have a considerable influence, and if not held constant in the investigation, could mask the influence of buoyancy ratio and rotor spacing ratio. Indeed, these other design variables have a direct bearing on the vehicle mass distribution (thus moment of inertia) and on the effectiveness of available control forces. These aspects are discussed below.

**Size of Aerostat**

Assume that a comparison is to be made between two LTA vehicles of the same displaced volume (e.g. 1,500,000 cu. ft.), the same static lift (e.g. 94,000 lb.), and the same rotor spacing ratio (e.g. rotor spacing is 50% of overall length). However, let the fineness ratios of the two vehicles differ, so that vehicle A is twice as long as vehicle B, and that both vehicles have a moment of inertia distribution which is approximately uniform longitudinally. Then, since
moment of inertia in pitch or yaw varies as $L^2$, where $L$ is vehicle length, the ratio of moment of inertia will be

$$\frac{I_A}{I_B} = (2)^2 = 4$$

or $I_A = 4 I_B$

Control moments which can be developed are equal to the product of the rotor thrust component about the particular axis (assumed the same for both vehicles) times the longitudinal distance from rotor to c.g. Since vehicle A is twice as long as vehicle B, and both have the same rotor spacing ratio, it follows that vehicle A can develop a yawing or pitching moment, $M$, of twice that of vehicle B.

$$M_A = 2 M_B$$

The ratio of control effectiveness of the two vehicles, is measured by angular acceleration, $\alpha$, which is

$$\alpha = \frac{M}{I}$$

$$\frac{\alpha_A}{\alpha_B} = \frac{\frac{M_A}{I_A}}{\frac{M_B}{I_B}} = \frac{\frac{M_A}{I_A}}{\frac{M_B}{I_B}}$$

Substituting $\frac{I_A}{I_B} = 4$, and $\frac{M_A}{M_B} = 2$

$$\frac{\alpha_A}{\alpha_B} = \frac{2}{4} = 0.5$$
Vehicle C can develop one-half the angular acceleration of vehicle D. Thus differences in shape, alone, can mask the effects of either buoyancy ratio or rotor spacing ratio.

A similar situation develops if the fineness ratio is maintained constant, for two vehicles of different overall size, even if rotor spacing ratio and buoyancy ratio are held constant. Assume that vehicle C has twice the aerostat volume, twice the static lift, and twice the dynamic lift of vehicle D, but the same relative shape (fineness ratio).

The ratio of lengths, \( \frac{L_C}{L_D} \), will be approximately

\[
\frac{L_C}{L_D} = (2)^{1/3}
\]

The ratio of moments of inertia, \( \frac{I_C}{I_D} \), will be

\[
\frac{I_C}{I_D} = 2 \left( (2)^{1/3} \right)^2 = (2)^{5/3}
\]

The ratio of control moments, \( \frac{\kappa_C}{\kappa_D} \), will be

\[
\frac{\kappa_C}{\kappa_D} = 2 (2)^{1/3} = (2)^{4/3}
\]

The ratio of control effectiveness, or angular acceleration, will be

\[
\frac{\alpha_C}{\alpha_D} = \frac{\kappa_C \cdot I_D}{\kappa_D \cdot I_C} = \frac{(2)^{4/3}}{(2)^{5/3}} = (2)^{-1/3} = .79
\]
Because of this size effect, the investigation dealt with vehicles which all have the same displaced volume and shape.

**Ballonet Air Volume**

The volume of air in the aerostat ballonets, especially when the ballonets are located in the extreme bow and stern for effective trim control, will have a major effect on pitch and yaw moments of inertia. For example assume two LTA vehicles of identical shape and displaced volume (e.g. 1,500,000 ft$^3$), with the same rotor spacing (hence the same rotor spacing ratio), and operating at the same static lift/gross weight ratio (e.g. 0.5).

Suppose vehicle E is fully inflated with helium, and thus has a static lift of 94,000 lb. Since we have assumed a static lift/gross weight ratio of 0.5, the gross weight will be 188,000 lb., and the rotor lift will be 94,000 lb. The empty weight will probably be of the order of 65,000 lb., and the resulting useful load will be 123,000 lb. The latter will tend to be longitudinally concentrated near the vehicle c.g. and contribute relatively little to the overall vehicle moments of inertia in pitch and yaw.

Now let vehicle F be only 86% inflated with helium with the remaining 14% of the volume consisting of air in forward and aft ballonets. This is representative of a design pressure height of 5,000 feet, where the helium
would expand to fill the entire volume, and the ballonets would be fully collapsed. This vehicle would have a static lift of \( \frac{2}{3} \) of 94,000 lb., or 60,840 lb., and a gross weight of 161,680 lb., since we are holding the static lift/gross weight ratio constant at 0.5. Since the empty weight should be the same as for vehicle E, the useful load will be 96,880 lb., a reduction of 26,320 lb. compared to vehicle E. The air in the ballonets has a mass in excess of the displaced helium (expressed in pounds instead of slugs) equivalent to 14% of 94,000 lb., or 13,160 lb. A comparison of vehicles E and F is shown below:

<table>
<thead>
<tr>
<th>Units</th>
<th>Vehicle E</th>
<th>Vehicle F</th>
<th>Difference</th>
</tr>
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<tr>
<td>Displaced Volume</td>
<td>1,500,000</td>
<td>1,500,000</td>
<td></td>
</tr>
<tr>
<td>Pressure height</td>
<td>5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air in Ballonets</td>
<td>0</td>
<td>210,000</td>
<td>13,160</td>
</tr>
<tr>
<td>Air in Ballonets</td>
<td>13,160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static Lift</td>
<td>94,000</td>
<td>80,840</td>
<td></td>
</tr>
<tr>
<td>Rotor Lift</td>
<td>94,000</td>
<td>80,840</td>
<td></td>
</tr>
<tr>
<td>Gross Weight</td>
<td>188,000</td>
<td>161,680</td>
<td></td>
</tr>
<tr>
<td>Empty Weight</td>
<td>65,000</td>
<td>65,000</td>
<td></td>
</tr>
<tr>
<td>Useful Load</td>
<td>123,000</td>
<td>96,680</td>
<td>-26,320</td>
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Vehicle F has a useful load which is 26,320 lb. less than Vehicle E. However, since the useful load is more or less concentrated near the c.g., its effect on moment of inertia is small. On the other hand, vehicle F has 13,160 lb. of air contained in ballonets located at its extremities. This will cause a significant increase in pitch and yaw moments of inertia. At the same time, the rotor lift (which is vectored for yaw control) has been reduced by 14%. Thus these two vehicles, with the same size, shape, static lift/gross weight ratio, and rotor spacing ratio, will be significantly different in controllability.

To avoid this influence, the investigation dealt with a standardized pressure height of 5,000 feet, equivalent to a sea level helium inflation of 86%, with 14% of the volume consisting of air in ballonets located at the bow and stern.

**Rotor Diameter**

For reasons discussed above, the investigation has dealt with hybrid vehicles, all of which have aerostats of the same volume, shape, and static lift. It follows that variation of the static lift/gross weight ratio must involve variation of gross weight, and hence rotor lift. The question then arises as to how best to treat the variation of rotor thrust.
One method would be to maintain a constant disk loading, allowing the rotor diameters to increase as the rotor lift increases. From a practical standpoint, this means that the minimum longitudinal rotor spacing which can be investigated would be governed by clearance considerations with the largest rotor, which would unduly restrict the range of rotor spacing ratios to be investigated. For this reason, the rotor diameter was held constant, and the disk loading allowed to increase with increased rotor lift. This scheme has the additional valuable feature that variation of rotor lift is representative of operating a given vehicle at various loading conditions, including minimum flying weight, thus providing greater insight into the effect of payload variation on flying qualities in a given vehicle.

**Vectoring Angle of Main Rotor Thrust**

Vectoring of the thrust of the lifting rotors of the hybrid lift vehicle is the primary means of providing control forces and moments for translational and rotational motion in all axes. The term "vectoring" includes variation in the size of the vector as well as in its direction. Clearly if the maximum amount of vectoring is permitted to be different in two vehicles which are otherwise identical, then their maneuverability will be different. It is essential to maintain uniform concept for maximum vectoring among all
the vehicles under consideration. For angular deflection of the thrust vector a maximum value of 12 degrees was maintained, longitudinally and laterally (independently). This value is representative of maximum longitudinal and lateral cyclic pitch control of typical helicopter rotors. The maximum magnitude of differential thrust was plus or minus 30% of the maximum steady-state value (typical for tandem helicopters). However, the configurations with static-lift/gross-weight ratio of .85 can be considered representative of the configurations with a .609 ratio when the latter are flying with about 50% payload. (The smaller payload results in a smaller gross weight, which in turn means a larger ratio of static-lift/gross weight.) Therefore, an additional series of cases was calculated, using the weights and inertias of the .85 designs, but the control forces of the .609 designs.

**Horizontal Thrusters**

When the hybrid LTA vehicle is operating at a relatively low static lift/gross weight ratio, and hence a substantial amount of rotor lift, the latter forces can be vectored for propulsion and control about all axes (see previous paragraph). However, when the vehicle is operating at a high static lift/gross weight ratio (above about 0.8), and hence small values of rotor thrust, then the force vectors become too small to be effective, even when vectored to large deflection angles.

A solution to this situation is to use horizontal thrust units, such as propellers, mounted to produce thrust
vectors directed in a variable azimuth, but in a horizontal plane. These units can be driven from the same powerplants or from their own separate powerplants. For the purpose of this controllability study it does not matter. The vehicles investigated were considered to be provided with thrust means capable of producing horizontal forces in the range of 3% to 100% of main rotor maximum steady-state thrust. The specific amount constitutes an additional variable in the study matrix (see "Methodology," the next subsection of the report).
METHOD OF ANALYSIS (Cont'd)

Methodology

The first step required in the analytical study was to establish a matrix of point designs covering a broad interval of rotor spacing ratio and buoyancy ratio (static lift to gross weight ratio). The point designs have been selected with due consideration given to the design aspects discussed above, and their major characteristics are listed in the chart, Fig. 2.

The model designation code contains the most significant feature of each design. The numeral before the "/" is the longitudinal rotor spacing, in feet. Associated with each of the three rotor spacings is the letter A, B, or C, primarily to aid the reader's memory. The decimal fraction after the "/" is the ratio of static-lift to gross weight, of which there are three. Thus Fig. 2 shows nine point designs, in addition to the reference design, model 97-1 from Ref. 1.

Analyses were carried out for each of the nine matrix design points, which were further subdivided with regard to the amount of horizontal thrust assumed. Four constant ratios of horizontal thrust to main rotor thrust were used: .03, .125, .50, and 1.00, thus making 36 distinct design points. Fig. 3 is a composite three-view drawing, showing, the assumed aerostat shape and the three different locations of the propulsors (helicopters).
FIG. 2  MATRIX OF CONFIGURATIONS OF HYBRID LTA VEHICLES

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<tr>
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<th>REF. MODEL 97-1</th>
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<th></th>
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<tr>
<td>VOLUME</td>
<td>CU.FT.</td>
<td>2,900,000</td>
<td>1,500,000</td>
<td>1,500,000</td>
<td>1,500,000</td>
</tr>
<tr>
<td>OVERALL LENGTH, AEROSTAT (L)</td>
<td>FT.</td>
<td>384</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>LONGIT. DIST. BETWEEN ROTORS (X_R)</td>
<td>FT.</td>
<td>295.25</td>
<td>76</td>
<td>130</td>
<td>184</td>
</tr>
<tr>
<td>LONGIT. RTR. SPACING RATIO (X_R/L)</td>
<td>-</td>
<td>.769</td>
<td>.317</td>
<td>.542</td>
<td>.767</td>
</tr>
<tr>
<td>MAX. DIAM., AEROSTAT</td>
<td>FT.</td>
<td>124</td>
<td>103</td>
<td>103</td>
<td>103</td>
</tr>
<tr>
<td>STATIC LIFT AT 5,000 FT.PRESS.HT.</td>
<td>LB.</td>
<td>140,800</td>
<td>80,900</td>
<td>80,900</td>
<td>80,900</td>
</tr>
<tr>
<td>AUX. HORIZONTAL THRUST (MIN/MAX)</td>
<td>LB.</td>
<td></td>
<td>5,900/19,700</td>
<td>5,900/19,700</td>
<td>5,900/19,700</td>
</tr>
<tr>
<td>MODEL DESIGNATION</td>
<td>-</td>
<td>C-76/.85</td>
<td>B-130/.85</td>
<td>A-184/.85</td>
<td></td>
</tr>
<tr>
<td>STATIC LIFT/GROSS WT. RATIO</td>
<td>-</td>
<td>.85</td>
<td>.85</td>
<td>.85</td>
<td></td>
</tr>
<tr>
<td>GROSS WEIGHT</td>
<td>LB.</td>
<td>95,180</td>
<td>95,180</td>
<td>95,180</td>
<td></td>
</tr>
<tr>
<td>ROTOR LIFT, TOTAL</td>
<td>LB.</td>
<td>14,280</td>
<td>14,280</td>
<td>14,280</td>
<td></td>
</tr>
<tr>
<td>ROTOR THRUST, EACH</td>
<td>LB.</td>
<td>3,570</td>
<td>3,570</td>
<td>3,570</td>
<td></td>
</tr>
<tr>
<td>ROTOR DIA./DISK-LOADING</td>
<td>FT/PSF</td>
<td>56/1.45</td>
<td>56/1.45</td>
<td>56/1.45</td>
<td></td>
</tr>
<tr>
<td>MODEL DESIGNATION</td>
<td>-</td>
<td>97-1</td>
<td>C-76/.609</td>
<td>B-130/.609</td>
<td>A-184/.609</td>
</tr>
<tr>
<td>STATIC LIFT/GROSS WT. RATIO</td>
<td>-</td>
<td>.438</td>
<td>.609</td>
<td>.609</td>
<td>.609</td>
</tr>
<tr>
<td>GROSS WEIGHT</td>
<td>LB.</td>
<td>321,600</td>
<td>132,900</td>
<td>132,900</td>
<td>132,900</td>
</tr>
<tr>
<td>ROTOR LIFT, TOTAL</td>
<td>LB.</td>
<td>180,800</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
</tr>
<tr>
<td>ROTOR THRUST, EACH</td>
<td>LB.</td>
<td>45,200</td>
<td>13,000</td>
<td>13,000</td>
<td>13,000</td>
</tr>
<tr>
<td>ROTOR DIA./DISK-LOADING</td>
<td>FT/PSF</td>
<td>72/11.10</td>
<td>56/5.28</td>
<td>56/5.28</td>
<td>56/5.28</td>
</tr>
<tr>
<td>STATIC LIFT/GROSS WT. RATIO</td>
<td>-</td>
<td>.291</td>
<td>.291</td>
<td>.291</td>
<td>.291</td>
</tr>
<tr>
<td>GROSS WEIGHT</td>
<td>LB.</td>
<td>277,940</td>
<td>277,940</td>
<td>277,940</td>
<td></td>
</tr>
<tr>
<td>ROTOR LIFT, TOTAL</td>
<td>LB.</td>
<td>197,040</td>
<td>197,040</td>
<td>197,040</td>
<td></td>
</tr>
<tr>
<td>ROTOR THRUST, EACH</td>
<td>LB.</td>
<td>49,260</td>
<td>49,260</td>
<td>49,260</td>
<td></td>
</tr>
<tr>
<td>ROTOR DIA./DISK-LOADING</td>
<td>FT/PSF</td>
<td>56/20.0</td>
<td>56/20.0</td>
<td>56/20.0</td>
<td>56/20.0</td>
</tr>
</tbody>
</table>
Next, the following inertial and aerodynamic properties were determined for each point design.

1. Weight breakdown, including aero-stat propulsors, interconnecting structure, and payload, and c.g.

2. Mass, including components of item 1, above, plus enclosed air, helium, and additional apparent mass.

3. Moments of inertia in pitch, roll, and yaw, including additional apparent inertia.

4. Drag at airspeeds of 15, 25, and 35 knots, and at sideslip angles of 0, 30, 60, and 90 degrees.

5. Aerodynamic yawing moments at airspeeds of 15, 25, and 35 knots, and sideslip angles of 0, 30, 60, and 90 degrees.

6. Control forces and moments available from the main and auxiliary rotors.
At each sideslip angle and speed considered, the control forces necessary to trim the vehicle were calculated. Finally, maximum accelerations were calculated based on maximum control forces available after subtracting those required for trim. Controllability analyses were made for the following flight conditions.

1. Acceleration in pitch and in forward translation (independently), at zero sideslip angle, zero pitch angle, and forward speeds of 0, 15, 25, and 35 knots.

2. Acceleration in roll, from trimmed roll attitude, at sideways velocities ($\beta = 90$ degrees) of 0, 15, 25, and 35 knots. Since longitudinal rotor spacing has no effect on lateral flight at $\beta = 90$ degrees, except for a minor effect on lateral drag, this analysis was carried out for only one value of rotor spacing.

3. Acceleration in lateral translation, after achieving the maximum roll attitude, at sideways velocities ($\phi = 90$ degrees) of 0, 15, 25, and 35 knots. Again, this was done at only one value of longitudinal rotor spacing.

4. Acceleration in yaw, from trimmed attitude, at speeds of 0, 15, 25, and 35 knots, and at sideslip angles of 0, 30, 60, and 90 degrees.

In all cases, the acceleration was in the direction with least control remaining. Thus, if the vehicle was trimmed in a right roll (to maintain right sideslip), the least roll control remaining was to roll further to the right. If trimmed in yaw to maintain a sideslip angle (other than zero) at a constant
airspeed, the least yaw control remaining was to reduce the sideslip, since the vehicle was unstable in yaw, tending to yaw to a greater sideslip angle unless resisted by control forces.

Sources of control forces and moments are shown in Fig. 4.

RESULTS OF ANALYSES

Longitudinal Acceleration

Fig. 5 shows maximum longitudinal acceleration capability plotted against static lift/gross weight ratio for zero forward speed and 35 knots, and for the various ratios of horizontal propulsion thrust to total rotor lift \( \frac{T_{p_{\text{max}}}}{T_{z_{\text{total}}}} \). The control forces for producing longitudinal acceleration are the thrust of horizontal propulsive units \( T_{p_X} \) and the \( X \) component of rotor thrust. Both of these parameters are independent of longitudinal rotor spacing, which is, therefore, not a parameter for this motion. The influence of forward speed is quite minor, as evidenced by the small separation of the graphs for zero and 35 knots. The 15-knot and 25-knot speeds would fall within this spacing, and for the sake of clarity are not plotted. Longitudinal acceleration has an inverse, but non-linear relationship to static-lift/gross weight ratio. This is to be expected, since the \( X \) component of rotor thrust is directly proportional to total rotor thrust \( \frac{T_{z_{\text{total}}}}{T_{z_{\text{total}}}} \), which decreases toward zero as the static
**FIG. 5** LONGITUDINAL ACCELERATION CAPABILITY VS. STATIC LIFT/GROSS WEIGHT RATIO
lift/gross weight ratio increases toward 1.0. The amount of horizontal thrust available has a predictably important influence on longitudinal acceleration, although one should note that it has been varied over a very large range (from 3% to 100% of the dynamic lift). At high values of static lift/gross weight ratio the horizontal thrust is the primary means for producing longitudinal acceleration.

Two points are shown in Fig. 5, for zero and 35 knots, for Piasecki Model 97-1 (from Ref. 1), which had no horizontal thrust provisions. These points are quite consistent with the trends of the parametric curves falling slightly below the curves for 3% horizontal thrust.

**Pitching Acceleration**

Pitching control moments are produced by differential thrust variation between the forward and aft vertical thrust units (designated $\Delta T_2$). At forward speed, part of this moment is needed to counteract the nose-up moment of the thrust units, which in the configuration studied (see Fig. 4) are located substantially below the center of buoyancy and center of gravity.

Fig. 6 shows the strong inverse relationship between pitching acceleration capability and static lift/gross weight ratio for all speeds and all rotor spacing ratios considered. The reason for this is that the maximum amount of differential thrust at each vertical thrust unit was assumed to be a
constant 30% of the basic (average) thrust, a value representative of typical tandem helicopters. Thus for a static lift/gross weight ratio approaching 1.0, the dynamic thrust is relatively low, and so is the amount available for differential thrust. On the other hand, for a static lift/gross weight ratio approaching zero, the dynamic thrust is large, and so is the differential thrust.

Although Fig. 6 indicates that the pitching acceleration capability increases with increasing longitudinal rotor spacing, this effect is shown more clearly on Fig. 7, where acceleration is plotted against rotor spacing.

The effect of longitudinal moment of inertia ($I_x$) can be seen in Fig. 7. For values of static lift/gross weight ratio approaching 1.0 (for example the 0.85 set of curves in Fig. 7) most of the effective pitching moment of inertia is due to the mass of the aerostat envelope, the internal gases, and the additional apparent mass of the surrounding air. Thus for this condition $I_x$ is essentially constant, independent of rotor spacing ratio. The curves are nearly straight lines. For lower values of static lift/gross weight ratio a greater part of the total $I_x$ is due to the mass of the thrust units, and $I_x$ increases with increasing rotor spacing. This, in turn, reduces the increase in acceleration which would otherwise result from the increased moment arms of the thrust units, and the curves are strongly curved concave

-27-
FIG. 6
PITCHING ACCELERATION CAPABILITY VS. STATIC LIFT/G.W. RATIO

\[ \frac{\text{ROTOR SPACING}}{\text{OVERALL LENGTH}} = \frac{x_{\text{RTR}}}{L} \]

\[ V = 0 \quad \text{MODEL 97-1 (REF.)} \]

\[ V = 35 \text{ KT.} \quad \frac{x_{\text{RTR}}}{L} = 0.769 \]

\[ V = 0 \quad 15 \text{ KT.} \]
\[ 25 \text{ KT.} \]
\[ 35 \text{ KT.} \]

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FIG. 7 PITCHING ACCELERATION CAPABILITY VS.
RATIO OF ROTOR LONGIT. SPACING/OVERALL LENGTH
Both Figs. 6 and 7 show that the pitching acceleration capability becomes smaller with increasing forward speed. The increased drag, acting approximately at the center of buoyancy, requires a larger amount of differential thrust for trim, because of the low position of the thrust units. Hence less differential thrust is available for acceleration. The effect of speed is accentuated at high static lift/gross weight ratios because the amount of differential thrust is smaller to begin with, and the amount required for trim is a larger percentage of the total.

Model 97-1, also plotted on Figs. 6 and 7, is seen to be consistent with the trend curves within about 10%. Its pitching acceleration capability is about 10% higher than the parametric point with the same rotor spacing ratio and static lift/gross weight ratio (best seen in Fig. 6). The probable reason is that this model, having a rigid aero-stat, does not have ballonets at each end, with their mass of air which would add a significant contribution to moment of inertia in pitch. Thus, the Model 97-1 has a relatively smaller moment of inertia, and a correspondingly higher acceleration capability.
Lateral Acceleration

Lateral rotor spacing was not considered as a variable in this study. All of the matrix designs have the same clearance between rotors and aerostat hull, and consequently the lateral spacing on all is nearly the same, (see Fig. 3). Calculations for lateral controllability were based on the 76-ft. longitudinal spacing.

Fig. 8 shows lateral (or sideways) acceleration capability (\(\ddot{y}\)) plotted versus static-lift/gross-weight ratio for lateral velocities from zero to 35 knots. Lateral acceleration has a strong inverse relationship with static-lift/gross-weight ratio for the same reasons as does longitudinal acceleration, described earlier. Velocity, however, has a much greater influence on lateral than on longitudinal acceleration because of the much greater drag in the lateral direction (compare Figs. 8 and 5).

The effect of lateral velocity is shown more directly in Fig. 9, where lateral acceleration capability is plotted versus lateral airspeed. Model 97-1 is also shown on this figure, and is seen to display approximately the same trend as the matrix designs.

Roll Acceleration

Fig. 10 shows roll acceleration capability (\(\dot{p}\)) plotted versus static-lift/gross-weight ratio. Once again there is a strong inverse relationship because the rolling moment is
Fig. 8 Lateral Acceleration Capability vs. Static-Lift/Gross-Weight Ratio

Static-Lift/Gross-Weight Ratio

Lateral Acceleration: \( \ddot{y} \) - ft/sec\(^2\)

Knots Lateral Airspeed:
- 0
- 15
- 25
- 35
STATIC LIFT
GROSS WEIGHT

-0.291
-0.438 (MODEL 97-1, REF.)
-0.609
-0.850

-0.850 WITH LATERALDIFFERENTIAL THRUST
($\Delta T_2$) SAME AS FOR
$L_5/W = 0.609$

FIG. 9 LATERAL ACCELERATION CAPABILITY VS. AIRSPEED

-33-
ROLL ACCELERATION - $\dot{\beta}$ - RAD/SEC$^2$

0 KNOTS LATERAL AIRSPEED
15
25
35

STATIC-LIFT/GROSS-WEIGHT RATIO

FIG. 10 ROLL ACCELERATION CAPABILITY VS. STATIC-LIFT GROSS-WEIGHT RATIO ($\beta = 90^\circ$)
comprised of the lateral differential thrust, which is assumed at a constant 30% of the average thrust (see discussion of pitching acceleration). The roll acceleration capability is reduced with increasing velocity to a greater degree than is pitching acceleration, because the lateral drag is much higher. (Compare Figs. 10, 6 and 7).

Roll acceleration capability is plotted directly against lateral airspeed in Fig. 11. For each static-lift/gross-weight ratio there is a limiting lateral velocity where all available roll control moment is needed merely to trim the vehicle into a rolled attitude, so that none remains for acceleration to an increased roll attitude. This limiting velocity is seen to vary inversely with the static-lift/gross-weight ratio. Model 97-1 has been plotted on Fig. 11, and is seen to display the same general trend as the matrix vehicles.
STATIC LIFT
GROSS-WEIGHT

0.291
0.438 (MODEL 97-1, REF.)
0.609
0.85
0.85 WITH LATERAL-
DIFFERENTIAL THRUST
(ΔT₂) SAME AS FOR
Lₕ/W = 0.609

ROLL ACCELERATION - ̇p - RAD/SEC²

LATERAL AIRSPEED - KNOTS

FIG. 11 ROLL ACCELERATION CAPABILITY VS. LATERAL AIRSPEED (θ = 90°)

-36-
ACCELERATION IN YAW

The effect of five distinct parameters on yaw acceleration capability has been investigated. To show the separate effects of so many parameters on any single presentation become extremely confusing. Consequently, their effects are shown in five different ways, Figs. 12 through 16. On each of these figures variation in either three or four parameters are shown, while a typical constant value is maintained for the other(s).

Figs. 12 and 13 show that yaw acceleration capability decreases with increasing rotor spacing, except for high ratios of static-lift/gross weight. This was an unexpected result, since intuitively it seemed that a longer moment arm for the yaw-producing forces should produce a higher yaw acceleration. However, the weight of the thrust-producing units increases the yaw inertia of the vehicle sufficiently to more than offset the increased yaw moment. At a static-lift gross weight ratio of .85, the weight of the thrust-producing units relative to the aerostat is sufficiently small that the additional moment of inertia from increased spacing is balanced by the additional moment arm, and the acceleration is essentially independent of spacing.

Speed in itself does not have much influence, particularly at zero sideslip angle, as seen by the small change between zero and 35 knots (Fig. 12). In combination with high angles of sideslip, however, speed becomes significant, as can be seen in Fig. 14.
Fig. 12 also shows that the static-lift/gross-weight ratio is a highly significant parameter. The vehicle with the smallest percentage of static lift is the most maneuverable. This relationship is shown more clearly in Figs. 14 and 15, where yawacceleration capability is plotted directly against static-lift/gross weight ratio.

Use of auxiliary thrust in the horizontal plane is a powerful method of providing yaw moment. In the present study horizontal thrust of varying magnitude was assumed to act in a fore-and-aft direction at a location behind each of the aft main lifting rotors (see Fig. 4). The magnitude of the maximum available horizontal thrust is expressed as a fraction of the rotor lift. Acting together, the horizontal thrusters produce forward (or aft) propulsion, but acting differentially they produce a yawing moment. Their effectiveness is clearly shown in Figs. 13 and 15.

As expected, the yaw acceleration capability at air-speeds other than zero is dependent upon the sideslip angle since the wind then produces its own yawing moment. This dependency on sideslip is shown in Fig. 16 for a wind speed of 25 knots. The aerodynamic moment produced by the wind is greatest at 45 degrees; hence the acceleration capability is smallest at that azimuth. Also, Fig. 16 again points out that the acceleration capability is higher with a smaller rotor spacing.
FIG. 12 YAW ACCELERATION CAPABILITY VS. ROTOR SPACING RATIO
(MAX. HORIZ. PROPULSIVE THRUST/DYNAMIC LIFT RATIO = 0.125;
SIDESLIP ANGLE = 0°)
FIG. 13: YAW ACCELERATION CAPABILITY VS. RATIO OF ROTOR LONGITUDINAL SPACING/OVERALL LENGTH. (V = 25 KNOTS; STATIC LIFT/GROSS WEIGHT RATIO = .609)
**Fig. 14** Yaw acceleration capability vs. static-lift/gross weight ratio. (Max. horiz. propulsive thrust/rotor lift ratio = 0.125)
FIG. 15 YAW ACCELERATION CAPABILITY VS. STATIC-LIFT/GROSS WEIGHT RATIO. (ROTOR SPACING/OVERALL LENGTH RATIO = .542; V = 25 KNOTS)
FIG. 16 YAW ACCELERATION CAPABILITY VS. YAW ANGLE. (V = 25 KNOTS; MAX. HORIZ. PROPULSIVE THRUST/DYNAMIC LIFT RATIO = .125)
Comparison with Heli-Stat Model 97-1

The Piasecki Heli-Stat Model 97-1, described and analyzed in Ref. 1, had geometric and dynamic characteristics as shown in Fig. 2. From interpolation of results from the matrix point designs to correspond with the ratios of static-lift to gross weight, and of rotor longitudinal spacing to overall length, the comparison table, Fig. 17, is obtained.

The correlation between Model 97-1 and the matrix points is seen to be within 12% for speeds of zero and 25 knots and for all axes except lateral translation and roll. The lower degree of correlation in these two axes is the result of a somewhat different lateral control configuration. As shown in Fig. 4, lateral forces are produced in the matrix designs by lateral thrusters (tail rotors) on the two forward main thrust units, as well as by lateral components of the main rotor thrusts. The two aft thrust units are equipped with horizontal thrusters for longitudinal thrust only. Model 97-1, on the other hand, had lateral thrusters on all four main thrust units and, therefore, twice as much lateral thrust from this source. It is this feature which gives Model 97-1 a higher lateral acceleration capability. Moreover, Model 97-1 can be trimmed for a given lateral airspeed at a smaller roll angle because it was designed with greater lateral thrust than the matrix designs. Hence a larger proportion of roll control is available for roll acceleration.
**FIG. 17** CONTROLLABILITY COMPARISON BETWEEN MODEL 97-1 HELI-STAT AND INTERPOLATIONS FROM MATRIX POINT DESIGNS

<table>
<thead>
<tr>
<th>CONTROL AXIS</th>
<th>ACCELERATION UNITS</th>
<th>$V=0$</th>
<th>$V=25$ KNOTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>97-1 DESIGN MATRIX</td>
<td>97-1</td>
<td>97-1 DESIGN MATRIX</td>
</tr>
<tr>
<td>LONGITUDINAL</td>
<td>FT/SEC$^2$</td>
<td>2.88</td>
<td>3.16</td>
</tr>
<tr>
<td>TRANSLATION</td>
<td>RAD/SEC$^2$</td>
<td>.0546</td>
<td>.0525</td>
</tr>
<tr>
<td>PITCH</td>
<td>FT/SEC$^2$</td>
<td>7.85</td>
<td>4.45</td>
</tr>
<tr>
<td>LATERAL TRANSLATION</td>
<td>FT/SEC$^2$</td>
<td>.1203</td>
<td>.0885</td>
</tr>
<tr>
<td>ROLL</td>
<td>RAD/SEC$^2$</td>
<td>.0898</td>
<td>.0825</td>
</tr>
</tbody>
</table>
Application to Real Designs

The parametric analyses conducted for this report were based on a grid, or matrix, of point designs having three fixed values for static-lift/gross weight ratio. In any real design this quantity is a variable, dependent upon the vehicle's empty weight and the amount of useful load being carried. However, from these parametric results the behavior of such a real design can be estimated.

To illustrate a typical real-design application, Model C-76/.609 has been selected. The .609 ratio of static lift to gross weight has been taken to represent the fully loaded condition, for which estimated weight breakdowns can be found in the Appendix. When off-loaded approximately 50%, this design is found to have a ratio of static-lift to gross weight of 0.85, another of the fixed values used in the matrix study. However, since it is now considered to be a fixed design, operating at part load rather than full load, the control available for pitch, roll, and yaw (differential thrust and auxiliary horizontal thrust) will remain the same as they were in the fully loaded condition, as opposed to the smaller values found in the .85 ratio matrix points.

The .85-static-lift/gross weight ratio designs were, therefore, re-analyzed using the values for differential thrust and auxiliary thrust from the .609-ratio designs. Results are shown as follows:
Longitudinal Translation is shown on Fig. 18 plotted against airspeed, for an horizontal thrust ratio of .125, one of the constant ratios used in the matrix (solid line), and a ratio of .455, which represents the same value of horizontal thrust, in pounds, as the corresponding matrix point with .609 static-lift gross-weight ratio (dotted line). The dotted line can be considered to show the .609-ratio matrix designs when operating with approximately 50% design payloads.

Pitch is shown on Fig. 19 plotted against longitudinal spacing ratio for speeds of zero and 35 knots. The solid curves \( \frac{\Delta T_{X_{\text{max}}}}{T_Z} = .30 \) are identical to those in Fig. 7. The dotted curves \( \frac{\Delta T_{Z_{\text{max}}}}{T_Z} \) once again are representative of the .609-ratio matrix designs operating with approximately 50% design payload.

Lateral Translation and Roll are shown plotted against airspeed on previous Figs. 9 and 11. On each, along with the regular matrix designs is shown a curve for the .85 static-lift ratio, but with lateral differential thrust taken from the .609 ratio.

Yaw is shown on Fig. 20 plotted against sideslip angle at a speed of 15 knots. As in Fig. 18 the solid curves are for an auxiliary thrust ratio of .125, while the dotted curves are for a ratio of .455.
$T_{p_{x_{\text{max}}}} / T_{z_{\text{total}}} = .455$, representative of the 2.609 static-lift ratio vehicles with $T_{p_{x_{\text{max}}}} / T_{z_{\text{total}}} = .125$, operating at approx. 50% design payload.

$T_{p_{x_{\text{max}}}} / T_{z_{\text{total}}} = .125$, as used for matrix design points.

FIG. 18 LONGITUDINAL ACCELERATION CAPABILITY VS. AIRSPEED, as affected by available horizontal propulsive thrust/dynamic lift ratio ($T_{p_{x_{\text{max}}}} / T_{z_{\text{total}}}$).

STATIC LIFT/GROSS WEIGHT RATIO = 0.85

-48-
\[
\Delta T_z \max /T_z = 1.09, \text{ representative of the 0.609 static-lift ratio vehicles operating at approx. 50% design payload.}
\]

\[
\Delta T_z \max /T_z = 0.30, \text{ as used for all matrix design points. Same as Fig. 7.}
\]

**Fig. 19** Pitching acceleration capability vs. ratio of longitudinal spacing/overall length, as affected by available differential thrust \((\Delta T_z)\). Static-lift/gross weight ratio = 0.85.
--- --- --- $\frac{T_p}{T_z}$ = .455, REPRESENTATIVE OF THE .609 STATIC-LIFT RATIO VEHICLE OPERATING AT APPROX. 50% DESIGN PAYLOAD.

$\frac{T_p}{T_z}$ = .125, AS USED FOR MATRIX DESIGN POINTS

FIG. 20 YAW ACCELERATION CAPABILITY VS. SIDESLIP ANGLE, AS AFFECTED BY AVAILABLE HORIZONTAL PROPULSIVE THRUST/DYNAMIC LIFT RATIO ($\frac{T_p}{T_z}$), STATIC LIFT/GROSS WT. RATIO = .85; V = 15 KNOTS
Final graphs of controllability vs. loading condition are shown on Fig. 21. These graphs were constructed using points for 100" and 50" payload as described in the preceding paragraphs. They were then extrapolated down to zero payload.

For zero airspeed, pitch and roll controllability decrease with increasing payload, since the available control moments (from differential thrust) remain constant, while moments of inertia are increased. (Even though the payload was considered as essentially a point mass, its location well below the vehicle center of mass gave it a significant contribution to pitch and roll, but not yaw moments of inertia). However, longitudinal and lateral translation and yaw controllability all decrease with decreasing payload. Main rotor thrust vector components play a large part in these particular modes. Since these thrust components are a direct function of dynamic lift, they become smaller with decreased payload.

At 15-knots airspeed longitudinal translation, pitch, and yaw acceleration are not greatly different from their zero-speed values. Lateral translation is substantially reduced, and the slope of the graph for roll is reversed. A reduction in lateral translation capability is accompanied by increased roll control and roll angle to maintain lateral force trim. Thus less roll control is available for roll acceleration.
FIG. 21 CONTROLLABILITY VARIATION WITH LOADING CONDITION: MODEL C-76/609
In a light condition (payload ratio less than .35), the maximum sideward airspeed for lateral trim is about 15 knots. However, hovering flight in a 90-degree crosswind will normally not be required. For those applications when it would be required, provision would have to be made for ample lateral thrust under conditions of light loading.

Thus the parametric results developed herein can be used to determine the control response of a "real" preliminary design vehicle. The example just described represents a design which the fully loaded condition, happens to fit one of the matrix points and in the 50%-loaded condition to nearly fit another matrix point. Hence Figs. 18, 19, and 20 could be constructed directly from calculated values, without the need for interpolation. However, other designs falling within the matrix limits can be analyzed in similar fashion. Although all possible combinations of parameters have not been plotted in the figures in this report, the calculated results can all be found in the Appendix. Data for designs with parameters within the matrix limits but not equal to any of the specific matrix points can be easily interpolated, using the nearest appropriate points.
Comparison With Specification MIL-H-8501A

Specifications or standards have not been promulgated for controllability requirements of a lighter-than-air vehicle (hybrid or not). As a matter of interest, however, Model C-76/.609 has been evaluated in pitch, roll, and yaw, in terms of paragraphs 3.2.13, 3.3.10, and 3.3.5, respectively, of Spec. MIL-H-8501A, Amendment 1 (Ref. 4). This specification, of course, when written was dealing with a vehicle of the order of one-tenth or less of the size of an anticipated LTA vehicle. However, the effect of size on controllability requirement was considered to some degree, in that the formulas for controllability permit slower motions for increased size of helicopter. The calculated values shown in Fig. 22 for the Heli-Stat Model C-76/.609 are several orders of magnitude superior to past Navy Blimp LTA vehicles of the ZPG-2W size, although lower than the requirements of the helicopter spec.
<table>
<thead>
<tr>
<th>AIRSPEED (KNOTS)</th>
<th>SIDESLIP ANGLE (DEG.)</th>
<th>SOURCE OF VALUES</th>
<th>LOADING CONDITION</th>
<th>PITCH DEGREES ATTITUDE CHANGE IN ONE SECOND WITH FULL CONTROL DISPLACEMENT FROM TRIM</th>
<th>ROLL DEGREES ATTITUDE CHANGE IN ONE SECOND WITH FULL CONTROL DISPLACEMENT FROM TRIM</th>
<th>YAW DEGREES ATTITUDE CHANGE IN ONE SECOND WITH FULL CONTROL DISPLACEMENT FROM TRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N.A.</td>
<td>MIL-H-8501-A REQUIREMENT</td>
<td>ALL G.W.</td>
<td>3.52</td>
<td>1.77</td>
<td>6.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CALCULATED CONTROL RESPONSE</td>
<td>FULL DESIGN PAYLOAD</td>
<td>.58</td>
<td>1.81</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50% PAYLOAD</td>
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**FIG. 22.** COMPARISON OF MODEL C-76/.609 WITH HELICOPTER FLYING QUALITIES SPECIFICATION MIL-H-8501-A
6. CONCLUSIONS

A systematic investigation of controllability of hybrid LTA vehicles with varying ratios of static-lift to gross-weight and of longitudinal rotor spacing to overall length, has led to the following conclusions.

(1) Longitudinal translational acceleration has an inverse relationship to static-lift/gross-weight ratio.

(2) Longitudinal translational acceleration strongly depends on the amount of horizontal thrust. At high ratios of static-lift/gross-weight, horizontal thrust is the basic means of propulsion and control.

(3) Pitching acceleration has an inverse relationship with the static-lift/gross-weight ratio.

(4) Pitching acceleration increases with increasing longitudinal rotor spacing.

(5) At airspeeds up to at least 35 knots, the dependency of acceleration on speed, for either longitudinal translation or pitch, is minor, probably because of the relatively low body drag at these speeds. However, the dependency on speed becomes more significant at high ratios of static-lift/gross-weight, with acceleration decreasing with increasing speed.
6. **CONCLUSIONS (Cont'd)**

(6) Both lateral translational and roll acceleration have a strong inverse relationship with static-lift/gross-weight ratio and with lateral airspeed.

(7) Yaw acceleration has a strong inverse relationship to static-lift/gross-weight ratio.

(8) Except for high ratios of static-lift/gross-weight (greater than 0.85), an increasing rotor spacing results in a decrease in yaw acceleration.

(9) The use of horizontal thrust which can produce yawing moments is a highly effective method of increasing yaw maneuverability.

(10) Yaw acceleration capability depends on the relative instantaneous wind direction. For the configurations analyzed, with no stabilizing tail fins, the aerodynamic moment at an angle of yaw is high, becoming maximum at 45 degrees, and is a critical maneuverability condition for design.
6. CONCLUSIONS (Cont'd)

(11) The inverse relationship with static-lift/gross-weight ratio for pitch and roll acceleration, stated in conclusions (3) and (6), hold only for vehicles designed with thrusters limited in capacity consistent with their normal operation at high static-lift/gross-weight ratios. Vehicles with thrusters sized for operation at moderate to low static-lift/gross-weight ratio (not greater than 0.65) will have greater, not less, pitch and roll maneuverability when operating light (and thus at a higher static-lift/gross-weight ratio).

(12) The results herein can be useful in assessing the control response of a "real" hybrid LTA vehicle while still in the preliminary-design stage.
V. RECOMMENDATIONS

(1) The most suitable of the hybrid configurations studied herein should be tested in full scale to correlate the actual versus calculated control reaction times and the resultant effect on required flight maneuvers.

(2) The flight maneuvers required for distinct aerial-crane mission functions should be broken down into flight elements and the times for the hybrid configurations, used herein, to perform these segments should be calculated for each of the required flight maneuvers under various sets of assumed environmental conditions. The flight maneuvers contained in the following missions are of interest for such calculations:

a. Electrical transmission tower placement precision operations.

b. Contractor ship (loading and unloading) precision shuttle operations.

c. Rigging chutes operations.
## 8. REFERENCES AND BIBLIOGRAPHY

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<td>97-X-11</td>
<td>Piasecki Aircraft</td>
<td>&quot;Design Feasibility Analysis, Ultra-Heavy Vertical Lift System-The Heli-Stat&quot;</td>
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<td>24 June 76</td>
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<td>4.</td>
<td>MIL-H-8501A, Amendment 1</td>
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<td>&quot;Helicopter Flying and Ground Handling Qualities; General Requirements for&quot;</td>
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## ABBREVIATIONS AND SYMBOLS

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<th>Units</th>
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<td>acceleration, linear</td>
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</tr>
<tr>
<td>C.B.</td>
<td>center of buoyancy</td>
<td></td>
</tr>
<tr>
<td>C.G.</td>
<td>center of gravity</td>
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</tr>
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</tr>
<tr>
<td>$C_L$</td>
<td>lift coefficient, based on $\frac{V^{2/3}}{}$</td>
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</tr>
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<td>$C_M$</td>
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<td>$c$</td>
<td>center-line</td>
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<td>cubic feet</td>
<td>ft.$^3$</td>
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<tr>
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<td>ft.</td>
</tr>
<tr>
<td>deg.</td>
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</tr>
<tr>
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<td>for example</td>
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<tr>
<td>ft.</td>
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<td>f.r.</td>
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<td>$I_Y$</td>
<td>coefficient of additional apparent mass for longitudinal motion</td>
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<td>coefficient of additional apparent mass for transverse motion</td>
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<td>min.</td>
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<tr>
<td>min.</td>
<td>minimum</td>
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<tr>
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<td>X</td>
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<td>($''\cdot$)</td>
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**Summary of Inertial Properties of Vehicle Configurations**

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<td>C.G. BELOW C.B.</td>
<td>( I_X )</td>
<td>( I_Y )</td>
<td>( I_Z )</td>
<td>APPARENT IN PITCH</td>
<td>TOTAL EQUIV.</td>
<td>TOTAL EQUIV.</td>
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<td>VOLUME (FT³)</td>
<td>DRAG AREA (FT²)</td>
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MODEL

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<th>VINYL AREA (FT²)</th>
<th>DRAG AREA (FT²)</th>
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<td>1133</td>
</tr>
<tr>
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<td>4900</td>
<td>3300</td>
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<td>3450</td>
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</tbody>
</table>

NOTE: CD = \[ \text{DRAG AREA (VOL/27/3)} \]

-68-
### SUMMARY OF TOTAL VEHICLE DRAGS

<table>
<thead>
<tr>
<th>YAW ANGLE, DEG.</th>
<th>SPEED - KNOTS</th>
<th>0</th>
<th>25</th>
<th>35</th>
<th>0</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>0</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>DYN. PRESS. - LB/FT²</td>
<td>0</td>
<td>.7638</td>
<td>2.212</td>
<td>4.158</td>
<td>0</td>
<td>.7638</td>
<td>2.212</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>MODEL</th>
<th>DRAG (POUNDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>97-1 (REF)</td>
<td>0</td>
</tr>
<tr>
<td>C-76/.85</td>
<td>0</td>
</tr>
<tr>
<td>C-76/.609</td>
<td>0</td>
</tr>
<tr>
<td>C-76/.291</td>
<td>0</td>
</tr>
<tr>
<td>B-130/.85</td>
<td>0</td>
</tr>
<tr>
<td>B-130/.609</td>
<td>0</td>
</tr>
<tr>
<td>B-130/.291</td>
<td>0</td>
</tr>
<tr>
<td>A-184/.85</td>
<td>0</td>
</tr>
<tr>
<td>A-184/.609</td>
<td>0</td>
</tr>
<tr>
<td>A-184/.291</td>
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</tr>
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### SUMMARY OF TOTAL VEHICLE DRAGS (CONT'D)

<table>
<thead>
<tr>
<th>YAW ANGLE, DEG.</th>
<th>60</th>
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<tbody>
<tr>
<td>SPEED - KNOTS</td>
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</tr>
<tr>
<td>0</td>
<td>.7638</td>
<td>2.212</td>
</tr>
<tr>
<td>DYN. PRESS. - LB/FT²</td>
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<td>15</td>
</tr>
</tbody>
</table>

#### DRAG (POUNDS)

<table>
<thead>
<tr>
<th>MODEL</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>97-1 (REF.)</td>
<td>13,214</td>
<td>38,268</td>
<td>71,935</td>
<td>16,804</td>
<td>48,665</td>
<td>91,478</td>
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<tr>
<td>C-76/.85</td>
<td>5,106</td>
<td>14,787</td>
<td>27,796</td>
<td>5,956</td>
<td>17,249</td>
<td>32,423</td>
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<tr>
<td>C-76/.609</td>
<td>5,171</td>
<td>14,975</td>
<td>28,150</td>
<td>6,048</td>
<td>17,515</td>
<td>32,924</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-76/.291</td>
<td>5,568</td>
<td>16,125</td>
<td>30,311</td>
<td>6,488</td>
<td>28,790</td>
<td>35,320</td>
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</tr>
<tr>
<td>B-130/.85</td>
<td>5,247</td>
<td>15,196</td>
<td>28,564</td>
<td>6,162</td>
<td>17,845</td>
<td>33,545</td>
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<tr>
<td>B-130/.609</td>
<td>5,293</td>
<td>15,329</td>
<td>28,814</td>
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<td>17,935</td>
<td>33,714</td>
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<tr>
<td>B-130/.291</td>
<td>5,713</td>
<td>16,545</td>
<td>31,101</td>
<td>6,694</td>
<td>19,386</td>
<td>36,441</td>
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<tr>
<td>A-184/.85</td>
<td>5,446</td>
<td>15,772</td>
<td>29,647</td>
<td>6,372</td>
<td>18,454</td>
<td>34,688</td>
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<tr>
<td>A-184/.609</td>
<td>5,522</td>
<td>15,992</td>
<td>30,061</td>
<td>6,464</td>
<td>18,720</td>
<td>35,189</td>
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<tr>
<td>A-184/.291</td>
<td>5,889</td>
<td>17,055</td>
<td>32,059</td>
<td>6,899</td>
<td>19,980</td>
<td>37,557</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AERODYNAMIC YAWING MOMENT COEFFICIENT VS. YAW ANGLE
AERODYNAMIC YAWING MOMENT VS. YAW ANGLE
ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

\[ \begin{align*}
\text{VELOCITY (v)} & \quad \text{ft.} \\
\text{DYNAMIC PRESS. (q)} & \quad \text{lb. f. ft.} \\
\text{DRAG (D)} & \quad \text{lb.} \\
\Delta t_{\text{TRIM}} & \quad \text{lb.} \\
\Delta t_{\text{MAX}} & \quad \text{lb.} \\
\frac{\Delta t_{\text{MAX}}}{(\Delta t_{\text{TRIM}})^2} & \quad \text{lb.} \\
\end{align*} \]

<table>
<thead>
<tr>
<th>VEL (v)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT.</td>
<td>0</td>
<td>0.756</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>P.S.F.</td>
<td>0</td>
<td>1.121</td>
<td>3.247</td>
<td>6.10</td>
</tr>
<tr>
<td>LB.</td>
<td>0</td>
<td>70</td>
<td>207</td>
<td>382</td>
</tr>
<tr>
<td>PAR, SEC²</td>
<td>0.0546</td>
<td>0.0543</td>
<td>0.0538</td>
<td>0.0531</td>
</tr>
<tr>
<td>10 lb.</td>
<td>38.432</td>
<td>38.432</td>
<td>38.432</td>
<td>38.432</td>
</tr>
<tr>
<td>20 lb.</td>
<td>38.432</td>
<td>37.311</td>
<td>35.185</td>
<td>32.329</td>
</tr>
<tr>
<td>30 lb.</td>
<td>2.88</td>
<td>2.80</td>
<td>2.64</td>
<td>2.43</td>
</tr>
<tr>
<td>40 lb.</td>
<td>( (\Delta t_{\text{MAX}}) ) &amp; ( \frac{(\Delta t_{\text{MAX}})}{D} ) &amp; ( \frac{(\Delta t_{\text{MAX}})}{(\Delta t_{\text{TRIM}})^2} ) &amp; ( \frac{(\Delta t_{\text{MAX}})}{D} ) &amp; ( \frac{(\Delta t_{\text{MAX}})}{(\Delta t_{\text{TRIM}})^2} )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACCELERATION IN PITCH AND LATERAL TRANSLATION

<table>
<thead>
<tr>
<th>VELOCITY (V)</th>
<th>KT.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>L.B.</td>
<td>0</td>
<td>.766</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>L.B.</td>
<td>0</td>
<td>1.095</td>
<td>3.171</td>
<td>5.961</td>
</tr>
<tr>
<td>( \frac{2(\Delta T_{\text{MAX}} - \Delta T_{\text{TRIM}})}{\Delta T_{\text{TRIM}}} )</td>
<td>RADSEC</td>
<td>.0425</td>
<td>.0415</td>
<td>.0395</td>
<td>.0370</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TPX_MAX</th>
<th>LB.</th>
<th>47,790</th>
<th>47,790</th>
<th>47,790</th>
<th>47,790</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>LB.</td>
<td>47,790</td>
<td>46,695</td>
<td>44,619</td>
<td>41,829</td>
</tr>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>SEC</td>
<td>4.63</td>
<td>4.52</td>
<td>4.32</td>
<td>4.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TPX_MAX</th>
<th>LB.</th>
<th>66,480</th>
<th>66,480</th>
<th>66,480</th>
<th>66,480</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>LB.</td>
<td>66,480</td>
<td>65,385</td>
<td>63,309</td>
<td>60,519</td>
</tr>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>SEC</td>
<td>6.44</td>
<td>6.33</td>
<td>6.13</td>
<td>5.86</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TPX_MAX</th>
<th>LB.</th>
<th>140,400</th>
<th>140,400</th>
<th>140,400</th>
<th>140,400</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>LB.</td>
<td>140,400</td>
<td>139,305</td>
<td>137,229</td>
<td>134,439</td>
</tr>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>SEC</td>
<td>13.60</td>
<td>13.50</td>
<td>13.29</td>
<td>13.02</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TPX_MAX</th>
<th>LB.</th>
<th>238,920</th>
<th>238,920</th>
<th>238,920</th>
<th>238,920</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>LB.</td>
<td>238,920</td>
<td>237,825</td>
<td>235,749</td>
<td>232,959</td>
</tr>
<tr>
<td>( \frac{4}{v} T_x + \frac{16}{v} T_y ) ( \text{MAX} ) - D</td>
<td>SEC</td>
<td>23.14</td>
<td>23.04</td>
<td>22.84</td>
<td>22.57</td>
</tr>
</tbody>
</table>
### ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION

![Diagram](image)

**Accl 

\[
\begin{align*}
\Delta T_1 &= \frac{(6 \cdot T_x + T_p)_{\text{MAX}}}{2 \Delta T_2} \\
\Delta T_2 &= \frac{(4 \cdot T_x + T_p)_{\text{MAX}}}{2} \\
\Delta T_3 &= \frac{(4 \cdot T_x + T_p)_{\text{MAX}}}{2} \\
\Delta T_4 &= \frac{(4 \cdot T_x + T_p)_{\text{MAX}}}{2} \\
\end{align*}
\]

| VELOCITY (V) | FT. | 0 | 15 | 25 | 35 |
| DYNAMIC PRESS. (q) | P.S.I. | 0 | 764 | 212 | 416 |
| DRAG (D) | LB. | 0 | 957 | 2172 | 5210 |
| \(\Delta T_{\text{TRIM}} + \frac{D}{(\text{VTRK})^2}\) | LB. | 0 | 309 | 894 | 1680 |
| \(\frac{2 \Delta T_{\text{MAX}} - \Delta T_{\text{TRIM}}}{T_{\text{RTR}}^2}\) | RAD/SEC | .0202 | .0186 | .0156 | .0115 |
| \(\frac{12.612}{T_{\text{MAX}}^3} - \frac{12.612}{T_{\text{MAX}}^3}\) | LB. | 12.612 | 12.612 | 12.612 | 12.612 |
| \(\frac{12.612}{T_{\text{MAX}}^3} - D\) | LB. | 12.612 | 11.655 | 9.840 | 7.402 |
| \(\frac{2.17}{\text{SEC}^2}\) | LB. | 2.17 | 2.00 | 1.692 | 1.272 |
| \(\frac{17.552}{T_{\text{MAX}}^3} - \frac{17.552}{T_{\text{MAX}}^3}\) | LB. | 17.552 | 17.552 | 17.552 | 17.552 |
| \(\frac{17.552}{T_{\text{MAX}}^3} - D\) | LB. | 17.552 | 16.595 | 14.780 | 12.342 |
| \(\frac{3.02}{\text{SEC}^2}\) | LB. | 3.02 | 2.85 | 2.54 | 2.12 |
| \(\frac{37.052}{T_{\text{MAX}}^3} - \frac{37.052}{T_{\text{MAX}}^3}\) | LB. | 37.052 | 37.052 | 37.052 | 37.052 |
| \(\frac{37.052}{T_{\text{MAX}}^3} - D\) | LB. | 37.052 | 36.095 | 34.250 | 31.842 |
| \(\frac{6.370}{\text{SEC}^2}\) | LB. | 6.370 | 6.205 | 5.833 | 5.474 |
| \(\frac{63.052}{T_{\text{MAX}}^3} - \frac{63.052}{T_{\text{MAX}}^3}\) | LB. | 63.052 | 63.052 | 63.052 | 63.052 |
| \(\frac{63.052}{T_{\text{MAX}}^3} - D\) | LB. | 63.052 | 62.095 | 60.230 | 57.842 |
| \(\frac{10.84}{\text{SEC}^2}\) | LB. | 10.84 | 10.87 | 10.36 | 9.94 |

**Design No.**
C-76/1699

-75-
### Acceleration in Pitch and Longitudinal Translation

**Design No.**
C-76/85

![Diagram](image)

**Variables:**
- $a_{TR}$: Acceleration in pitch
- $T_{max}$: Thrust
- $I_y$: Moment of inertia about the center of gravity
- $I_{TR}$: Inertial moment
- $P$: Pressure
- $D$: Drag
- $q$: Dynamic pressure
- $T$: Thrust
- $L$: Lift
- $S$: Slugs
- $P_{s}$: Static pressure
- $C_{L}$: Lift coefficient
- $C_{D}$: Drag coefficient
- $C_{L_{max}}$: Maximum lift coefficient
- $C_{D_{max}}$: Maximum drag coefficient
- $V$: Velocity
- $V_{max}$: Maximum velocity

#### Table:

<table>
<thead>
<tr>
<th>Force (q)</th>
<th>Velocity (V)</th>
<th>15°</th>
<th>25°</th>
<th>35°</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.S.P</td>
<td>0</td>
<td>0</td>
<td>1.785</td>
<td>7,140</td>
</tr>
<tr>
<td>Drag (D)</td>
<td>0</td>
<td>865</td>
<td>2,599</td>
<td>959</td>
</tr>
<tr>
<td>$\Delta T_{trim}$</td>
<td>D($H_{TR}$)</td>
<td>0</td>
<td>229</td>
<td>806</td>
</tr>
<tr>
<td>$2(\Delta T_{RTR})$</td>
<td>$T_{RTR}$</td>
<td>0.008</td>
<td>0.059</td>
<td>0.002</td>
</tr>
<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{\Delta T</em>{trim}}$</td>
<td></td>
<td>3,464</td>
<td>3,464</td>
<td>3,464</td>
</tr>
<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{max}}$</td>
<td></td>
<td>4,821</td>
<td>4,821</td>
<td>4,821</td>
</tr>
<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{r}}$</td>
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<td>4,821</td>
<td>3,956</td>
<td>2,316</td>
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<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{imp}}$</td>
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<td>1,038</td>
<td>0.851</td>
<td>0.499</td>
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<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{r}}$</td>
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<td>10,176</td>
<td>10,176</td>
<td>10,176</td>
</tr>
<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{imp}}$</td>
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<td>2190</td>
<td>2004</td>
<td>1651</td>
</tr>
<tr>
<td>$\frac{(h T_{x} + T_{p})<em>{max}}{T</em>{r}}$</td>
<td></td>
<td>3,727</td>
<td>3,541</td>
<td>3,188</td>
</tr>
</tbody>
</table>

**Constants:**
- $k_{RTR} = 49.0$ ft.
- $I_{RTR} = 76$ ft.
- $T_{max} = 759$ lb.
- $\Delta T_{max} = 1,071$ lb.
- $a_{RTR} = 4,646$ slugs
- $I_{y} = 20,405,000$ sl. ft.$^2$
### Acceleration in Pitch and Longitudinal Translation

**Diagram:**

- $N_{RTR} = 49.0 \text{ ft.}$
- $X_{RTR} = 120 \text{ ft.}$
- $T_{T_{MAX}} = 10,470 \text{ lb.}$
- $(\Delta T_z)_{MAX} = 14.778 \text{ lb.}$
- $m = 10,322 \text{ slugs}$
- $L_t = 66,570,000 \text{ sl. ft.}^2$

#### Table

<table>
<thead>
<tr>
<th>$\text{VELOCITY } (V)$</th>
<th>$0$</th>
<th>$15$</th>
<th>$25$</th>
<th>$35$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{DYNAMIC PRESS. } (q)$</td>
<td>$0$</td>
<td>.764</td>
<td>2.17</td>
<td>4.16</td>
</tr>
<tr>
<td>$\text{DRAG } (D)$</td>
<td>$0$</td>
<td>1,116</td>
<td>3,232</td>
<td>6,075</td>
</tr>
<tr>
<td>$\Delta T_z \text{ TRIM } = D(N_{RTR})$</td>
<td>$0$</td>
<td>210</td>
<td>609</td>
<td>1,145</td>
</tr>
<tr>
<td>$X_t$</td>
<td>$0.0577$</td>
<td>$0.0569$</td>
<td>$0.0553$</td>
<td>$0.0532$</td>
</tr>
</tbody>
</table>

#### Equations

- $T_{P_{MAX}} = (h T_x + T_{P_{MAX}})$
- $2(\Delta T_z)_{MAX} = \frac{D(X_{RTR})}{T_{RTR}}$
- $X_t = \frac{2(\Delta T_z)_{MAX}}{T_{RTR} X_{RTR}}$

#### Calculations

- $T_{P_{MAX}} = 5.910 \text{ lb.}$
- $24,600 \text{ lb.}$
- $197,040 \text{ lb.}$

- $T_{P_{MAX}} = 66,480 \text{ lb.}$
- $66,480 \text{ lb.}$
- $66,480 \text{ lb.}$

- $T_{P_{MAX}} = 238,920 \text{ lb.}$
- $238,920 \text{ lb.}$
- $238,920 \text{ lb.}$

- $T_{P_{MAX}} = 23.15 \text{ sec}$
- $23.15 \text{ sec}$
- $23.15 \text{ sec}$

---
# Acceleration in Pitch and Longitudinal Translation

**Diagram:**

- V: Velocity
- D: Drag
- \( \Delta T \): Thrust
- \( T_{\text{MAX}} \): Maximum Thrust
- \( (\Delta T)_{\text{MAX}} \): Maximum Thrust
- \( T_{R} \): Thrust
- \( T_{\text{MAX}} \): Maximum Thrust
- \( (T_{\text{MAX}})_{\text{MAX}} \): Maximum Maximum Thrust
- \( I_{x} \): Inertia
- \( I_{y} \): Inertia
- \( I_{z} \): Inertia

### Design No.
8-130/0.609

### Table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta T_{\text{MAX}} )</td>
<td>LB.</td>
<td>2,703</td>
</tr>
<tr>
<td>( (\Delta T)_{\text{MAX}} )</td>
<td>LB.</td>
<td>3,900</td>
</tr>
</tbody>
</table>

### Data Table

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>FT.</th>
<th>( \Delta T_{\text{MAX}} )</th>
<th>( (\Delta T)_{\text{MAX}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>12,612</td>
<td>12,612</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
<td>12,612</td>
<td>12,612</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>12,612</td>
<td>12,612</td>
</tr>
</tbody>
</table>

### More Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{\text{MAX}} )</td>
<td>LB.</td>
<td>63,052</td>
</tr>
<tr>
<td>( (T_{\text{MAX}})_{\text{MAX}} )</td>
<td>LB.</td>
<td>63,052</td>
</tr>
</tbody>
</table>

### Notes

- The table provides data for different values of velocity and thrust conditions.
- The units used are pounds (LB.) and feet (FT.).

---

-73-
## Acceleration in Pitch and Yaw/Trim Translation

**Diagram:**

- Design No: B130/85
- RTR 
- Tp
- 2\(\Delta T_x\)TR

### Table

<table>
<thead>
<tr>
<th>(\text{VELOCITY (V)})</th>
<th>(\text{KT.})</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{DYNAMIC PRESS. (q)})</td>
<td>(\text{P.S.F.})</td>
<td>0</td>
<td>2.768</td>
<td>4.12</td>
<td>5.16</td>
</tr>
<tr>
<td>(\text{DRAG (D)})</td>
<td>(\text{LB.})</td>
<td>0</td>
<td>0.097</td>
<td>2.562</td>
<td>4.829</td>
</tr>
<tr>
<td>(\Delta T_x)TRIN</td>
<td>(\Delta T_x)TRIN (T(\text{TRIN}))</td>
<td>(\text{LB.})</td>
<td>0</td>
<td>167</td>
<td>454</td>
</tr>
<tr>
<td>(2(\Delta T_x)TRIN (T(\text{TRIN}))) (x_\text{MAX} = \frac{2(\Delta T_x)TRIN (T(\text{TRIN}))) (x_\text{MAX}}}{t})</td>
<td>rad/sec</td>
<td>0.0013</td>
<td>0.0095</td>
<td>0.0012</td>
<td>0.0017</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(425 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>3,464</td>
<td>3,454</td>
<td>3,464</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(425 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>3,464</td>
<td>2,577</td>
<td>895</td>
</tr>
<tr>
<td>(x_\text{MAX} = \frac{2(\Delta T_x)TRIN (T(\text{TRIN}))) (x_\text{MAX}}}{t})</td>
<td>rad/sec</td>
<td>0.748</td>
<td>0.557</td>
<td>0.693</td>
<td>0.295</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(1,765 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>4,821</td>
<td>4,821</td>
<td>4,821</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(1,765 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>4,821</td>
<td>3,934</td>
<td>2,252</td>
</tr>
<tr>
<td>(x_\text{MAX} = \frac{2(\Delta T_x)TRIN (T(\text{TRIN}))) (x_\text{MAX}}}{t})</td>
<td>rad/sec</td>
<td>1.042</td>
<td>0.650</td>
<td>0.467</td>
<td>0.002</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(14,280 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>17,316</td>
<td>17,316</td>
<td>17,316</td>
</tr>
<tr>
<td>(T_{FMAX})</td>
<td>(14,280 \text{ LB.})</td>
<td>(\text{LB.})</td>
<td>17,316</td>
<td>16,429</td>
<td>14,747</td>
</tr>
<tr>
<td>(x_\text{MAX} = \frac{2(\Delta T_x)TRIN (T(\text{TRIN}))) (x_\text{MAX}}}{t})</td>
<td>rad/sec</td>
<td>3.743</td>
<td>3.551</td>
<td>3.108</td>
<td>2.699</td>
</tr>
</tbody>
</table>

**Note:**

- \(x_\text{MAX}\) is the maximum acceleration in rad/sec.
- Units for force are in pounds (LB.).
- Units for velocity are in knots (KT.).

---

-79-
### Acceleration in Pitch and Longitudinal Translation

Design No.: A-184/291

<table>
<thead>
<tr>
<th>VELOCITY (y)</th>
<th>KFT.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>F.S.P.</td>
<td>0</td>
<td>.764</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>LB.</td>
<td>0</td>
<td>1.127</td>
<td>3.264</td>
<td>6.135</td>
</tr>
<tr>
<td>$\alpha_{TRM} - \frac{D}{2T_{RTR}}$</td>
<td>LB.</td>
<td>0</td>
<td>150</td>
<td>435</td>
<td>817</td>
</tr>
<tr>
<td>$\frac{2(\alpha_{TRM} - \frac{D}{2T_{RTR}})}{T_{RTR}}$</td>
<td>KAC/PSEC</td>
<td>.0125</td>
<td>.0698</td>
<td>.0108</td>
<td>.0590</td>
</tr>
<tr>
<td>$T_{P\text{MAX}} = \frac{(4T_x + T_p)}{T_{P\text{MAX}}}$</td>
<td>LB.</td>
<td>47,790</td>
<td>47,790</td>
<td>47,790</td>
<td>47,790</td>
</tr>
<tr>
<td>5,910 LB.</td>
<td>47,790</td>
<td>46,663</td>
<td>44,526</td>
<td>41,655</td>
<td></td>
</tr>
<tr>
<td>$\frac{(4T_x + T_p)}{T_{P\text{MAX}}}$</td>
<td>SEC</td>
<td>4.63</td>
<td>4.52</td>
<td>4.31</td>
<td>4.04</td>
</tr>
<tr>
<td>$\frac{x}{T_{P\text{MAX}}}$</td>
<td>LB.</td>
<td>66,480</td>
<td>66,480</td>
<td>66,480</td>
<td>66,480</td>
</tr>
<tr>
<td>24,600 LB.</td>
<td>66,480</td>
<td>65,353</td>
<td>63,216</td>
<td>60,345</td>
<td></td>
</tr>
<tr>
<td>$\frac{(4T_x + T_p)}{T_{P\text{MAX}}}$</td>
<td>SEC</td>
<td>6.44</td>
<td>6.33</td>
<td>6.12</td>
<td>5.85</td>
</tr>
<tr>
<td>$\frac{x}{T_{P\text{MAX}}}$</td>
<td>LB.</td>
<td>238,920</td>
<td>238,920</td>
<td>238,920</td>
<td>238,920</td>
</tr>
<tr>
<td>197,040 LB.</td>
<td>238,920</td>
<td>237,793</td>
<td>235,655</td>
<td>232,785</td>
<td></td>
</tr>
<tr>
<td>$\frac{(4T_x + T_p)}{T_{P\text{MAX}}}$</td>
<td>SEC</td>
<td>23.15</td>
<td>23.04</td>
<td>22.83</td>
<td>22.55</td>
</tr>
<tr>
<td>$\frac{x}{T_{P\text{MAX}}}$</td>
<td>LB.</td>
<td>87,045,000</td>
<td>87,045,000</td>
<td>87,045,000</td>
<td>87,045,000</td>
</tr>
</tbody>
</table>

**Units:**
- KFT: Thousands of Feet
- LB: Pounds
- F.S.P: Feet Per Second
- KAC/PSEC: Kilometers Per Second squared
- SEC: Seconds

**Notes:**
- $T_p$ represents the pitch control force.
- $T_x$ represents the longitudinal control force.

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---
### Acceleration in Pitch and Longitudinal Translation

**Design No.** A-194/604

<table>
<thead>
<tr>
<th>VELOCITY (V)</th>
<th>KT.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>F.S.P.</td>
<td>0</td>
<td>0.764</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (q)</td>
<td>LB.</td>
<td>0</td>
<td>9.90</td>
<td>2.86</td>
<td>5.38</td>
</tr>
<tr>
<td>C(T)TRIM = D(N)TRI</td>
<td>LB.</td>
<td>0</td>
<td>132</td>
<td>362</td>
<td>718</td>
</tr>
<tr>
<td>2[(C)TRIM -C]TRIM (I)TRI</td>
<td>FT. SEC</td>
<td>0.0350</td>
<td>0.0338</td>
<td>0.0316</td>
<td>0.0286</td>
</tr>
</tbody>
</table>

**T**<sub>pX</sub> MAX

<table>
<thead>
<tr>
<th>1,500 LB.</th>
<th>6,500 LB.</th>
<th>52,000 LB.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
</tr>
<tr>
<td>LB.</td>
<td>LB.</td>
<td>LB.</td>
</tr>
<tr>
<td>12,612</td>
<td>17,552</td>
<td>63,052</td>
</tr>
<tr>
<td>12,612</td>
<td>17,552</td>
<td>63,052</td>
</tr>
<tr>
<td>12,612</td>
<td>17,552</td>
<td>63,052</td>
</tr>
</tbody>
</table>

**T**<sub>pX</sub> MAX

<table>
<thead>
<tr>
<th>1,500 LB.</th>
<th>6,500 LB.</th>
<th>52,000 LB.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
<td>(4 T&lt;sub&gt;x&lt;/sub&gt; + T&lt;sub&gt;pX&lt;/sub&gt;) MAX</td>
</tr>
<tr>
<td>LB.</td>
<td>LB.</td>
<td>LB.</td>
</tr>
<tr>
<td>2.17</td>
<td>3.02</td>
<td>10.84</td>
</tr>
<tr>
<td>1.921</td>
<td>2.85</td>
<td>10.67</td>
</tr>
<tr>
<td>1.598</td>
<td>2.52</td>
<td>10.35</td>
</tr>
<tr>
<td>1.184</td>
<td>2.09</td>
<td>9.91</td>
</tr>
</tbody>
</table>

**Notes:**
- K<sub>TR</sub> = 49.0 FT.
- T<sub>TR</sub> = 164 FT.
- T<sub>max</sub> = 2,763 LB.
- (C)T<sub>max</sub> = 3,900 LB.
- m = 5,817 SL.
- I<sub>y</sub> = 46,973,000 SL. FT. 2

---

-Pl-
### Acceleration in Pitch and Longitudinal Translation

![Diagram of the acceleration in pitch and longitudinal translation](image)

**Design No.:** A-184/85

<table>
<thead>
<tr>
<th>VELOCITY (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>0</td>
<td>1.268</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>0</td>
<td>838</td>
<td>2,401</td>
<td>4,849</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( T_{F \text{MAX}} )</th>
<th>428 Lb.</th>
<th>( T_{F \text{MAX}} )</th>
<th>1,785 Lb.</th>
<th>( T_{F \text{MAX}} )</th>
<th>14,280 Lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{F \text{MAX}} )</td>
<td>( T_{F \text{MAX}} )</td>
<td>( T_{F \text{MAX}} )</td>
<td>( T_{F \text{MAX}} )</td>
<td>( T_{F \text{MAX}} )</td>
<td>( T_{F \text{MAX}} )</td>
</tr>
<tr>
<td>( \frac{(4T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>3,464</td>
<td>3,464</td>
<td>3,464</td>
<td>3,464</td>
</tr>
<tr>
<td>( \frac{(8T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>3,464</td>
<td>2,566</td>
<td>863</td>
<td>-1,425</td>
</tr>
<tr>
<td>( \frac{(4T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>4,821</td>
<td>4,821</td>
<td>4,821</td>
<td>4,821</td>
</tr>
<tr>
<td>( \frac{(8T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>4,821</td>
<td>3,923</td>
<td>2,220</td>
<td>-68</td>
</tr>
<tr>
<td>( \frac{(4T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>11,316</td>
<td>17,316</td>
<td>17,316</td>
<td>17,316</td>
</tr>
<tr>
<td>( \frac{(8T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>11,316</td>
<td>16,418</td>
<td>14,715</td>
<td>12,427</td>
</tr>
<tr>
<td>( \frac{(4T_{x} + T_{F})_{\text{MAX}}}{D} )</td>
<td>Lb.</td>
<td>3,727</td>
<td>3,534</td>
<td>3,167</td>
<td>2,675</td>
</tr>
</tbody>
</table>

**Note:** All values are in pounds (lb) and seconds (sec).
### Acceleration in Pitch and Longitudinal Translation

**Design No.**
C-76/85-009

<table>
<thead>
<tr>
<th>VELOCITY (V)</th>
<th>KT.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>PSI</td>
<td>0</td>
<td>.269</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>LB.</td>
<td>0</td>
<td>865</td>
<td>2,505</td>
<td>4,709</td>
</tr>
<tr>
<td>$\Delta T_{TRIM} - U(HAT)$</td>
<td>LB.</td>
<td>0</td>
<td>279</td>
<td>808</td>
<td>1,518</td>
</tr>
<tr>
<td>$\frac{2(TP_{MAX} - TP_{TRIM})}{V}$</td>
<td>$\frac{1}{c^2}$</td>
<td>.0291</td>
<td>.0270</td>
<td>.0230</td>
<td>.0177</td>
</tr>
</tbody>
</table>

**TP_{MAX} = 1,560 LB.**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>AX</td>
<td>LB.</td>
<td>9,536</td>
<td>9,536</td>
<td>9,536</td>
<td>9,536</td>
</tr>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>MAX - D</td>
<td>LB.</td>
<td>9,536</td>
<td>8,871</td>
<td>7,031</td>
<td>4,827</td>
</tr>
<tr>
<td>$\chi^*$</td>
<td>LB.</td>
<td>2.053</td>
<td>1.867</td>
<td>1.513</td>
<td>1.039</td>
<td></td>
</tr>
</tbody>
</table>

**TP_{AX} = 6,500 LB.**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>AX</td>
<td>LB.</td>
<td>29,036</td>
<td>29,036</td>
<td>29,036</td>
<td>29,036</td>
</tr>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>MAX - D</td>
<td>LB.</td>
<td>29,036</td>
<td>28,171</td>
<td>26,531</td>
<td>24,327</td>
</tr>
<tr>
<td>$\chi^*$</td>
<td>LB.</td>
<td>6.250</td>
<td>6.064</td>
<td>5.711</td>
<td>5.236</td>
<td></td>
</tr>
</tbody>
</table>

**TP_{AX} = 20,000 LB.**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>AX</td>
<td>LB.</td>
<td>55,036</td>
<td>55,036</td>
<td>55,036</td>
<td>55,036</td>
</tr>
<tr>
<td>(4 $T_X + TP_X$)</td>
<td>MAX - D</td>
<td>LB.</td>
<td>55,036</td>
<td>54,171</td>
<td>52,531</td>
<td>50,327</td>
</tr>
<tr>
<td>$\chi^*$</td>
<td>LB.</td>
<td>11,846</td>
<td>11,660</td>
<td>11,307</td>
<td>10,832</td>
<td></td>
</tr>
</tbody>
</table>

**m = 4,646 SLUGS**

$T_Y = 20,405,000$ GL. FT.²
### Acceleration in Pitch and Longitudinal Translation

**Design No.:** 8-130/85-609

<table>
<thead>
<tr>
<th>VELCIETY (V)</th>
<th>KT.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC PRESS. (q)</td>
<td>P.S.I.</td>
<td>0</td>
<td>.766</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>LB.</td>
<td>0</td>
<td>887</td>
<td>2,569</td>
<td>4,829</td>
</tr>
<tr>
<td>( \Delta T_{\beta \text{TRIN}} = \frac{\Delta T_{\beta \text{TR}}}{\Delta T_{\beta \text{TR}}.} )</td>
<td>LB.</td>
<td>0</td>
<td>147</td>
<td>484</td>
<td>910</td>
</tr>
<tr>
<td>( 2(\Delta T_{\beta \text{MAX}} - \Delta T_{\beta \text{REV}})(x_{\beta \text{TR}}) )</td>
<td>SEC</td>
<td>.0411</td>
<td>.0393</td>
<td>.0360</td>
<td>.0315</td>
</tr>
<tr>
<td>( T_{\beta \text{MAX}} )</td>
<td>LB.</td>
<td>4,596</td>
<td>4,596</td>
<td>4,596</td>
<td>4,596</td>
</tr>
<tr>
<td>1,560 LB.</td>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}})}{x_{\beta \text{MAX}}} )</td>
<td>LB.</td>
<td>4,596</td>
<td>3,709</td>
<td>2,027</td>
</tr>
<tr>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}}) - D}{x_{\beta \text{MAX}}} )</td>
<td>SEC</td>
<td>.983</td>
<td>.798</td>
<td>.436</td>
<td>-.050</td>
</tr>
<tr>
<td>( T_{\beta \text{MAX}} )</td>
<td>LB.</td>
<td>9,536</td>
<td>9,536</td>
<td>9,536</td>
<td>9,536</td>
</tr>
<tr>
<td>6,500 LB.</td>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}})}{x_{\beta \text{MAX}}} )</td>
<td>LB.</td>
<td>9,536</td>
<td>8,467</td>
<td>4,707</td>
</tr>
<tr>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}}) - D}{x_{\beta \text{MAX}}} )</td>
<td>SEC</td>
<td>2.553</td>
<td>1.862</td>
<td>1.50</td>
<td>1.01</td>
</tr>
<tr>
<td>( T_{\beta \text{MAX}} )</td>
<td>LB.</td>
<td>29,036</td>
<td>29,036</td>
<td>29,036</td>
<td>29,036</td>
</tr>
<tr>
<td>26,000 LB.</td>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}})}{x_{\beta \text{MAX}}} )</td>
<td>LB.</td>
<td>29,036</td>
<td>28,159</td>
<td>26,467</td>
</tr>
<tr>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}}) - D}{x_{\beta \text{MAX}}} )</td>
<td>SEC</td>
<td>6.25</td>
<td>6.06</td>
<td>5.70</td>
<td>5.21</td>
</tr>
<tr>
<td>( T_{\beta \text{MAX}} )</td>
<td>LB.</td>
<td>55,036</td>
<td>55,036</td>
<td>55,036</td>
<td>55,036</td>
</tr>
<tr>
<td>52,000 LB.</td>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}})}{x_{\beta \text{MAX}}} )</td>
<td>LB.</td>
<td>55,036</td>
<td>54,149</td>
<td>52,467</td>
</tr>
<tr>
<td>( \frac{(4 T_{\beta} + T_{\beta \text{MAX}}) - D}{x_{\beta \text{MAX}}} )</td>
<td>SEC</td>
<td>11.48</td>
<td>11.65</td>
<td>11.89</td>
<td>10.81</td>
</tr>
</tbody>
</table>
**ACCELERATION IN PITCH AND LONGITUDINAL TRANSLATION**

### Design No.
A-184/.85/.609

<table>
<thead>
<tr>
<th>VEL (V)</th>
<th>KT</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYN PRESS (q)</td>
<td>P.S.I.</td>
<td>0</td>
<td>.764</td>
<td>2.12</td>
<td>4.16</td>
</tr>
<tr>
<td>DRAG (D)</td>
<td>LB.</td>
<td>0</td>
<td>858</td>
<td>2,601</td>
<td>4,889</td>
</tr>
<tr>
<td>(\Delta T_{\text{TRI}}^{\text{MAX}} - D)</td>
<td>LB.</td>
<td>0</td>
<td>120</td>
<td>346</td>
<td>651</td>
</tr>
<tr>
<td>(\frac{\Delta T_{\text{TRI}}^{\text{MAX}} - D}{\text{R.B.}})</td>
<td>SEC (^2)</td>
<td>.046</td>
<td>.045</td>
<td>.042</td>
<td>.039</td>
</tr>
</tbody>
</table>

### \(T_{P_x}^{\text{MAX}}\) (1,560 LB.)

| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 4,596 | 4,596 | 4,596 | 4,596 |

### \(T_{P_x}^{\text{MAX}}\) (6,500 LB.)

| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 4,596 | 3,698 | 1,995 | -293 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | SEC \(^2\) | .99 | .80 | .43 | -.063 |

### \(T_{P_x}^{\text{MAX}}\) (26,000 LB.)

| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 9,536 | 9,536 | 9,536 | 9,536 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 9,536 | 8,638 | 6,935 | 4,647 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | SEC \(^2\) | 2.05 | 1.86 | 1.49 | 1.00 |

### \(T_{P_x}^{\text{MAX}}\) (52,000 LB.)

| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 29,036 | 29,036 | 29,036 | 29,036 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 29,036 | 28,136 | 26,435 | 24,147 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | SEC \(^2\) | 6.23 | 6.06 | 5.70 | 5.20 |

### \(T_{P_x}^{\text{MAX}}\) (6500 LB.)

| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 55,036 | 55,036 | 55,036 | 55,036 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | LB. | 55,036 | 54,136 | 52,435 | 50,147 |
| \(\frac{(4T_x + T_{P_x})^{\text{MAX}}}{D}\) | SEC \(^2\) | 11.85 | 11.65 | 11.29 | 10.79 |
Equations of Motion for Lateral Translation and Roll.

Maximum roll acceleration is produced when $T_Y$, $T_{RY}$, and $T_Z$ are co-ordinated to produce pure roll (zero lateral translation acceleration). Therefore, for $\dot{Y} = 0$,

$$\dot{Y} = 0.$$

$$\sin \phi = \frac{D-4T_Y -2T_{RYmax}}{4T_Z}$$

If $\phi$ is calculated to be negative, the vehicle can be trimmed at the particular lateral velocity in level attitude and need not be banked. Therefore, in such a case $\phi$ is made equal to zero.

$$\dot{Y} = 0.$$

$$\Delta T_{Ztrim} = \frac{D(H_{rtr}) + (L_B H_{rtr} - \omega^2 H_{cg}) \sin \phi}{2Y_{rtr}}$$

$$\ddot{p} = \frac{2Y_{rtr} \Delta T_{Zmax} - DH_{rtr} \sin \phi (L_B H_{rtr} - \omega^2 H_{cg})}{I_X}$$

Maximum lateral linear acceleration is produced when $T_Y$, $T_{RY}$, and $T_Z$ are coordinated to produce pure linear motion (zero roll acceleration). Therefore, for $\ddot{p} = 0$,

$$\dot{Y} = 0.$$

$$\sin \phi = \frac{D+\dot{m}y -4T_Y -2T_{RYmax}}{4T_Z}$$

$$\dot{N}_{rtr} = 0.$$

$$\sin \phi = 2 \Delta T_{Zmax} \frac{Y - \omega^2 (D+\dot{m}y)}{L_B H_{rtr} rtr}$$

Combining (1) and (2) and simplifying:

$$\dot{Y} = \frac{4T_Z (2 \Delta T_{Zmax} \frac{Y - DH_{rtr}}{L_B H_{rtr} rtr} + (L_B H_{rtr} - \omega^2 H_{cg}) (D+4T_Y -2T_{RYmax}))}{m(L_B H_{rtr} + L_B H_{rtr} - \omega^2 H_{cg})}$$
ACCELERATION IN LATERAL TRANSLATION AND ROLL

\[ \psi = 90 \text{ deg.} \]

**Diagram**: 
- H_trt \(-I_x\hat{p}\)
- 2 \(\Delta T_z\)
- 2 \(T_y\)
- 2 \(T_z\)
- H_prim \(-a_y\)
- 2 \(\Delta T_z\)
- 2 \(T_y\)
- \(T_{Ry}\)
- W

**Design No. C-76/821**

\[ c_1 = (I_B h_{trt}) - (W H_{cg}) = 5,214,820 \text{ ft. lb.} \]

\[ c_2 = 2 Y_{trt} \left( \Delta T_{z_{max}} \right) = 4,817,628 \text{ ft. lb.} \]

\[ c_3 = 4 T_z H_{trt} + c_1 = 14,869,793 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>( V )</th>
<th>Velocity (sideways)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Drag</td>
<td>lb.</td>
<td>0</td>
<td>6,488</td>
<td>18,790</td>
<td>33,320</td>
</tr>
<tr>
<td>( \varepsilon_1 )</td>
<td>( B = \varepsilon_{trt} - 2 \varepsilon_{Ry_{max}} )</td>
<td>lb.</td>
<td>-43,380</td>
<td>-36,892</td>
<td>-24,590</td>
<td>-8,060</td>
</tr>
<tr>
<td>( \sin \phi )</td>
<td>( \frac{c_1}{H_{trt}} )</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \varepsilon_2 )</td>
<td>( -\varepsilon_{(H_{trt})} )</td>
<td>ft. lb.</td>
<td>0</td>
<td>317.9</td>
<td>920.7</td>
<td>1,730.7</td>
</tr>
<tr>
<td>( \varepsilon_3 )</td>
<td>( c_2 - \varepsilon_2 )</td>
<td>ft. lb.</td>
<td>4,516</td>
<td>4,500</td>
<td>3,897</td>
<td>3,087</td>
</tr>
<tr>
<td>( \hat{p} )</td>
<td>( \dot{\varepsilon}_3 - c_1 \sin \phi )</td>
<td>rad. sec(^2)</td>
<td>.1084</td>
<td>.1012</td>
<td>.0876</td>
<td>.0694</td>
</tr>
<tr>
<td>( \varepsilon_4 )</td>
<td>( 4 \varepsilon_3 \left( \varepsilon_3 \right) - c_1 \left( \varepsilon_1 \right) )</td>
<td>ft. lb.</td>
<td>117.55</td>
<td>.0790</td>
<td>89.608</td>
<td>65.028</td>
</tr>
<tr>
<td>( \dot{\gamma} )</td>
<td>( \dot{\varepsilon}_4 )</td>
<td>ft. sec(^2)</td>
<td>6.436</td>
<td>5.908</td>
<td>4.907</td>
<td>3.561</td>
</tr>
</tbody>
</table>

*If \( \sin \phi \leq 0\), make it = 0. Negative \( \sin \phi \) indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle \( (\phi) \leq 0\).*
ACCELERATION IN LATERAL TRANSLATION AND ROLL

\[ \psi = 90 \text{ DEG.} \]

**DESIGN NO. C-76/769**

\[ c_1 = (L_B H_{rtr}) - (W H_{cg}) = 2,781,290 \text{ ft. lb.} \]

\[ c_2 = 2 T_{rtr} (\Delta T_{z_{max}}) = 1,271,400 \text{ ft. lb.} \]

\[ c_3 = 4 T_z H_{rtr} + c_1 = 5,329,290 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>( V )</th>
<th>( V = \text{Velocity (sideways)} )</th>
<th>( \text{kt.} )</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D )</td>
<td>( \text{Drag} )</td>
<td>( \text{lb.} )</td>
<td>0</td>
<td>6,048</td>
<td>17,915</td>
<td>32,924</td>
</tr>
<tr>
<td>( \xi_1 )</td>
<td>( D - 4 T_{\text{max}} - 2 T_{r_{max}} )</td>
<td>( \text{lb.} )</td>
<td>-12,552</td>
<td>-6,504</td>
<td>4,963</td>
<td>20,372</td>
</tr>
<tr>
<td>( \frac{\sin \phi}{4 \xi_2} )</td>
<td>( \text{lb.} )</td>
<td>0</td>
<td>0</td>
<td>0,0954</td>
<td>0,3918</td>
<td></td>
</tr>
<tr>
<td>( \xi_2 )</td>
<td>( D (H_{rtr}) )</td>
<td>( \text{ft. lb.} )</td>
<td>1,000</td>
<td>296,3</td>
<td>858,2</td>
<td>1,613,3</td>
</tr>
<tr>
<td>( \xi_3 )</td>
<td>( c_2 - \xi_2 )</td>
<td>( \text{lb.} )</td>
<td>106</td>
<td>0,975</td>
<td>0,413</td>
<td>-0,342</td>
</tr>
<tr>
<td>( \phi )</td>
<td>( \frac{\xi_3 - c_1 \sin \phi}{I_x} )</td>
<td>( \text{rad. sec}^{-2} )</td>
<td>0,0635</td>
<td>0,0487</td>
<td>0,0074</td>
<td>-0,0715</td>
</tr>
<tr>
<td>( \xi_4 )</td>
<td>( 4 T_z (\xi_3) - c_1 (\xi_1) )</td>
<td>( \text{ft. lb}^2 )</td>
<td>10,102</td>
<td>6,8792</td>
<td>0,7681</td>
<td>-7,444</td>
</tr>
<tr>
<td>( \theta )</td>
<td>( \frac{\xi_4}{a (\xi_3)} )</td>
<td>( \text{sec}^{-2} )</td>
<td>2,437</td>
<td>1,6590</td>
<td>1853</td>
<td>-1,796</td>
</tr>
</tbody>
</table>

* If \( \sin \phi < 0 \), make it 0. Negative \( \sin \phi \) indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle \( \phi = 0 \).

* Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.
ACCELERATION IN LATERAL TRANSLATION AND ROLL

\( \psi = 90 \text{ DEG.} \)

\[ H_{\text{rtr}} = 49.0 \text{ ft.} \]
\[ W_{\text{SE}} = 14.8 \text{ ft.} \]
\[ T_{\text{rmax}} = 759 \text{ lb.} \]
\[ \Delta T_{2\max} = 107 \text{ lb.} \]
\[ n = 6.666 \text{ slugs} \]
\[ I_X = 15,247,000 \text{ slug ft.}^2 \]
\[ T_2 = 3.570 \text{ lb.} \]
\[ L_B = 80,900 \text{ lb.} \]
\[ W = 95,180 \text{ lb.} \]
\[ Y_{\text{rtr}} = 163 \text{ ft.} \]
\[ T_{\text{rmax}} = 750 \text{ lb.} \]

DESIGN NO. C-76/85

\[ c_1 = \frac{L_B H_{\text{rtr}}}{(W H_{\text{SE}})} = 2,555.436 \text{ ft. lb.} \]
\[ c_2 = 2 Y_{\text{rtr}} (\Delta T_{2\max}) = 349.146 \text{ ft. lb.} \]
\[ c_3 = 4 T_2 Y_{\text{rtr}} + c_1 = 3,255.156 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>( V )</th>
<th>Velocity (sideways)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D )</td>
<td>Drag</td>
<td>lb.</td>
<td>0</td>
<td>5.956</td>
<td>17.249</td>
<td>32.423</td>
</tr>
<tr>
<td>( \eta_1 )</td>
<td>( D - 4T_{\max} - 2T_{\text{rmax}} )</td>
<td>lb.</td>
<td>-4536</td>
<td>1,420</td>
<td>12,713</td>
<td>27,887</td>
</tr>
<tr>
<td>( \sin \phi )</td>
<td>( \frac{\eta_1}{L_2} )</td>
<td>-</td>
<td>0</td>
<td>0.0994</td>
<td>0.8903</td>
<td>*1.953</td>
</tr>
<tr>
<td>( \eta_2 )</td>
<td>( D (H_{\text{rtr}}) )</td>
<td>1,000 ft. lb.</td>
<td>0</td>
<td>291.8</td>
<td>845.2</td>
<td>1,588.7</td>
</tr>
<tr>
<td>( \eta_3 )</td>
<td>( c_2 - \eta_2 )</td>
<td>106 ft. lb.</td>
<td>.3491</td>
<td>.0573</td>
<td>-1.4961</td>
<td>-1.240</td>
</tr>
<tr>
<td>( \theta )</td>
<td>( \frac{\eta_3 - c_1 \sin \phi}{\eta_1} )</td>
<td>rad. sec.</td>
<td>-</td>
<td>-0.0129</td>
<td>-0.1167</td>
<td>-</td>
</tr>
<tr>
<td>( \eta_4 )</td>
<td>( 4 T_2 (\eta_3) - c_1 (\eta_1) )</td>
<td>10 ft. lb.</td>
<td>1.6577</td>
<td>-0.2810</td>
<td>-3.957</td>
<td>-8.897</td>
</tr>
<tr>
<td>( \psi )</td>
<td>( \frac{\eta_4}{m (\eta_3)} )</td>
<td>ft. sec.</td>
<td>.7709</td>
<td>-1.3069</td>
<td>-1.840</td>
<td>-</td>
</tr>
</tbody>
</table>

*Sin \( \phi \) cannot exceed 1.0 (\( \phi = 90 \text{ degrees} \)). At this lateral airspeed the vehicle cannot be trimmed.

Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.
ACCELERATION IN LATERAL TRANSLATION AND ROLL

$\psi = 90$ deg.

**Design No. 97-1**

$c_1 = (L_B H_{rtr}) - (W H_{ce}) = 4,006.816 \text{ ft. lb.}$

$c_2 = 2 \gamma_{rtr} (\Delta T_{2\text{max}}) = 4,501.920 \text{ ft. lb.}$

$c_3 = 4 T_2 H_{rtr} \gamma_{rtr} = 10,696.416 \text{ ft. lb.}$

<table>
<thead>
<tr>
<th>$V$</th>
<th>Velocity (Sideways)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Drag</td>
<td>lb.</td>
<td>0</td>
<td>16.808</td>
<td>46.640</td>
<td>91.520</td>
</tr>
<tr>
<td>$E_1$</td>
<td>$= D - 4\gamma_{max} - 2\gamma_{rtr \text{max}}$</td>
<td>lb.</td>
<td>-76.032</td>
<td>-59.224</td>
<td>-29.392</td>
<td>+15.409</td>
</tr>
<tr>
<td>$\sin \phi$</td>
<td>$= \frac{E_1}{4 \gamma_2}$</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0857</td>
</tr>
<tr>
<td>$E_2$</td>
<td>$= D (H_{rtr})$</td>
<td>1,000</td>
<td>ft. lb.</td>
<td>0</td>
<td>621.9</td>
<td>1,726</td>
</tr>
<tr>
<td>$E_3$</td>
<td>$= c_2 - E_2$</td>
<td>106</td>
<td>ft. lb.</td>
<td>4.502</td>
<td>3.880</td>
<td>2.776</td>
</tr>
<tr>
<td>$p$</td>
<td>$= \frac{E_3 - c_1 \sin \phi}{H_{rtr}}$</td>
<td>rad. sec.$^{-1}$</td>
<td>0.1203</td>
<td>0.1037</td>
<td>0.0741</td>
<td>0.0206</td>
</tr>
<tr>
<td>$E_4$</td>
<td>$= 4 T_2 (E_3) - c_1 (E_1)$</td>
<td>10$^{10}$</td>
<td>ft. lb$^2$</td>
<td>111.86</td>
<td>93.88</td>
<td>61.97</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>$= \frac{E_4}{m (E_3)}$</td>
<td>ft. sec.$^{-2}$</td>
<td>7.846</td>
<td>6.585</td>
<td>4.347</td>
<td>0.980</td>
</tr>
</tbody>
</table>

* If $\sin \phi \leq 0$, make it = 0. Negative $\sin \phi$ indicates that the lateral control force components available are more than sufficient to counteract the lateral drag at a roll angle ($\phi$) = 0.
ACCELERATION IN LATERAL TRANSLATION AND ROLL
\( \psi = 90 \text{ deg.} \)

DESIGN NO. C-76/.05-.609

\[ a_1 = \left( \frac{L_B}{W} H_{trr} \right) - (W H_{cg}) = \frac{W Y_{trr}}{\frac{W}{H_{cg}}} \text{ ft. lb.} \]
\[ c_2 = 2 Y_{trr} (\Delta T_{2 \text{max}}) = 1,271,400 \text{ ft. lb.} \]
\[ c_3 = 4 T_2 H_{trr} + a_1 = 3,255,156 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>V = Velocity</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>D = Drag</td>
<td>lb.</td>
<td>0</td>
<td>5,956</td>
<td>17,219</td>
<td>32,423</td>
</tr>
<tr>
<td>( \varepsilon_1 ) = ( D - 4T_{Y_{\text{max}}} - 2T_{R_{Y_{\text{max}}}} )</td>
<td>lb.</td>
<td>-4536</td>
<td>1,420</td>
<td>12,713</td>
<td>27,887</td>
</tr>
<tr>
<td>( \sin \phi ) = ( \frac{\varepsilon_1}{\Delta T_2} )</td>
<td>-</td>
<td>0</td>
<td>.0994</td>
<td>.8903</td>
<td>1.053</td>
</tr>
<tr>
<td>( \varepsilon_2 ) = ( D (H_{trr}) )</td>
<td>ft. lb.</td>
<td>1,000</td>
<td>0</td>
<td>291.8</td>
<td>846.2</td>
</tr>
<tr>
<td>( \varepsilon_3 ) = ( c_2 - \varepsilon_2 )</td>
<td>ft. lb.</td>
<td>106</td>
<td>1,2714</td>
<td>.9796</td>
<td>.4267</td>
</tr>
<tr>
<td>( \theta_\varphi ) = ( \frac{\varepsilon_3 - a_1 \sin \phi}{\varphi} )</td>
<td>rad. ( T_2 )</td>
<td>.0834</td>
<td>.476</td>
<td>-1.123</td>
<td></td>
</tr>
<tr>
<td>( \theta_\beta ) = ( 4T_2 (\varepsilon_3) - a_1 (\varepsilon_1) )</td>
<td>ft. lb.</td>
<td>10^10</td>
<td>2.9747</td>
<td>20</td>
<td>-2.6403</td>
</tr>
<tr>
<td>( \theta_\gamma ) = ( \frac{\varepsilon_4}{\varphi (a_3)} )</td>
<td>ft. ( \text{sec}^2 )</td>
<td>1.3838</td>
<td>117</td>
<td>-1.2278</td>
<td></td>
</tr>
</tbody>
</table>

* Sin \( \phi \) cannot exceed 1.0 (\( \phi \) = 90 degrees). At this lateral airspeed the vehicle cannot be trimmed.

* Negative values indicate that the vehicle cannot be trimmed in roll at this lateral airspeed within the roll control moments available.
ACCELERATION IN YAW

\[
\begin{align*}
\frac{dx}{dt} &= 0 \\
4T_x + 2T_p &= D \cos \psi \\
2T_x + T_p &= \frac{D \cos \psi}{2} \\
\frac{dy}{dt} &= 0 \\
2T_{R_y} + 4T_y &= D \sin \psi
\end{align*}
\]

Max. Available moment

\[
M_{z,\text{max}} = Y_{rtr} \left[ 2(T_{X,\text{max}} - T_x) + (T_{P,\text{max}} - T_p) \right] + 2X_{rtr} (T_y - T_{Y,\text{max}}) + 2X_{TR} (T_{hY,\text{max}} - T_{R_y,\text{max}}) - (2 \cos \Psi)
\]

\[
= Y_{rtr} \left[ (2T_{X,\text{max}} + T_{P,\text{max}}) - (2T_x + T_p) \right] + 2X_{rtr} T_{Y,\text{max}} + 2X_{TR} T_{R_y,\text{max}} - (2X_{rtr} T_{hY} + 2X_{TR} T_{R_y})
\]

\[
= Y_{rtr} \frac{2T_{X,\text{max}} + T_{P,\text{max}}}{2} - \frac{D \cos \psi}{2} + 2X_{rtr} T_{Y,\text{max}} + 2X_{TR} T_{R_y,\text{max}} - 2X_{rtr} T_{hY} - 2X_{TR} T_{R_y}
\]

\[
M_{Z,\text{max}} - M_{Z,\text{trim}} &= i
\]

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ACCELERATION IN YAW

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2Y_{rtr} T_{x_{max}} + 2 \left( X_{rtr} T_{y_{max}} + X_{TR} T_{r_{y_{max}}} \right) = 14,014,080 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>0</td>
<td>1,121</td>
<td>3,247</td>
<td>6,103</td>
</tr>
<tr>
<td>Aero. Yawing Moment (M_z_{trim})</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 = D \sin \psi )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_2 = Y_{rtr} D \cos \psi )</td>
<td>ft. lb.</td>
<td>0</td>
<td>93,043</td>
<td>269,501</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{y_{max}} \), \( T_Y_1 = T_{y_{max}} \) and \( T_{r_{y_{max}}} = 2 (\epsilon_1 - T_{y_{max}}) \)

\( \epsilon_1 \leq T_{y_{max}} \), \( T_Y_1 = \epsilon_1 \) and \( T_{r_{y_{max}}} = 0 \)

| \( T_Y_1 \) | lb. | 0 | 0 | 0 | 0 |
| \( T_{r_{y_{max}}} \) | lb. | 0 | 0 | 0 | 0 |

\( \epsilon_3 = c_1 - \epsilon_2 - 2X_{rtr} T_{r_{y_{max}}} - 2X_{TR} T_{r_{y_{max}} \max} \)

\( \frac{M_{z_{max}} - M_{z_{trim}}}{I_2} \) \( \text{rad. sec}^2 \)

\( \frac{\epsilon_3 \cdot Y_{rtr} T_{y_{max}} - M_{z_{trim}}}{I_2} \) \( \text{rad. sec}^2 \)

\( T_{r_{y_{max}}} \) (lb) \( \frac{\epsilon_3}{\text{rad. sec}^2} \)

\( 0 \) \( .0898 \) \( .092 \) \( .091 \) \( .0866 \)
ACCELERATION IN YAW

\[
\begin{align*}
X_{\text{max}} &= 759 \text{ lb.} \\
Y_{\text{max}} &= 759 \text{ lb.} \\
X_{\text{rtr}} &= 76 \text{ ft.} \\
Y_{\text{rtr}} &= 163 \text{ ft.} \\
T_{\text{Y,max}} &= 750 \text{ lb.} \\
I_2 &= 17,645,000 \text{ sl. ft.}^2 \\
X_{\text{TR}} &= 5 \text{ ft.} \\

\end{align*}
\]

DESIGN NO. C-76/85
\[
\psi = 0 \text{ Degrees}
\]
\[
c_1 = 2Y_{\text{rtr}}X_{\text{max}} + 2(X_{\text{rtr}}Y_{\text{max}} + X_{\text{TR}}T_{\text{Y,max}}) = 370,302 \text{ ft.} lb.
\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dray (D)</td>
<td>lb.</td>
<td>0</td>
<td>666</td>
<td>2,402</td>
<td>4,713</td>
</tr>
<tr>
<td>Aerc. Yawing Mom. (M_2\text{-trim})</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\theta_1) = (D \sin \psi)</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\theta_2) = (Y_{\text{rtr}} \frac{D \cos \psi}{2})</td>
<td>ft. lb.</td>
<td>0</td>
<td>70,579</td>
<td>195,763</td>
<td>384,109</td>
</tr>
</tbody>
</table>

If \(\theta_1 \geq T_{\text{Y,max}}\), \(T_{Y_1} = T_{\text{Y,max}}\) and \(T_{R Y_1} = 2(\theta_1 - T_{\text{Y,max}})\)

\[
\theta_1 < T_{\text{Y,max}}, T_{Y_1} = \theta_1 \quad \text{and} \quad T_{R Y_1} = 0
\]

| \(T_{Y_1}\) | lb. | 0 | 0 | 0 | 0 |
| \(T_{R Y_1}\) | lb. | 0 | 0 | 0 | 0 |

\[
X_{\text{max}} = \frac{M_2 - M_2\text{-trim}}{I_2} \quad \text{rad.} \quad \text{sec.}^2
\]
\[
\theta_3 = Y_{\text{rtr}} \frac{T_{\text{Fmax}} - M_2\text{-trim}}{2Y_{\text{rtr}} X_{\text{max}}} \quad \text{rad.} \quad \text{rad.} \quad \text{sec.}^2
\]

<table>
<thead>
<tr>
<th>(T_{\text{Pmax}}) (lb)</th>
<th>(T_{\text{Fmax}}/T_2\text{total})</th>
<th>(\dot{\theta})</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>.030</td>
<td>rad. \text{sec.}^2</td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>rad. \text{sec.}^2</td>
</tr>
<tr>
<td>7,140</td>
<td>.500</td>
<td>rad. \text{sec.}^2</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>rad. \text{sec.}^2</td>
</tr>
</tbody>
</table>

\(-94-\)
ACCELERATION IN YAW

\[ V \]

Design No. C-76/609

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2Y_{rtr} \max T_x^{\max} + 2(X_{rtr} Y_{max} + X_{rtr} T_{max}) = 1,328,214 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>950</td>
<td>2,656</td>
<td>5,212</td>
</tr>
<tr>
<td>Aero. Yawing</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_1 ) = \frac{D \sin \psi}{4}</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_2 ) = \frac{Y_{rtr} D \cos \psi}{2}</td>
<td>ft.lb.</td>
<td>0</td>
<td>77,995</td>
<td>216,464</td>
<td>424,778</td>
</tr>
</tbody>
</table>

If \( \delta_1 \geq T_y^{\max} \), \( T_y_1 = T_y^{\max} \) and \( T_{rY_1} = 2(\delta_1 - T_y^{\max}) \)

| \( T_y_1 \) | lb. | 0 | 0 | 0 | 0 |
| \( T_{rY_1} \) | lb. | 0 | 0 | 0 | 0 |
| \( \delta_3 = c_1 - \delta_2 - 2X_{rtr} T_{y_1} \) | ft.lb. | 1,328,214 | 1,250,219 | 1,111,750 | 903,436 |
| \( X_{rtr} T_{rY_1} \) | rad.| \( \frac{M_z^{\max} - M_z^{\trim}}{I_z} \) | \( \frac{\delta_3 + Y_{rtr} T_{p_{max}} - M_z^{\trim}}{I_z} \) |
| \( T_{p_{max}} \) (lb) | \( T_{p_{max}} / T_z^{\text{total}} \) | \( \ddot{r} \) |
| 1,550 | 0.030 | rad. | 0.084 | 0.0842 | 0.0737 | 0.0625 |
| 6,590 | 0.125 | rad. | 0.084 | 0.0842 | 0.0737 | 0.0625 |
| 26,000 | 0.500 | rad. | 0.084 | 0.0842 | 0.0737 | 0.0625 |
| 52,000 | 1.000 | rad. | 0.084 | 0.0842 | 0.0737 | 0.0625 |

-95-
ACCELERATION IN YAW

\[ T_x = 10,470 \text{ lb.} \]
\[ T_y = 10,470 \text{ lb.} \]
\[ X_{rtr} = 76 \text{ ft.} \]
\[ Y_{rtr} = 163 \text{ ft.} \]
\[ T_{r_{y_{\text{max}}}} = 750 \text{ lb.} \]
\[ I_z = 41,236,000 \text{ sl. ft.}^2 \]
\[ L_{r_{T_{r}}} = 5 \text{ ft.} \]

DESIGN NO. C-76/291

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2Y_{rtr} T_{x_{\text{max}}} + 2(X_{rtr} T_{y_{\text{max}}} + X_{T_{r}} T_{r_{y_{\text{max}}}}) = 5,012,160 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V) (kt.)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D) (lb.)</td>
<td></td>
<td>1,095</td>
<td>3,038</td>
<td>5,961</td>
</tr>
<tr>
<td>Aero. Yawing Nom. (W_{z_{\text{trim}}}) (ft.lb.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( s_1 ) = ( D \sin \psi ) (lb.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( s_2 ) = ( Y_{rtr} D \cos \psi ) (ft.lb.)</td>
<td>0</td>
<td>89,242</td>
<td>247,597</td>
<td>485,821</td>
</tr>
</tbody>
</table>

If \( s_1 \geq T_{y_{\text{max}}}, \quad T_{y_{1}} = T_{y_{\text{max}}} \) and \( T_{r_{y_{1}}} = 2(s_1 - T_{y_{\text{max}}}) \)

\[ e_1 \leq T_{y_{\text{max}}}, \quad T_{y_{1}} = e_1 \quad \text{and} \quad T_{r_{y_{1}}} = 0 \]

| \( T_{y_{1}} \) (lb.) | 0 | 0 | 0 | 0 |
| \( T_{r_{y_{1}}} \) (lb.) | 0 | 0 | 0 | 0 |

\[ e_3 = c_1 - s_2 - 2X_{rtr} T_{y_{1}} - 2X_{T_{r}} T_{r_{y_{1}}} \]

\[ \frac{M_{z_{\text{max}}} - M_{z_{\text{trim}}}}{I_z} \quad \text{rad.} \quad \text{sec.}^2 \]

\[ e_3 + Y_{rtr} \frac{T_{p_{x_{\text{max}}}} - M_{z_{\text{trim}}}}{I_z} \]

| \( T_{p_{x_{\text{max}}}} \) (lb.) | 5,510 | 24,600 | 98,540 | 197,040 |
| \( T_{p_{x_{\text{max}}}} \sqrt{T_{z_{\text{total}}}} \) | .030 | .125 | .500 | 1.000 |

\[ r \]

\[ \begin{array}{cccc}
0.1449 & 0.1427 & 0.1389 & 0.1331 \\
0.2188 & 0.2166 & 0.2128 & 0.2070 \\
0.5110 & 0.5088 & 0.5039 & 0.4992 \\
0.9004 & 0.8983 & 0.8944 & 0.8886 \\
\end{array} \]
Design No. D-130/85

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2 Y_{rtr} T_{y_{max}} + 2 \left( Y_{rtr} T_{y_{max}} + X_{TR} T_{r_{y_{max}}} \right) = 479,112 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>T_{x_{max}}</th>
<th>T_{x_{max}}</th>
<th>X_{rt}</th>
<th>Y_{rtr}</th>
<th>T_{y_{max}}</th>
<th>I_z</th>
<th>X_{TR}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vm (kt.)</td>
<td>0</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>759</td>
<td>759</td>
<td>130</td>
</tr>
<tr>
<td>Drug (D)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8_1 = 0.1 \sin \psi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8_2 = Y_{rtr} \tan \psi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \( c_1 \geq T_{y_{max}} \), \( T_{y_1} = T_{y_{max}} \) and \( T_{r_{y_1}} = 2 \left( c_1 - T_{y_{max}} \right) \)

\[ c_1 \leq T_{y_{max}} \]

\[ T_{y_1} = T_{y_{max}} \]

\[ T_{r_{y_1}} = 0 \]

\[ e_3 = c_1 - c_2 - 2 X_{rtr} T_{y_1} \]

\[ = -2 X_{TR} T_{r_{y_{max}}} \]

\[ \iota = \frac{M_{z_{max}} - M_{z_{trim}}}{I_z} \]

\[ c_3 = Y_{rtr} T_{r_{x_{max}}} - M_{z_{trim}} \]

\[ \frac{T_{x_{max}}}{I_z} \]

\[ \frac{c_{r_{x_{max}}}}{I_z} \]

<table>
<thead>
<tr>
<th>( T_{x_{max}} )</th>
<th>( c_{r_{x_{max}}}/I_z )</th>
<th>( \iota )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.030</td>
<td>0.0253</td>
</tr>
<tr>
<td>1.785</td>
<td>0.125</td>
<td>0.0350</td>
</tr>
<tr>
<td>7.140</td>
<td>0.500</td>
<td>0.0732</td>
</tr>
<tr>
<td>14.200</td>
<td>1.000</td>
<td>0.1242</td>
</tr>
</tbody>
</table>
Accelerates in yaw

\[ T_{x_{\text{max}}} = 2,763 \text{ lb.} \]
\[ T_{y_{\text{max}}} = 2,763 \text{ lb.} \]
\[ X_{\text{rtr}} = 130 \text{ ft.} \]
\[ Y_{\text{rtr}} = 154 \text{ ft.} \]
\[ T_{R_{\text{max}}} = 750 \text{ lb.} \]
\[ I_z = 23,298,000 \text{ ft.}^2 \]
\[ X_{\text{rtr}} = 32 \text{ ft.} \]

Design No. B-130/609

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2 X_{\text{rtr}} T_{x_{\text{max}}} + 2 (X_{\text{rtr}} T_{y_{\text{max}}} + X_{\text{rtr}} T_{R_{\text{max}}}) = 1,617,384 \text{ ft.} \text{lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (h)</td>
<td>lb.</td>
<td>0</td>
<td>979</td>
<td>2,716</td>
<td>5,329</td>
</tr>
<tr>
<td>Aero. Yawing load (M_{\text{z trim}})</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 = \frac{D \sin \psi}{h} )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_2 = Y_{\text{rtr}} \frac{D \cos \psi}{2} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>75,383</td>
<td>209,132</td>
<td>410,333</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{y_{\text{max}}} \), \( T_{y_1} = T_{y_{\text{max}}} \) and \( T_{R_{y_1}} = 2 (\epsilon_1 - T_{y_{\text{max}}}) \)

| \( T_{y_1} \) | lb. | 0 | 0 | 0 | 0 |
| \( T_{R_{y_1}} \) | lb. | 0 | 0 | 0 | 0 |

\[ \epsilon_3 = \epsilon_1 - \epsilon_2 - 2 X_{\text{rtr}} T_{y_1} - 2 X_{\text{rtr}} T_{R_{y_1}} \]

\[ M_{\text{z trim}} = \frac{M_{\text{z_{max}}}}{I_z} \]

\[ \frac{M_{\text{z_{max}}}}{I_z} \]

\[ \dot{\epsilon} = \frac{\epsilon_3 + Y_{\text{rtr}} T_{p_{\text{max}}} - M_{\text{z trim}}}{I_z} \]

<table>
<thead>
<tr>
<th>( T_{p_{\text{max}}} ) (lb)</th>
<th>( T_{p_{\text{max}}}/I_z )</th>
<th>( \dot{\epsilon} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>0.030</td>
<td>rad. sec. ^2</td>
</tr>
<tr>
<td>6,500</td>
<td>0.125</td>
<td>rad. sec. ^2</td>
</tr>
<tr>
<td>26,000</td>
<td>0.500</td>
<td>rad. sec. ^2</td>
</tr>
<tr>
<td>52,000</td>
<td>1.000</td>
<td>rad. sec. ^2</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[
\begin{align*}
&T_{X_{\text{max}}} = 10,470 \text{ lb.} \\
&T_{Y_{\text{max}}} = 10,470 \text{ lb.} \\
&X_{\text{rtr}} = 130 \text{ ft.} \\
&Y_{\text{rtr}} = 154 \text{ ft.} \\
&T_{Y_{\text{max}}} = 750 \text{ lb.} \\
&I_2 = 52,686,000 \text{ sl. ft.}^2 \\
&X_{\text{TR}} = 32 \text{ ft.}
\end{align*}
\]

\[
\psi = 0 \text{ Degrees}
\]

\[
c_1 = 2Y_{\text{rtr}}T_{X_{\text{max}}} + 2(X_{\text{rtr}}T_{Y_{\text{max}}} + X_{\text{TR}}T_{Y_{\text{max}}}) = 5,994,960 \text{ ft.lb.}
\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>1,116</td>
<td>3,097</td>
</tr>
<tr>
<td>Aero. Yawing</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(e_1 = \frac{D \sin \psi}{V})</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(e_2 = \frac{Y_{\text{rtr}}D \cos \psi}{V})</td>
<td>ft.lb.</td>
<td>0</td>
<td>85,932</td>
<td>238,469</td>
</tr>
</tbody>
</table>

If \(e_1 \geq T_{Y_{\text{max}}}, \quad T_{Y_1} = T_{Y_{\text{max}}} \) and \(T_{R_{Y_1}} = 2(e_1 - T_{Y_{\text{max}}})\)

\[
\begin{align*}
T_{Y_1} & = 0 \\
T_{R_{Y_1}} & = 0
\end{align*}
\]

\[
e_3 = c_1 - e_2 - 2X_{\text{rtr}}T_{Y_1}
\]

\[
= \frac{M_{\text{z, max}} - M_{\text{z, trim}}}{I_2}
\]

\[
\dot{\rho} = \frac{M_{\text{z, max}} - M_{\text{z, trim}}}{I_2}
\]

\[
e_3 + Y_{\text{rtr}}T_{P_{\text{x, max}}} = M_{\text{z, trim}}
\]

\[
T_{P_{\text{x, max}}} = \frac{1}{I_2}
\]

<table>
<thead>
<tr>
<th>(T_{\text{P}_{\text{x, max}}} / I_2) total</th>
<th>(\dot{\rho})</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910 \text{ lb.} / \text{sec.}^2</td>
<td>.1311</td>
</tr>
<tr>
<td>24,600 \text{ lb.} / \text{sec.}^2</td>
<td>.1857</td>
</tr>
<tr>
<td>98,820 \text{ lb.} / \text{sec.}^2</td>
<td>.4017</td>
</tr>
<tr>
<td>197,040 \text{ lb.} / \text{sec.}^2</td>
<td>.6897</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ c_1 = 2 y_{\text{rtr}} T_x_{\text{max}} + 2 (x_{\text{rtr}} T_y_{\text{max}} + x_{\text{TR}} T_{\text{TR}}) = 575,778 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V) (kt.)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D) (lb.)</td>
<td>0</td>
<td>898</td>
<td>2,493</td>
<td>4,892</td>
</tr>
<tr>
<td>Aero. Yawing Mom. (M_{2\text{trim}}) (ft.lb.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 = \frac{D \sin \psi}{4} ) (lb.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_2 = \frac{y_{\text{rtr}} D \cos \psi}{2} ) (ft.lb.)</td>
<td>0</td>
<td>61,513</td>
<td>170,770</td>
<td>335,102</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_y_{\text{max}} \), \( T_x_1 = T_y_{\text{max}} \) and \( T_{\text{TR1}} = 2 (\epsilon_1 - T_y_{\text{max}}) \)

\[ T_x_1 = \frac{M_{2\text{max}} - M_{2\text{trim}}}{I_2} \]

\[ T_{\text{TR1}} = \frac{M_{2\text{max}} - M_{2\text{trim}}}{I_2} \]

\[ \epsilon_3 + y_{\text{rtr}} T_{x_{\text{max}}} - M_{2\text{trim}} \]

\[ T_{x_{\text{max}}} \]

<table>
<thead>
<tr>
<th>( T_{x_{\text{max}}} ) (lb.)</th>
<th>( T_{x_{\text{max}}} / T_{z_{\text{total}}} )</th>
<th>( \epsilon_3 )</th>
<th>( \epsilon_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>0.030</td>
<td>0.02349</td>
<td>0.0212</td>
</tr>
<tr>
<td>1,785</td>
<td>0.125</td>
<td>0.03037</td>
<td>0.0281</td>
</tr>
<tr>
<td>7,140</td>
<td>0.500</td>
<td>0.0575</td>
<td>0.0553</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>0.0938</td>
<td>0.0915</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ V_z = V_y z - T_x x \]

\[ T_x = \frac{2,763 \text{ lb.}}{2} \]

\[ X_{br} = 184 \text{ ft.} \]

\[ Y_{br} = 137 \text{ ft.} \]

\[ T_{RY_{max}} = 750 \text{ lb.} \]

\[ I_z = 29,940,000 \text{ sl. ft.}^2 \]

\[ X_{br} = 59 \text{ ft.} \]

**Design No. A-104/609**

\[ \psi = 0 \text{ Degrees} \]

\[ c_1 = 2 (T_{br} T_{max} + X_{br} T_{br} T_{RY_{max}}) + 1,862,346 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>(kt.)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (C)</td>
<td>lb.</td>
<td>0</td>
<td>990</td>
<td>2,748</td>
<td>5,391</td>
</tr>
<tr>
<td>Aero. Yawing Mom. (Mz_{trim})</td>
<td>ft.lbf.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 )</td>
<td>lb.</td>
<td>( \frac{D \sin \psi}{4} )</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_2 )</td>
<td>ft.lbf.</td>
<td>( \frac{Y_{br} D \cos \psi}{2} )</td>
<td>0</td>
<td>67,815</td>
<td>188,238</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{Y_{max}} \)

\[ T_{Y_{max}} = \frac{T_{Y_{br}}}{2} \]

\[ T_{Y_{br}} = \frac{T_{Y_{br}}}{2} \]

\[ \epsilon_1 \leq T_{Y_{max}} \]

\[ T_{Y_{br}} = \epsilon_1 \]

\[ T_{Y_{br}} = 0 \]

| \( T_{Y_{max}} \) | lb. | 0 | 0 | 0 | 0 |
| \( T_{Y_{br}} \) | lb. | 0 | 0 | 0 | 0 |

\[ \epsilon_3 = c_1 - \epsilon_2 - 2X_{br} T_{Y_{br}} \]

\[ -2 X_{br} T_{Y_{br}} \]

\[ \epsilon_3 = \frac{M_{z_{max}} - M_{z_{trim}}}{I_z} \]

\[ \frac{\epsilon_3 + Y_{br} T_{FP_{max}} - M_{z_{trim}}}{I_z} \]

\[ T_{FP_{max}} \text{ (lb.)} \]

\[ \frac{T_{FP_{max}}}{I_z^{1/2}} \text{ total} \]

\[ r \]

| 1,560 | .030 | \( \text{rad.} \) | .0693 | .0671 | .0631 | .0570 |
| 6,500 | .125 | \( \text{rad.} \) | .0919 | .0897 | .0857 | .0796 |
| 26,000 | .500 | \( \text{rad.} \) | .1812 | .1789 | .1749 | .1688 |
| 52,000 | 1.000 | \( \text{rad.} \) | .3001 | .2979 | .2939 | .2873 |
### ACCUMULATION IN YAW

![Diagram of Yaw](diagram)

**Design No. A-184/291**

Ψ = 0 Degrees

\[ c_1 = 2Y_{trr} T_{x_{max}} + 2 (X_{trr} T_{y_{max}} + X_{TR} T_{Ry_{max}}) = 6,810,240 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aero Yawing Kom. (Mz trim)</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_1 = D \sin \Psi )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_2 = Y_{trr} D \cos \Psi )</td>
<td>ft.lb.</td>
<td>0</td>
<td>77,268</td>
<td>214,336</td>
</tr>
</tbody>
</table>

If \( \delta_1 \geq T_{y_{max}} \), \( T_{y_1} = T_{y_{max}} \) and \( T_{Ry_1} = 2 (\delta_1 - T_{y_{max}}) \)

If \( \delta_1 < T_{y_{max}} \), \( T_{y_1} = \delta_1 \) and \( T_{Ry_1} = 0 \)

|  | lb. | 0  | 0  | 0  | 0  |
|  | lb. | 0  | 0  | 0  | 0  |
| \( T_{y_1} \) | ft.lb. | 6,810,240 | 6,732,972 | 6,595,904 | 6,389,650 |
| \( T_{Ry_1} \) | rad. sec. | .1095 | .1084 | .1064 | .1035 |
| \( r = \frac{M_{z_{max}} - M_{z_{trim}}}{I_Z} \) | rad. sec. | .1463 | .1452 | .1432 | .1403 |
| \( \delta_3 = Y_{rtr} T_{p_{max}} - M_{z_{trim}} \) | rad. sec. | .2919 | .2908 | .2888 | .2858 |

<table>
<thead>
<tr>
<th>( T_{p_{max}} ) (lb)</th>
<th>( T_{p_{max}} / T_{p_{total}} )</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>.030</td>
<td>.1095</td>
</tr>
<tr>
<td>24,670</td>
<td>.125</td>
<td>.1463</td>
</tr>
<tr>
<td>98,520</td>
<td>.500</td>
<td>.2919</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
<td>.4059</td>
</tr>
</tbody>
</table>

---

*Note: All calculations involve airflow and structural integrity for flight at various velocities and yaw angles.*
ACCELERATION IN YAW

\[ c_1 = 2y_{rtr} + 2(y_{rtr} + x_{tr} + x_{rtr}) = 370.302 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>2,592</td>
<td>7,166</td>
</tr>
<tr>
<td>Aero.Yawing Moment (M_{z,trim})</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
</tr>
<tr>
<td>( \theta_1 = \frac{D \sin \psi}{4} )</td>
<td>lb.</td>
<td>0</td>
<td>322</td>
<td>895</td>
</tr>
<tr>
<td>( \theta_2 = y_{rtr} \frac{D \cos \psi}{2} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>182,240</td>
<td>505,783</td>
</tr>
</tbody>
</table>

If \( \theta_1 \geq T_{y,\text{max}} \), \( T_{y_1} = T_{y,\text{max}} \) and \( T_{r_{rtr}} = 2(\theta_1 - T_{y,\text{max}}) \)

\( \theta_1 \leq T_{y,\text{max}} \), \( T_{y_1} = \theta_1 \) and \( T_{r_{rtr}} = 0 \)

| \( T_{y_1} \) | lb. | 0 | 322 | 759 | 759 |
| \( T_{r_{rtr}} \) | lb. | 0 | 0 | 272 | 1,996 |
| \( \theta_3 = c_1 - \theta_2 - 2y_{rtr} T_{y_1} \) | ft.lb. | 370.302 | 139,118 | -253,569 | -757,466 |

\( \omega = \frac{M_{z,\text{max}} - M_{z,\text{trim}}}{I_z} \)

\( \omega = y_{rtr} T_{r_{rtr}} \frac{M_{z,\text{max}} - M_{z,\text{trim}}}{I_z} \)

<table>
<thead>
<tr>
<th>( T_{r_{rtr}} ) (lb)</th>
<th>( T_{y,\text{max}} / I_z \text{ total} )</th>
<th>( \omega )</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>0.30</td>
<td>( \text{rad. sec}^{-2} )</td>
</tr>
<tr>
<td>1,795</td>
<td>0.125</td>
<td>( \text{rad. sec}^{-2} )</td>
</tr>
<tr>
<td>7,140</td>
<td>0.500</td>
<td>( \text{rad. sec}^{-2} )</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>( \text{rad. sec}^{-2} )</td>
</tr>
</tbody>
</table>

\( \psi = 30 \text{ Degrees} \)
ACCELERATION IN YAW

\[ T_x^{\max} = 2.763 \text{ lb.} \]
\[ T_y^{\max} = 2.763 \text{ lb.} \]
\[ X_r^{\max} = 76 \text{ ft.} \]
\[ Y_r^{\max} = 163 \text{ ft.} \]
\[ T_{HY}^{\max} = 750 \text{ lb.} \]
\[ I_z = 18,523,000 \text{ sl. ft.}^2 \]
\[ X_{TR} = 5 \text{ ft.} \]

DESIGN NO. C-76/1.609
ψ = 37° Degrees

\[ c_1 = 2Y_r^{\max}T_y^{\max} + 2(X_r^{\max}T_x^{\max} + X_{TR} T_{RY}^{\max}) = 1,320,214 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug (D)</td>
<td>lb.</td>
<td>0</td>
<td>2,643</td>
<td>7,335</td>
</tr>
<tr>
<td>Aero. Yawing Kom. (M2_trim)</td>
<td>ft. lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
</tr>
<tr>
<td>$\delta_1 = \frac{D \sin \psi}{4}$</td>
<td>lb.</td>
<td>0</td>
<td>330</td>
<td>916</td>
</tr>
<tr>
<td>$\delta_2 = \frac{X_r^{\max} D \cos \psi}{2}$</td>
<td>ft. lb.</td>
<td>0</td>
<td>186,545</td>
<td>517,712</td>
</tr>
</tbody>
</table>

If $\delta_1 \geq T_y^{\max}$, $T_y^{\max} = T_y^{\max}$ and $T_{RY}^{\max} = 2(\delta_1 - T_y^{\max})$

\[ T_y^{\max} = \begin{cases} 330 & \text{for } \delta_1 \leq T_y^{\max} \\ 0 & \text{for } \delta_1 > T_y^{\max} \end{cases} \]

<table>
<thead>
<tr>
<th>$T_{RY}^{\max}$</th>
<th>lb.</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
</table>

\[ \delta_3 = c_1 - \delta_2 - 2X_r^{\max}T_y^{\max} - 2X_{TR} T_{RY}^{\max} \]

\[ I = \frac{M_z^{\max} - M_z^{\trim}}{I_z} \text{ rad. sec}^2 \]

\[ \dot{\theta} = \frac{\delta_3 + Y_r^{\max} T_{P_X}^{\max} - M_z^{\trim}}{I_z} \]

<table>
<thead>
<tr>
<th>$T_{P_X}^{\max}$ (lb)</th>
<th>$\frac{T_{P_X}^{\max}}{I_z$ total}</th>
<th>$\dot{\theta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.030</td>
<td>rad. sec.² / 2</td>
</tr>
<tr>
<td>6,500</td>
<td>.125</td>
<td>rad. sec.² / 2</td>
</tr>
<tr>
<td>26,000</td>
<td>.500</td>
<td>rad. sec.² / 2</td>
</tr>
<tr>
<td>52,000</td>
<td>1.000</td>
<td>rad. sec.² / 2</td>
</tr>
</tbody>
</table>
### ACCELERATION IN YAW

\[ V_y' = F_z + x_{TR} \frac{T_y}{T_{\text{max}}} \]

\[ Y_{rtr} = 163 \text{ ft.} \]

\[ T_y = 10,470 \text{ lb.} \]

\[ T_{\text{max}} = 10,470 \text{ lb.} \]

\[ X_{rtr} = 76 \text{ ft.} \]

\[ X_{\text{max}} = 76 \text{ ft.} \]

\[ T_{\text{max}} = 5 \text{ ft.} \]

\[ I_z = 41,236,000 \text{ sl. ft.}^2 \]

\[ c_1 = \frac{K_{rtr} T_{\text{max}}}{2} (x_{rtr} T_{\text{max}} + x_{TR} T_{\text{max}}) = 5,012,160 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (( v ))</th>
<th>Drag (D)</th>
<th>( c_1 )</th>
<th>( c_2 )</th>
<th>( c_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft.</td>
<td>lb.</td>
<td>0</td>
<td>2,827</td>
<td>7,488</td>
</tr>
<tr>
<td>ft.</td>
<td>lb.</td>
<td>0</td>
<td>48</td>
<td>1,235</td>
</tr>
<tr>
<td>ft.</td>
<td>lb.</td>
<td>0</td>
<td>197,532</td>
<td>1,038,793</td>
</tr>
</tbody>
</table>

If \( c_1 \geq T_{\text{max}}, Y_1 = T_{\text{max}} \text{ and } T_{\text{Y}} = 2 (c_1 - T_{\text{max}}) \)

\[ T_{Y_1} = \frac{B_2}{C_2} \]

\[ T_{\text{Y}} = \frac{B_2}{C_2} \]

\[ B_2 = Y_{rtr} T_{\text{Y}} - x_{rtr} T_{\text{Y}} \]

\[ \frac{B_2}{C_2} = \frac{M_{\text{max}} - \frac{K_{rtr}}{i_{\text{Y}}} Y_{rtr}}{y_{rtr}} \]

\[ \frac{B_2}{C_2} = \frac{M_{\text{max}} - \frac{K_{rtr}}{i_{\text{Y}}} Y_{rtr}}{y_{rtr}} \]

\[ T_{\text{max}} \]

\[ T_{\text{max}} \]

\[ t \]

\[ 5,910 \]

\[ 24,600 \]

\[ 91,900 \]

\[ 197,000 \]

\[ t \]
ACCELERATION IN Y'Y

\[ T_{Y, \text{max}} = 750 \text{ lb.} \]
\[ T_{T, \text{max}} = 625 \text{ lb.} \]
\[ X_{T, \text{max}} = 150 \text{ ft.} \]
\[ Y_{T, \text{max}} = 150 \text{ ft.} \]
\[ T_{Y, \text{max}} = 750 \text{ lb.} \]
\[ I_z = 21,567,000 \text{ in.}^2 \text{ft.}^2 \]
\[ X_{T, \text{max}} = 32 \text{ ft.} \]

**DESIGN NO. B-130/85**

\[ \psi = 30 \text{ Degrees} \]

\[ \epsilon_1 = 2X_{T, \text{max}} T_{Y, \text{max}} + 2(X_{T, \text{max}} T_{Y, \text{max}} + X_{T, \text{max}} T_{Y, \text{max}}) = 479,112 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity ((v))</th>
<th>kt</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb</td>
<td>0</td>
<td>2,636</td>
<td>7,314</td>
<td>14,352</td>
</tr>
<tr>
<td>Aero. Yawing Mom. ((M_{2, \text{trim}}))</td>
<td>ft.lb</td>
<td>0</td>
<td>27,228</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>(\epsilon_1 = D \sin \psi)</td>
<td>lb</td>
<td>0</td>
<td>329</td>
<td>914</td>
<td>1,794</td>
</tr>
<tr>
<td>(\epsilon_2 = Y_{T, \text{max}} D \cos \psi)</td>
<td>ft.lb</td>
<td>0</td>
<td>175,718</td>
<td>487,726</td>
<td>957,048</td>
</tr>
</tbody>
</table>

If \(\epsilon_1 \geq T_{Y, \text{max}}\), \(T_{Y_1} = T_{Y, \text{max}}\) and \(T_{R_{Y_1}} = 2(\epsilon_1 - T_{Y, \text{max}})\)

| \(T_{Y_1}\) | lb  | 0  | 329 | 759 | 759 |
| \(T_{R_{Y_1}}\) | lb  | 0  | 0  | 310 | 2,070 |

\[ \epsilon_3 = \epsilon_1 - \epsilon_2 - 2X_{T, \text{max}} T_{Y_1} \]

\[ r = \frac{M_{2, \text{trim}}}{I_z} \]

\[ \epsilon_3 = Y_{T, \text{max}} T_{P_{X, \text{max}}} - M_{2, \text{trim}} \]

<table>
<thead>
<tr>
<th>(T_{P_{X, \text{max}}} (lb))</th>
<th>(T_{P_{X, \text{max}}} / I_z \text{total})</th>
<th>(r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>.030</td>
<td>.0253</td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>.0350</td>
</tr>
<tr>
<td>7,140</td>
<td>.500</td>
<td>.0732</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>.1242</td>
</tr>
</tbody>
</table>
### Acceleration in Yaw

- $\psi = 30$ Degrees
- $e_1 = 2x_{rtr} T_y_{max} + 2(x_{rtr} T_y_{max} + x_{TR} T_{RY_{max}}) = 1,617.334$ ft.lb.

#### Table: Yawing Moments

<table>
<thead>
<tr>
<th>Velocity (V) (kt.)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug (D) (lb.)</td>
<td>0</td>
<td>2.674</td>
<td>7.420</td>
<td>14,260</td>
</tr>
<tr>
<td>Aero. Yawing Kom. ($M_z_{trim}$) (ft. lb.)</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>$\delta_1 = \frac{D \sin \psi}{4}$ (lb.)</td>
<td>0</td>
<td>334</td>
<td>927</td>
<td>1,820</td>
</tr>
<tr>
<td>$\delta_2 = \frac{Y_{rtr} D \cos \psi}{2}$ (ft. lb.)</td>
<td>0</td>
<td>178,312</td>
<td>494,794</td>
<td>970,918</td>
</tr>
</tbody>
</table>

If $\delta_1 \geq T_y_{max}$, $T_{Y_1} = T_y_{max}$ and $T_{RY_1} = 2(\delta_1 - T_y_{max})$

If $\delta_1 \leq T_y_{max}$, $T_{Y_1} = \delta_1$ and $T_{RY_1} = 0$

| $T_{Y_1}$ (lb.) | 0 | 334 | 927 | 1,820 |
| $T_{RY_1}$ (lb.) | 0 | 0 | 0 | 0 |

$\varepsilon_3 = \frac{c_1 - \delta_2 - 2x_{rtr} T_y_{max}}{2x_{TR} T_{RY_{max}}}$ (ft. lb.)

$\ddot{r} = \frac{M_y_{max} - M_z_{trim}}{I_z}$ (rad./sec.$^2$)

$\ddot{\varepsilon}_3 + Y_{rtr} T_p_{x_{max}} - M_z_{trim}$

<table>
<thead>
<tr>
<th>$T_p_{x_{max}}$ (lb.)</th>
<th>$\frac{T_p_{x_{max}}}{T_z_{total}}$</th>
<th>$\ddot{r}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.550</td>
<td>.030</td>
<td>.0797</td>
</tr>
<tr>
<td>6,500</td>
<td>.125</td>
<td>.1124</td>
</tr>
<tr>
<td>26,000</td>
<td>.500</td>
<td>.2413</td>
</tr>
<tr>
<td>52,000</td>
<td>1.600</td>
<td>.4131</td>
</tr>
</tbody>
</table>

-107-
ACCELERATION IN YAW

\[ T_X_{\text{max}} = 10,470 \text{ lb.} \]
\[ T_Y_{\text{max}} = 10,470 \text{ lb.} \]
\[ X_{\text{rtr}} = 130 \text{ ft.} \]
\[ Y_{\text{rtr}} = 154 \text{ ft.} \]
\[ T_{\text{RY}}_{\text{max}} = 750 \text{ lb.} \]
\[ I_Z = 52,668,000 \text{lbf. ft.}^2 \]
\[ X_{\text{TR}} = 32 \text{ ft.} \]

**DESIGN NO. B-130/0.291**

\[ \psi = 30 \text{ Degrees} \]

\[ c_1 = 2X_{\text{rtr}} T_X_{\text{max}} + 2(X_{\text{rtr}} T_Y_{\text{max}} + X_{\text{TR}} T_{\text{RY}}_{\text{max}}) = 5,994,960 \text{ lbf. ft.} \]

<table>
<thead>
<tr>
<th>Velocity ((V))</th>
<th>Drag (D)</th>
<th>Aero.Yawing Moment ((M_{z_{\text{trim}}}))</th>
<th>Drag (D)</th>
<th>Yawing Moment ((M_{x_{\text{trim}}}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>kt.</td>
<td>lb.</td>
<td>ft.lbf.</td>
<td>lb.</td>
<td>ft.lbf.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>2,910</td>
<td>0</td>
<td>272,839</td>
</tr>
<tr>
<td>15</td>
<td>2,910</td>
<td>272,839</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
</tbody>
</table>

\[ \epsilon_1 = \frac{D \sin \psi}{4} \]

\[ \epsilon_2 = \frac{Y_{\text{rtr}} D \cos \psi}{2} \]

If \(\epsilon_1 \geq T_X_{\text{max}}\), 
\[ T_Y_{1} = T_Y_{\text{max}} \quad \text{and} \quad T_{\text{RY}}_{1} = 2(\epsilon_1 - T_Y_{\text{max}}) \]

If \(\epsilon_1 \leq T_X_{\text{max}}\), 
\[ T_Y_{1} = \epsilon_1 \quad \text{and} \quad T_{\text{RY}}_{1} = 0 \]

<table>
<thead>
<tr>
<th>(T_Y_{1})</th>
<th>(T_{\text{RY}}_{1})</th>
<th>(\epsilon_2)</th>
<th>(\epsilon_3)</th>
<th>(\epsilon_3 - X_{\text{rtr}} T_{\text{RY}}<em>{1} - 2X</em>{\text{rtr}} T_{\text{RY}}_{1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>lb.</td>
<td>ft.lbf.</td>
<td>ft.lbf.</td>
<td>5,994,960</td>
</tr>
</tbody>
</table>

\[ \frac{M_{z_{\text{max}}}}{I_Z} = \frac{M_{z_{\text{trim}}}}{I_Z} \]

\[ \epsilon_3 + Y_{\text{rtr}} T_{\text{FX}}_{\text{max}} = \frac{M_{2_{\text{trim}}}}{I_Z} \]

<table>
<thead>
<tr>
<th>(T_{\text{FX}}_{\text{max}}) (lb)</th>
<th>(T_{\text{FX}}_{\text{max}} / I_Z)</th>
<th>(\epsilon_3)</th>
<th>(\epsilon_3 / I_Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>0.030</td>
<td>0.1311</td>
<td>0.1204</td>
</tr>
<tr>
<td>24,500</td>
<td>0.125</td>
<td>0.1704</td>
<td>0.1560</td>
</tr>
<tr>
<td>98,520</td>
<td>0.500</td>
<td>0.3017</td>
<td>0.3164</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
<td>0.6897</td>
<td>0.6791</td>
</tr>
</tbody>
</table>

\(i\)
**DESIGN NO. A-184/85**

\[ \psi = 30 \text{ Degrees} \]

\[ \phi_1 = 2Y_{rtr} T_{rmax} + 2(Y_{rtr} T_{y_{max}} + X_{TR} T_{r_{max}}) = 575,778 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>k.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>2,705</td>
<td>7,505</td>
<td>14,726</td>
</tr>
<tr>
<td>AERO.Yawing K.m.(M2trim)</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,938</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>( \delta_1 = \frac{D \sin \psi}{4} )</td>
<td>lb.</td>
<td>0</td>
<td>338</td>
<td>936</td>
<td>1,840</td>
</tr>
<tr>
<td>( \delta_2 = \frac{Y_{rtr} D \cos \psi}{2} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>160,468</td>
<td>445,217</td>
<td>873,586</td>
</tr>
</tbody>
</table>

If \( \delta_1 \geq T_{r_{max}} \), \( T_{y_{1}} = T_{y_{max}} \) and \( T_{r_{1}} = 2(\delta_1 - T_{r_{max}}) \)

\( \delta_1 \leq T_{r_{max}} \), \( T_{y_{1}} = \delta_1 \) and \( T_{r_{1}} = 0 \)

| \( T_{y_{1}} \) | lb. | 0 | 338 | 759 | 759 |
| \( T_{r_{1}} \) | lb. | 0 | 0 | 358 | 2,162 |

\( \delta_3 = \phi_1 - \delta_2 - 2X_{rtr} T_{y_{1}} - 2X_{TR} T_{r_{1}} \)

\( \dot{r} = \frac{M_{y_{max}} - M_{y_{trim}}}{I_{z}} \)

\( \dot{r} = \frac{\delta_3 + Y_{rtr} T_{P_{x_{max}}}}{I_{z}} \frac{T_{P_{x_{max}}}}{I_{z_{total}}} \)

<table>
<thead>
<tr>
<th>( T_{P_{x_{max}}} ) (lb.)</th>
<th>( T_{P_{x_{max}}}/I_{z_{total}} )</th>
<th>( \dot{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>.030</td>
<td>rad/sec²</td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>rad/sec²</td>
</tr>
<tr>
<td>7,140</td>
<td>.500</td>
<td>rad/sec²</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>rad/sec²</td>
</tr>
</tbody>
</table>
**ACCELERATION IN YAW**

\[
M_z = \frac{M_{z_{\text{max}}}}{I_z}
\]

\[
T_x = T_{\text{max}} = 2,763 \text{ lb.}
\]

\[
T_y = T_{\text{max}} = 2,763 \text{ lb.}
\]

\[
x_{rtr} = 184 \text{ ft.}
\]

\[
y_{rtr} = 137 \text{ ft.}
\]

\[
T_{\text{max}} = 750 \text{ lb.}
\]

\[
l_z = 29,940,000 \text{ sl. ft.}^2
\]

\[
x_{\text{TR}} = 59 \text{ ft.}
\]

**DESIGN NO. A-184/609**

\[
\Psi = 30 \text{ Degrees}
\]

\[
\phi_1 = 2y_{rtr} T_x T_{\text{max}} + 2(x_{rtr} T_y + x_{\text{TR}} T_{\text{TR}} T_{\text{max}}) = 1,862,346 \text{ ft. lb.}
\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aer. Yawing Mom. ((M_{2 \text{trim}}))</td>
<td>ft.lbm.</td>
<td>0</td>
<td>272,838</td>
<td>775,882</td>
</tr>
<tr>
<td>(\epsilon_1 = \frac{D \sin \Psi}{4})</td>
<td>lb.</td>
<td>0</td>
<td>341</td>
<td>948</td>
</tr>
<tr>
<td>(\epsilon_2 = \frac{y_{rtr} D \cos \Psi}{2})</td>
<td>ft.lbm.</td>
<td>0</td>
<td>162,247</td>
<td>450,259</td>
</tr>
</tbody>
</table>

If \(\epsilon_1 > T_{\text{y, max}}\), \(T_{y_1} = T_{\text{y, max}}\) and \(T_{R1} = 2(\epsilon_1 - T_{\text{y, max}})\)

If \(\epsilon_1 < T_{\text{y, max}}\), \(T_{y_1} = \epsilon_1\) and \(T_{R1} = 0\)

\[
T_{y_1} = \frac{y_{rtr} T_{\text{y, max}}}{2}
\]

\[
T_{R1} = \frac{y_{rtr} T_{\text{y, max}}}{2}
\]

\[
\epsilon_3 = c_1 - \epsilon_2 - 2x_{rtr} T_{y_1} - 2x_{\text{TR}} T_{R1}
\]

\[
\epsilon_3 = \frac{M_{2 \text{max}} - M_{2 \text{trim}}}{I_z}
\]

\[
T_p = \frac{T_{\text{p, max}}}{I_z}
\]

\[
T_p / T_{\text{p, max}}
\]

\[
T_p / T_{\text{p, max}} / I_z \text{total}
\]

<table>
<thead>
<tr>
<th>(T_p)_{\text{lb}}\</th>
<th>(T_p / T_{\text{p, max}})</th>
<th>(T_p / T_{\text{p, max}} / I_z \text{total})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500</td>
<td>.030</td>
<td>rad. (\frac{1}{2})</td>
</tr>
<tr>
<td>6,500</td>
<td>.125</td>
<td>rad. (\frac{1}{2})</td>
</tr>
<tr>
<td>26,000</td>
<td>.500</td>
<td>rad. (\frac{1}{2})</td>
</tr>
<tr>
<td>52,000</td>
<td>1.000</td>
<td>rad. (\frac{1}{2})</td>
</tr>
</tbody>
</table>

\[
\bar{t} = \frac{0.0693}{0.0506 - 0.0173 - 0.0326}
\]

\[
\bar{t} = \frac{0.0919}{0.0732 - 0.0399 - 0.0101}
\]

\[
\bar{t} = \frac{0.1812}{0.1624 - 0.1292 - 0.0792}
\]

\[
\bar{t} = \frac{0.3001}{0.2814 - 0.2481 - 0.1981}
\]
ACCELERATION IN YAW

\[ c_1 = 2X_{rtr} T_{X_{\text{max}}} + 2(X_{rtr} T_{Y_{\text{max}}} + X_{TR} T_{P_Y}) = 6,810,240 \text{ ft.lb.} \]

**Design No.** A-184/291

**\( \Psi = 30 \text{ degrees} \)**

\[ c_1 = 2X_{rtr} T_{X_{\text{max}}} + 2(X_{rtr} T_{Y_{\text{max}}} + X_{TR} T_{P_Y}) = 6,810,240 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>Velocity (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(kt)</td>
<td>(lb.)</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>2,980</td>
</tr>
<tr>
<td>25</td>
<td>8,268</td>
</tr>
<tr>
<td>35</td>
<td>16,224</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drag (D)</th>
<th>Drag (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>ft.lbf.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2,980</td>
<td>272,838</td>
</tr>
<tr>
<td>8,268</td>
<td>757,882</td>
</tr>
<tr>
<td>16,224</td>
<td>1,485,449</td>
</tr>
</tbody>
</table>

\[ \delta_1 = \frac{D \sin \Psi}{b} \]

<table>
<thead>
<tr>
<th>( \delta_1 )</th>
<th>( \delta_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>ft.lbf.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>372</td>
<td>1,033</td>
</tr>
<tr>
<td>2,028</td>
<td></td>
</tr>
</tbody>
</table>

\[ \delta_2 = \frac{Y_{rtr} \cos \Psi}{2} \]

If \( \delta_1 \geq Y_{Y_{\text{max}}} \), \( T_{Y_1} = T_{Y_{\text{max}}} \) and \( T_{R_{Y_1}} = 2(\delta_1 - T_{Y_{\text{max}}}) \)

\[ \delta_1 \leq Y_{Y_{\text{max}}} \], \( T_{Y_1} = \delta_1 \) and \( T_{R_{Y_1}} = 0 \)

<table>
<thead>
<tr>
<th>( T_{Y_1} )</th>
<th>( T_{R_{Y_1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>lb.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>372</td>
<td>1,033</td>
</tr>
<tr>
<td>2,028</td>
<td></td>
</tr>
</tbody>
</table>

\[ \delta_3 = c_1 - \delta_2 - 2X_{rtr} T_{Y_1} \]

-2 \( X_{TR} T_{P_{Y,\text{max}} - M_{Z_{\text{trim}}}} \)

\[ \dot{r} = \frac{M_{Z_{\text{max}}} - M_{Z_{\text{trim}}}}{I_2} \]

\[ \delta_3 = Y_{rtr} T_{P_{Y,\text{max}} - M_{Z_{\text{trim}}}} \]

\[ \dot{r} = \frac{I_2}{T_{P_{X_{\text{max}}}} / T_{Z_{\text{total}}}} \]

<table>
<thead>
<tr>
<th>( T_{P_{X_{\text{max}}}} ) (lb)</th>
<th>( T_{P_{X_{\text{max}}}} / T_{Z_{\text{total}}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>.030</td>
</tr>
<tr>
<td>.1095</td>
<td>.1011</td>
</tr>
<tr>
<td>.0861</td>
<td>.0636</td>
</tr>
<tr>
<td>22,600</td>
<td>.125</td>
</tr>
<tr>
<td>.1463</td>
<td>.1379</td>
</tr>
<tr>
<td>.1229</td>
<td>.1004</td>
</tr>
<tr>
<td>29,520</td>
<td>.500</td>
</tr>
<tr>
<td>.2919</td>
<td>.2834</td>
</tr>
<tr>
<td>.2685</td>
<td>.2560</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
</tr>
<tr>
<td>.4859</td>
<td>.4774</td>
</tr>
<tr>
<td>.4625</td>
<td>.4400</td>
</tr>
</tbody>
</table>
Acceleration in Yaw

\[ c_1 = Z Y_{rtr} T_{x_{max}} + 2 (x_{rtr} T_{y_{max}} + x_{TR} T_{y_{TR_{max}}}) = 370,302 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5.107</td>
<td>14.172</td>
<td>27.810</td>
</tr>
<tr>
<td>Aero.Yawing Mom.((M_{r_{trim}}'))</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
</tbody>
</table>

\[ \delta_1 = \frac{D \sin \psi}{g} \]

\[ \delta_2 = \frac{Y_{rtr} D \cos \psi}{g} \]

If \( \delta_1 > T_{y_{max}} \)

\[ T_{y_1} = T_{y_{max}} \quad \text{and} \quad T_{y_{TR_1}} = 2 (\delta_1 - T_{y_{max}}) \]

If \( \delta_1 \leq T_{y_{max}} \)

\[ T_{y_1} = \delta_1 \quad \text{and} \quad T_{y_{TR_1}} = 0 \]

| \( T_{y_1} \) | lb. | 0   | 759 | 759 | 759 |
| \( T_{y_{TR_1}} \) | lb. | 0   | 692 | 4,618 | 10,524 |
| \( \delta_3 = \delta_1 - \delta_2 - 2x_{rtr} T_{y_1} - 2x_{TR} T_{y_{TR_1}} \) | ft.lb. | 370,302 | 39,504 | -368,755 | -983,563 |

\[ \epsilon = \frac{M_{o_{max}} - M_{z_{trim}}}{I_z} \]

\[ \epsilon_3 = Y_{rtr} T_{p_{x_{max}}} - M_{z_{trim}} \]

<table>
<thead>
<tr>
<th>( T_{p_{x_{max}}} ) (lb)</th>
<th>( T_{p_{x_{max}}}/I_z ) total</th>
<th>( \epsilon )</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>.030</td>
<td>.0249  -.0092  -.0599  -.1360</td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>.0375  .0033  -.0474  -.1234</td>
</tr>
<tr>
<td>7,140</td>
<td>.500</td>
<td>.0869  .0528  .0021  -.0740</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>.1529  .1187  .0681  -.0080</td>
</tr>
</tbody>
</table>

\( -112 - \)
### VELOCITY (V)

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>ft./sec</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5.177</td>
<td>14.322</td>
<td>23.163</td>
</tr>
<tr>
<td>AERO. YAWING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIND. (M)</td>
<td>ft./lb.</td>
<td>0</td>
<td>272.838</td>
<td>757.882</td>
<td>1,485.449</td>
</tr>
<tr>
<td>Pitching</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moment (M</td>
<td>lb.</td>
<td>0</td>
<td>1.111</td>
<td>3.197</td>
<td>6.097</td>
</tr>
<tr>
<td>Yawing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moment (M</td>
<td>ft./lb.</td>
<td>0</td>
<td>210.759</td>
<td>584.844</td>
<td>1,147.642</td>
</tr>
</tbody>
</table>

If $\psi \geq T_{Y_{max}}$, $T_{Y_{1}} = T_{Y_{max}}$ and $\psi_{1} = \psi$ and $T_{R_{y_{1}}} = 0$

| $T_{Y_{1}}$ | lb.     | 0     | 1.119| 2.763| 2.763|
| $T_{R_{y_{1}}}$ | lb.     | 0     | 0     | 688  | 6.668|
| $e_{3} = c_{1} - e_{2} - 2x_{y_{r}}T_{Y_{1}} - 2x_{y_{r}}T_{R_{y_{1}}}$ | ft./lb. | 1,328,214| 547,367| 316,114| -306,034|

| $e_{3} + y_{r}r_{y_{r}}$ | rad. | 1.000 |
| $-r_{y_{r}}$ | rad. | 0     |

| $r = \frac{r_{y_{r}}}{I_{z}}$ | rad. | sec.² | rad. | sec.² |
| $e_{3} + y_{r}r_{y_{r}}$ | rad. | sec.² |

<table>
<thead>
<tr>
<th>$T_{P_{X_{max}}}$ (lb)</th>
<th>$T_{R_{X_{max}}}$ (lb)</th>
<th>$T_{Q_{max}}$ (lb)</th>
<th>$T_{P_{B_{max}}}$ (lb)</th>
<th>$T_{Q_{B_{max}}}$ (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>0.030</td>
<td>0.0854</td>
<td>0.0501</td>
<td>-0.0101</td>
</tr>
<tr>
<td>10,000</td>
<td>0.125</td>
<td>0.1269</td>
<td>0.0936</td>
<td>0.0334</td>
</tr>
<tr>
<td>50,000</td>
<td>0.000</td>
<td>0.3905</td>
<td>0.2652</td>
<td>0.2050</td>
</tr>
<tr>
<td>50,000</td>
<td>1.000</td>
<td>0.5000</td>
<td>0.4948</td>
<td>0.4338</td>
</tr>
</tbody>
</table>

**Design No. C-726, 699**

$\psi = 60$ deg. 

$s_{1} = 2y_{r-tr}X_{max} + 2(x_{r-tr}T_{r-y_{max}} + x_{y_{r-tr}}T_{y_{max}}) = 1.325, 714$ ft./lb.
ACCELERATION IN YAW

\[ \psi = 60 \text{ Degrees} \]

\[ c_1 = 2 Y_{rtr} T_{x_{max}} + 2 (Y_{rtr} T_{y_{max}} + X_{TR} T_{y_{max}}) = 5,012,160 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5,570</td>
<td>15,455</td>
</tr>
<tr>
<td>Aero.Yawing Koe. (Mz)$^\text{trim}$</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
</tr>
<tr>
<td>( \delta_1 ) = ( D \sin \psi )</td>
<td>lb.</td>
<td>0</td>
<td>1,205</td>
<td>3,346</td>
</tr>
<tr>
<td>( \delta_2 ) = ( Y_{rtr} D \cos \psi )</td>
<td>ft.lb.</td>
<td>0</td>
<td>226,977</td>
<td>629,791</td>
</tr>
</tbody>
</table>

If \( \delta_1 \geq T_{y_{max}} \), \( T_{Y_1} = T_{y_{max}} \) and \( T_{RX_1} = 2 (\delta_1 - T_{y_{max}}) \)

| \( T_{Y_1} \) | lb.| 0 | 1,205 | 3,346 | 6,565 |
| \( T_{RX_1} \) | lb.| 0 | 0 | 0 | 0 |

\[ \delta_3 = c_1 - \delta_2 - 2 Y_{rtr} T_{y_{1}} - 2 X_{TR} T_{y_{1}} \]

\[ \tau = \frac{M_{z_{max}} - M_{z_{trim}}}{I_2} \text{ rad. sec.}^2 \]

\[ \delta_3 + Y_{rtr} T_{P_{max}} - M_{z_{trim}} \]

<table>
<thead>
<tr>
<th>( T_{P_{max}} ) (lb.)</th>
<th>( T_{P_{max}} / I_2 \text{ total} )</th>
<th>( \tau )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.910</td>
<td>.030</td>
<td>.1449</td>
</tr>
<tr>
<td>24.600</td>
<td>.125</td>
<td>.2188</td>
</tr>
<tr>
<td>98.520</td>
<td>.500</td>
<td>.5110</td>
</tr>
<tr>
<td>197.040</td>
<td>1.000</td>
<td>.9004</td>
</tr>
</tbody>
</table>

-114-
ACCELERATION IN YAW

\[ c_1 = 2 \eta_{tr} T_{x_{\text{max}}} + 2 (\eta_{tr} T_{y_{\text{max}}} + \eta_{tr} T_{y_{\text{max}}}) = 479.112 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5249</td>
<td>14564</td>
<td>26579</td>
</tr>
<tr>
<td>Aero. Yawing</td>
<td>ft lb.</td>
<td>0</td>
<td>272838</td>
<td>757882</td>
<td>1485449</td>
</tr>
<tr>
<td>( \eta_1 = \frac{D \cos \psi}{g} )</td>
<td>lb.</td>
<td>0</td>
<td>1136</td>
<td>3153</td>
<td>6187</td>
</tr>
<tr>
<td>( \eta_2 = \frac{\eta_{tr} D \cos \psi}{2} )</td>
<td>ft lb.</td>
<td>0</td>
<td>202066</td>
<td>560714</td>
<td>1100291</td>
</tr>
</tbody>
</table>

If \( \eta_1 \geq T_{y_{\text{max}}} \), \( T_{y_1} = T_{y_{\text{max}}} \) and \( \eta_{tr} = 2 (\eta_1 - T_{y_{\text{max}}}) \)

\( \eta_1 \leq T_{y_{\text{max}}} \), \( T_{y_1} = \eta_1 \) and \( \eta_{tr} = 0 \)

| \( T_{y_1} \) | lb. | 0   | 759 | 759 | 759 |
| \( \eta_{tr} \) | lb. | 0   | 754 | 4788| 10856|

\( \eta_3 = \frac{c_1 - \eta_2 - 2 \eta_{tr} T_{y_1}}{-2 \eta_{tr} T_{y_{\text{max}}}} \) ft lb.

\( \eta_3 = \frac{\eta_{max} - \eta_{trim}}{I_2} \) \( \text{rad. sec.}^2 \)

\( \frac{\eta_{y_{tr}} T_{x_{\text{max}}}}{I_2}, \frac{-\eta_{z_{trim}}}{I_2} \)

<table>
<thead>
<tr>
<th>( T_{y_{\text{max}}} ) (lb)</th>
<th>( \eta_{y_{max}} )</th>
<th>( \eta_{max} )</th>
<th>( \eta_{max} )</th>
<th>( \eta_{max} )</th>
<th>( \eta_{max} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>428</td>
<td>.030</td>
<td>rad. sec.</td>
<td>.0253</td>
<td>-.0031</td>
<td>-.0425</td>
</tr>
<tr>
<td>1733</td>
<td>.125</td>
<td>rad. sec.</td>
<td>.0350</td>
<td>.0016</td>
<td>-.0329</td>
</tr>
<tr>
<td>7143</td>
<td>.560</td>
<td>rad. sec.</td>
<td>.0732</td>
<td>.0339</td>
<td>.0053</td>
</tr>
<tr>
<td>19270</td>
<td>1.000</td>
<td>rad. sec.</td>
<td>.1242</td>
<td>.0303</td>
<td>.0563</td>
</tr>
</tbody>
</table>

-115-
ACCELERATION IN YAW

\[
V = 0 \text{ Degrees}
\]

\[
c_1 = 2Y_{rtr} T_{x_{max}} + 2(X_{rtr} T_{y_{max}} + X_{TR} T_{r_{max}}) = 1,617,384 \text{ ft.lb.}
\]

<table>
<thead>
<tr>
<th>Velocity ((v))</th>
<th>(kt.)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5.295</td>
<td>14.692</td>
<td>28.829</td>
</tr>
<tr>
<td>Aero.Yawing mom.(M_{z_{trim}})</td>
<td>ft.lb.</td>
<td>0</td>
<td>278,293</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>(e_1 = \frac{D \sin \psi}{4})</td>
<td>lb.</td>
<td>0</td>
<td>1.146</td>
<td>3.180</td>
<td>6.241</td>
</tr>
<tr>
<td>(e_2 = \frac{Y_{rtr} D \cos \psi}{2})</td>
<td>ft.lb.</td>
<td>0</td>
<td>203,857</td>
<td>565,642</td>
<td>1,109,916</td>
</tr>
</tbody>
</table>

If \(e_1 \geq T_{y_{max}}\), \(T_{y_1} = T_{y_{max}}\) and \(T_{r_{y_1}} = 2(e_1 - T_{y_{max}})\)

\[
e_1 \leq T_{y_{max}}\), \(T_{y_1} = e_1\) and \(T_{r_{y_1}} = 0\)

| \(T_{y_1}\) | lb. | 0 | 1.146 | 2.763 | 2.763 |
| \(T_{r_{y_1}}\) | lb. | 0 | 0 | 834 | 6.956 |

\[
e_3 = -2X_{rtr} T_{y_{max}} - 2X_{TR} T_{r_{max}}
\]

| \(e_3 = c_1 - e_2 - 2X_{rtr} T_{y_{max}} - 2X_{TR} T_{r_{max}}\) | ft.lb. | 1,617,384 | 1,319,424 | 279,986 | -666,096 |

\[
\tau = \frac{M_{z_{max}} - M_{z_{trim}}}{I_z}
\]

\[
\dot{\phi} = \frac{e_3 + Y_{rtr} T_{p_{max}} - M_{z_{trim}}}{I_z} \frac{M_{z_{max}}}{I_z}
\]

<table>
<thead>
<tr>
<th>(T_{p_{max}} (lb))</th>
<th>(T_{p_{max}}/I_z)</th>
<th>(\tau)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>0.53</td>
<td>rad. sec.</td>
</tr>
<tr>
<td>6,600</td>
<td>0.125</td>
<td>rad. sec.</td>
</tr>
<tr>
<td>26,000</td>
<td>0.50</td>
<td>rad. sec.</td>
</tr>
<tr>
<td>52,000</td>
<td>1.00</td>
<td>rad. sec.</td>
</tr>
</tbody>
</table>
**ACCELERATION IN YAW**

![Diagram](image)

<table>
<thead>
<tr>
<th>Design No.</th>
<th>$\Psi$ = 60 Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_1 = 2y_{rtr} T_{x_{max}} + 2(x_{rtr} T_{y_{max}} + x_{tr} T_{y_{max}})$</td>
<td>$5,994,960$ ft.lb.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Velocity ($V$)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag ($D$)</td>
<td>lb.</td>
<td>0</td>
<td>5,715</td>
<td>15,850</td>
</tr>
<tr>
<td>Aero.Yawing Mox.($M_{z_{trim}}$)</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,034</td>
<td>757,403</td>
</tr>
<tr>
<td>$r_1 = \frac{\beta_{t}}{h}$</td>
<td>lb.</td>
<td>0</td>
<td>1,173</td>
<td>3,433</td>
</tr>
<tr>
<td>$e_2 = y_{rtr} \frac{D \cos \Psi}{2}$</td>
<td>ft.lb.</td>
<td>0</td>
<td>220,027</td>
<td>610,533</td>
</tr>
</tbody>
</table>

If $e_1 \geq T_{y_{max}}$, $T_{Y_1} = T_{y_{max}}$ and $T_{TR_1} = 2(e_1 - T_{y_{max}})$

If $e_1 \leq T_{y_{max}}$, $T_{Y_1} = e_1$ and $T_{TR_1} = 0$

| $T_{Y_1}$ | lb. | 0 | 1,237 | 3,433 | 6,737 |
| $T_{TR_1}$ | lb. | 0 | 0 | 0 | 0 |

$e_3 = c_1 - e_2 - 2x_{rtr} T_{y_1}$

$= 2x_{tr} T_{TR_1}$

$= \frac{M_{z_{max}} - M_{z_{trim}}}{I_2}$

$= \frac{e_3 + y_{rtr} T_{p_{x_{max}}}}{I_2}$

<table>
<thead>
<tr>
<th>$T_{p_{x_{max}}}$ (lb)</th>
<th>$\frac{I_2}{I_{total}}$</th>
<th>$\rho$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>0.030</td>
<td>0.1311</td>
</tr>
<tr>
<td>24,600</td>
<td>0.125</td>
<td>0.1557</td>
</tr>
<tr>
<td>95,500</td>
<td>0.500</td>
<td>0.4017</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
<td>0.6897</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ \psi = 60 \text{ Degrees} \]

\[ c_1 = 2Y_{rtr} T_{x_{max}} + 2(Y_{rtr} T_{y_{max}} + X_{TR} T_{r_{max}}) = 575,778 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>Drag (D)</th>
<th>Aerodynamic Yawing Kom. ( M_{z_{trim}} )</th>
<th>( \epsilon_1 = \frac{D \sin \psi}{4} )</th>
<th>( \epsilon_2 = \frac{Y_{rtr} D \cos \psi}{2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>kt.</td>
<td>lb.</td>
<td>ft.lb.</td>
<td>lb.</td>
<td>ft.lb.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>5,447</td>
<td>272,838</td>
<td>1,179</td>
<td>186,559</td>
</tr>
<tr>
<td>25</td>
<td>15,116</td>
<td>757,882</td>
<td>3,272</td>
<td>517,723</td>
</tr>
<tr>
<td>35</td>
<td>29,661</td>
<td>1,485,449</td>
<td>6,421</td>
<td>1,015,889</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{y_{max}} \), \( T_{y_1} = T_{y_{max}} \) and \( T_{r_{max}} = 2(\epsilon_1 - T_{y_{max}}) \)

If \( \epsilon_1 \leq T_{y_{max}} \), \( T_{y_1} = \epsilon_1 \) and \( T_{r_{1}} = 0 \)

\[ T_{y_1} = \begin{cases} 0 & \text{if } \epsilon_1 \leq T_{y_{max}} \\ T_{y_{max}} & \text{if } \epsilon_1 \geq T_{y_{max}} \end{cases} \]

\[ T_{r_{1}} = \begin{cases} 0 & \text{if } \epsilon_1 \leq T_{y_{max}} \\ 2X_{rtr} T_{y_1} & \text{if } \epsilon_1 \geq T_{y_{max}} \end{cases} \]

\[ \epsilon_3 = c_1 - \epsilon_2 - 2X_{rtr} T_{y_1} \]

\[ = 2X_{rtr} (T_{r_{max}} - T_{r_{1}}) \]

\[ = 2X_{rtr} \left( \frac{M_{z_{max}} - M_{z_{trim}}}{I_z} \right) \]

\[ \gamma = \frac{I_z}{M_{z_{max}} - M_{z_{trim}}} \]

\[ \epsilon_3 = Y_{rtr} T_{p_{x_{max}}} \frac{-M_{z_{trim}}}{I_z} \]

<table>
<thead>
<tr>
<th>( T_{p_{x_{max}}} ) (lb)</th>
<th>( \gamma )</th>
<th>( \frac{T_{p_{x_{max}}}}{I_z} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>426</td>
<td>.030</td>
<td>rad. ( \frac{sec}{2} )</td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>rad. ( \frac{sec}{2} )</td>
</tr>
<tr>
<td>7,140</td>
<td>.500</td>
<td>rad. ( \frac{sec}{2} )</td>
</tr>
<tr>
<td>14,280</td>
<td>1.000</td>
<td>rad. ( \frac{sec}{2} )</td>
</tr>
</tbody>
</table>

\[ I \approx 27,000,000 \text{ sl. ft.} \]

\[ X_{TR} = 59 \text{ ft.} \]
ACCELERATION IN Y:N

\[
\begin{align*}
\psi &= 60 \text{ Degrees} \\
c_1 &= 2Y_{\text{rrr}} X_{\text{max}} + 2(X_{\text{rrr}} T_{\text{max}} - X_{\text{rrr}} T_{\text{max}}) = 1,862,346 \text{ ft.lb.}
\end{align*}
\]

<table>
<thead>
<tr>
<th>( V )</th>
<th>( \text{ft/s} )</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Drag (D)} )</td>
<td>lb.</td>
<td>0</td>
<td>5,826</td>
<td>15,324</td>
<td>30,077</td>
</tr>
<tr>
<td>( \text{Aero.Yawing Kom. (Mz trim)} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,839</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>( G_1 = \frac{D \sin \psi}{\rho} )</td>
<td>lb.</td>
<td>0</td>
<td>1,195</td>
<td>3,318</td>
<td>6,511</td>
</tr>
<tr>
<td>( G_2 = Y_{\text{rrr}} \frac{D \cos \psi}{\rho} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>189,197</td>
<td>524,904</td>
<td>1,028,602</td>
</tr>
</tbody>
</table>

If \( g_1 \geq T_{\text{y max}} \), \( T_{\text{y1}} = T_{\text{max}} \) and \( T_{\text{ry1}} = 2(g_1 - T_{\text{y max}}) \)

<table>
<thead>
<tr>
<th>( T_{\text{y1}} )</th>
<th>lb.</th>
<th>0</th>
<th>1,195</th>
<th>2,763</th>
<th>2,763</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{\text{ry1}} )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>1,110</td>
<td>7,496</td>
</tr>
<tr>
<td>( e_1 = c_1 - G_2 - 2X_{\text{rrr}} T_{\text{y1}} - 2X_{\text{rrr}} T_{\text{ry1}} )</td>
<td>ft.lb.</td>
<td>1,862,346</td>
<td>1,233,399</td>
<td>185,598</td>
<td>-1,067,048</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\gamma &= \frac{M_{\text{y max}} - M_{\text{y trim}}}{I_2} \\
e_3 + Y_{\text{rrr}} T_{\text{pmax}} - M_{\text{y trim}}^2 \frac{c_2}{I_2} \\
r &= \frac{e_3 + Y_{\text{rrr}} T_{\text{Pmax}} - M_{\text{y trim}}^2 c_2}{I_2}
\end{align*}
\]

<table>
<thead>
<tr>
<th>( T_{\text{x max}} ) (lb)</th>
<th>( \frac{T_{\text{y max}}}{I_2} ) (rad/sec²)</th>
<th>( g ) (rad/sec²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500</td>
<td>0.030</td>
<td>0.0693</td>
</tr>
<tr>
<td>6,500</td>
<td>0.125</td>
<td>0.0919</td>
</tr>
<tr>
<td>25,000</td>
<td>0.500</td>
<td>0.1512</td>
</tr>
<tr>
<td>50,000</td>
<td>1.000</td>
<td>0.3001</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ T_{X_{\text{max}}} = 10,470 \text{ lb.} \]
\[ T_{Y_{\text{max}}} = 10,470 \text{ lb.} \]
\[ X_{rtr} = 1.84 \text{ ft.} \]
\[ Y_{rtr} = 1.37 \text{ ft.} \]
\[ T_{R_{Y_{\text{max}}}} = 750 \text{ lb.} \]
\[ I_2 = 69,575,000 \text{ sl. ft.}^2 \]
\[ X_{TR} = 59 \text{ ft.} \]

DESIGN NO. A-184/291

\[ \Psi = 60 \text{ Degrees} \]

\[ c_1 = 2X_{rtr} T_{X_{\text{max}}} + 2(X_{rtr} T_{Y_{\text{max}}} + X_{TR} T_{R_{Y_{\text{max}}}}) = 6,810,240 \text{ sl. ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5,890</td>
<td>16,345</td>
<td>32,074</td>
</tr>
<tr>
<td>Aero. Yawning M. (M_{z_{trim}})</td>
<td>ft. lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>( \epsilon_1 )</td>
<td>lb.</td>
<td>0</td>
<td>1,275</td>
<td>3,538</td>
<td>6,944</td>
</tr>
<tr>
<td>( \epsilon_2 )</td>
<td>ft. lb.</td>
<td>0</td>
<td>201,732</td>
<td>559,816</td>
<td>1,098,534</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{Y_{\text{max}}} \), \( T_{Y_1} = T_{Y_{\text{max}}} \) and \( T_{R_{Y_1}} = 2(\epsilon_1 - T_{Y_{\text{max}}}) \)

If \( \epsilon_1 \leq T_{Y_{\text{max}}} \), \( T_{Y_1} = \epsilon_1 \) and \( T_{R_{Y_1}} = 0 \)

| \( T_{Y_1} \) | lb. | 0 | 1,275 | 3,538 | 6,944 |
| \( T_{R_{Y_1}} \) | lb. | 0 | 0 | 0 | 0 |
| \( \epsilon_3 = c_1 - \epsilon_2 - 2X_{rtr} T_{Y_1} - 2X_{TR} T_{R_{Y_1}} \) | ft. lb. | 6,810,240 | 6,139,308 | 4,948,440 | 3,155,314 |

\[ \epsilon_3 = \frac{M_{z_{\text{max}}} - M_{z_{\text{trim}}}}{I_2} \]

\[ r = \frac{\epsilon_3 + Y_{rtr} T_{P_{X_{\text{max}}} - M_{z_{\text{trim}}}}}{I_2} \]

<table>
<thead>
<tr>
<th>( T_{P_{X_{\text{max}}} \text{(lb)}} )</th>
<th>( T_{P_{X_{\text{max}}} \text{/I}_2 \text{total}} )</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>.030</td>
<td>\text{rad. sec.}^2</td>
</tr>
<tr>
<td>24,600</td>
<td>.125</td>
<td>\text{rad. sec.}^2</td>
</tr>
<tr>
<td>98,520</td>
<td>.506</td>
<td>\text{rad. sec.}^2</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
<td>\text{rad. sec.}^2</td>
</tr>
</tbody>
</table>
### Table: Trailing-Edge Flap 

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5,012</td>
<td>15,540</td>
<td>32,440</td>
</tr>
<tr>
<td>Aero. Yl, lns (K&lt;sub&gt;1&lt;/sub&gt;):</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Y&lt;sub&gt;TTR&lt;/sub&gt;</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G&lt;sub&gt;1&lt;/sub&gt; = D&lt;sup&gt;0.03&lt;/sup&gt;</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G&lt;sub&gt;2&lt;/sub&gt; = Y&lt;sub&gt;TTR&lt;/sub&gt;</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If $E_1 \geq T_{y, max}$, $T_{y_1} = T_{y, max}$ and $T_{y, Y_1} = 2 (E_1 - T_{y, max})$

If $E_1 \leq T_{y, max}$, $T_{y_1} = E_1$ and $T_{y, Y_1} = 0$

| $T_{y_1}$ | lb. | 0  | 759 | 759 | 759 |
| $T_{y, Y_1}$ | lb. | 0  | 1,460 | 6,748 | 14,702 |
| $E_3 = E_1 - G_2 - 2X_{TTR} T_{y_1}$ | ft. lb. | 370.302 | 240.334 | 187.654 | 107.914 |

### Diagram

$\psi = \text{Drag}$

$c_1 = 2X_{TTR} T_{y, max} * \pi (E_{TTR} T_{y, max} * X_{in} T_{y, max})$

### Notes

- $T_{y, max} = 759$ lb.
- $T_{y, Y_1} = 729$ lb.
- $X_{TTR} = 76$ ft.
- $T_{y, Y_1} = 163$ ft.
- $T_{y, max} = 759$ lb.

- $I_2 = 17,645,000 \text{ in.}^2$
- $X_{TR} = 5$ ft.
ACCELERATION IN YAW

\[ T_{Y_{\max}} = 2,763 \text{ lb.} \]
\[ T_{R_{Y_{\max}}} = 2,763 \text{ lb.} \]
\[ X_{rtr} = 76 \text{ ft.} \]
\[ Y_{rtr} = 163 \text{ ft.} \]
\[ T_{R_{Y_{\max}}} = 750 \text{ lb.} \]
\[ I_{z} = 18,523,000 \text{ sl. ft.}^2 \]
\[ X_{bar} = - \text{ ft.} \]

**Design No. C-76/.609**

\[ \Psi = 90 \text{ Degrees} \]

\[ \alpha_1 = 2Y_{rtr} T_{X_{\max}} + 2(X_{rtr} T_{I_{\max}} + X_{TR} T_{R_{Y_{\max}}}) = 1,328,214 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>6,049</td>
<td>16,786</td>
</tr>
<tr>
<td>Aero-Yawing Kom. (M_{Z_{\trim}})</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \varepsilon_1 = \frac{D \sin \Psi}{4} )</td>
<td>lb.</td>
<td>0</td>
<td>1,512</td>
<td>4,196</td>
</tr>
<tr>
<td>( \varepsilon_2 = \frac{Y_{rtr} D \cos \Psi}{2} )</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \( \varepsilon_1 \geq T_{Y_{\max}} \), \( T_{Y_{1}} = T_{Y_{\max}} \) and \( T_{R_{Y_{1}}} = 2(\varepsilon_1 - T_{Y_{\max}}) \)

If \( \varepsilon_1 \leq T_{Y_{\max}} \), \( T_{Y_{1}} = \varepsilon_1 \) and \( T_{R_{Y_{1}}} = 0 \)

<table>
<thead>
<tr>
<th>( T_{Y_{1}} )</th>
<th>lb.</th>
<th>0</th>
<th>1,512</th>
<th>2,763</th>
<th>2,763</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{R_{Y_{1}}} )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>2,866</td>
<td>10,942</td>
</tr>
<tr>
<td>( \varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr} T_{Y_{1}} - 2X_{TR} T_{R_{Y_{1}}} )</td>
<td>ft. lb.</td>
<td>1,328,214</td>
<td>1,098,390</td>
<td>879,578</td>
<td>799,818</td>
</tr>
</tbody>
</table>

\[ r = \frac{M_{Z_{\max}} - M_{Z_{\trim}}}{I_{z}} \text{ rad. sec.}^2 \]

\[ \varepsilon_3 Y_{rtr} T_{P_{X_{\max}}} - M_{Z_{\trim}} \]

\[ T_{P_{X_{\max}}} (lb) \quad T_{P_{X_{\max}}} / I_{z} \text{ total} \]

<table>
<thead>
<tr>
<th>( T_{P_{X_{\max}}} )</th>
<th>( \frac{r}{r_{total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.560</td>
<td>.030</td>
</tr>
<tr>
<td>6.500</td>
<td>.125</td>
</tr>
<tr>
<td>26.000</td>
<td>.500</td>
</tr>
<tr>
<td>52.000</td>
<td>rad.</td>
</tr>
</tbody>
</table>
**ACCELERATION IN YAW**

\[
\begin{align*}
T_{r_{tr}} &= 10,470 \text{ lb.} \\
T_{y_{max}} &= 10,470 \text{ lb.} \\
X_{r_{tr}} &= 76 \text{ ft.} \\
Y_{r_{tr}} &= 163 \text{ ft.} \\
T_{R_{TR} max} &= 750 \text{ lb.} \\
I_2 &= 41,236,000 \text{ sl. ft.}^2 \\
X_{TR} &= 5 \text{ ft.}
\end{align*}
\]

**DESIGN NO. C-76/291**

\[\psi = 90 \text{ Degrees}\]

\[
c_1 = 2X_{r_{tr}} T_{y_{max}} + 2(X_{r_{tr}}T_{TR max} + X_{TR} T_{R_{TR} max}) = 5,012,160 \text{ ft. lb.}
\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>0</td>
<td>6,409</td>
<td>18,007</td>
<td>25,737</td>
</tr>
<tr>
<td>Aero.Yawing Moa.(K_{2_{trim}})</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>(\varepsilon_1 = \frac{D \sin \psi}{g})</td>
<td>0</td>
<td>1,622</td>
<td>4,501</td>
<td>8,833</td>
</tr>
<tr>
<td>(\varepsilon_2 = X_{r_{tr}} \frac{D \cos \psi}{g})</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

If \(\varepsilon_1 \geq T_{y_{max}}\), \(T_y  = T_{y_{max}}\) and \(T_{R_{TR} 1} = 2(\varepsilon_1 - T_{y_{max}})\)

If \(\varepsilon_1 \leq T_{y_{max}}\), \(T_y = \varepsilon_1\) and \(T_{R_{TR} 1} = 0\)

<table>
<thead>
<tr>
<th>0</th>
<th>1,622</th>
<th>4,501</th>
<th>8,833</th>
</tr>
</thead>
</table>

| 0 | 0 | 0 | 0 |

\(\varepsilon_3 = \varepsilon_1 - \varepsilon_2 - 2X_{r_{tr}} T_{y_{1}}\)

\(\varepsilon_3 = \frac{\varepsilon_1 - \varepsilon_2 - 2X_{r_{tr}} T_{y_{1}}}{X_{TR}}\)

\[
\alpha = \frac{T_{2_{max}} - m_{2_{trim}}}{I_2}
\]

\[
\frac{\varepsilon_3 + X_{r_{tr}} T_{y_{max}} - m_{2_{trim}}}{I_2}
\]

<table>
<thead>
<tr>
<th>(T_{y_{max}} \text{ (lb)})</th>
<th>(\varepsilon_3 / \alpha = 1)</th>
<th>(\varepsilon_3 / \alpha = 2)</th>
<th>(\varepsilon_3 / \alpha = 3)</th>
<th>(\varepsilon_3 / \alpha = 4)</th>
<th>(\varepsilon_3 / \alpha = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,910</td>
<td>0.939</td>
<td>1.399</td>
<td>1.283</td>
<td>1.124</td>
<td></td>
</tr>
<tr>
<td>24,600</td>
<td>0.125</td>
<td>0.185</td>
<td>0.212</td>
<td>0.207</td>
<td>0.185</td>
</tr>
<tr>
<td>95,520</td>
<td>0.501</td>
<td>0.510</td>
<td>0.515</td>
<td>0.504</td>
<td>0.477</td>
</tr>
<tr>
<td>197,040</td>
<td>1.000</td>
<td>0.904</td>
<td>0.824</td>
<td>0.783</td>
<td>0.707</td>
</tr>
</tbody>
</table>
**ACCELERATION IN YAW**

![Diagram](image)

\[
\begin{align*}
T_{x_{\text{max}}} &= 759 \text{ lb.} \\
T_{y_{\text{max}}} &= 759 \text{ lb.} \\
X_{\text{rtr}} &= 130 \text{ ft.} \\
Y_{\text{rtr}} &= 194 \text{ ft.} \\
T_{\text{RY}_{\text{max}}} &= 750 \text{ lb.} \\
I_2 &= 21,567,000 \text{ sl. ft.}^2 \\
X_{\text{TR}} &= 32 \text{ ft.}
\end{align*}
\]

1. SIGN NO. D-177/85

\[\gamma = \frac{\psi}{\pi} \text{ Degree}\]

\[c_1 = 2X_{\text{rtr}} T_{x_{\text{max}}} + 2(X_{\text{rtr}} T_{y_{\text{max}}} + X_{\text{TR}} T_{\text{RY}_{\text{max}}} - 479,112 \text{ ft. lb.}\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>516</td>
<td>7,116</td>
</tr>
<tr>
<td>Aero. Yawing</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yawing Comp.</td>
<td>(WZ)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\delta_1) = \frac{D \sin \psi}{4}</td>
<td>lb.</td>
<td>0</td>
<td>1,541</td>
<td>4,276</td>
</tr>
<tr>
<td>(\delta_2) = \frac{T_{\text{rtr}} D \cos \psi}{2}</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| If \(\delta_1 \geq T_{y_{\text{max}}}, T_{Y_1} = T_{y_{\text{max}}}, T_{\text{RY}_1} = 2(\delta_1 - T_{y_{\text{max}}})\)
| \(\delta_1 \leq T_{y_{\text{max}}}, T_{Y_1} = \delta_1, T_{\text{RY}_1} = 0\)
| T_{Y_1} | lb. | 0  | 759 | 759 | 759 |
| T_{\text{RY}_1} | lb. | 0  | 1,564 | 7,034 | 15,262 |
| \(\delta_3 = c_1 - \delta_2 - 2X_{\text{rtr}} T_{Y_1}\) | ft. lb. | 479,112 | 181,676 | -168,404 | -594,996 |
| \(\delta_3 + Y_{\text{rtr}} T_{P_{x_{\text{max}}}} W_{Z_{\text{trim}}} I_2\) | rad. sec. \(^2\) | 0.0253 | 0.0155 | -0.0048 | -0.0245 |
| \(T_{P_{x_{\text{max}}}}\) | \(\frac{T_{P_{x_{\text{max}}}}}{I_2} \text{ rad. sec.}^2\) | rad. sec. \(^2\) | 0.0350 | 0.0412 | -0.0148 |
| \(T_{P_{x_{\text{max}}}}\) | \(\frac{T_{P_{x_{\text{max}}}}}{I_2} \text{ rad. sec.}^2\) | rad. sec. \(^2\) | 0.0732 | 0.0510 | 0.0432 |
| \(T_{P_{x_{\text{max}}}}\) | \(\frac{T_{P_{x_{\text{max}}}}}{I_2} \text{ rad. sec.}^2\) | rad. sec. \(^2\) | 0.1146 | 0.1106 | 0.0744 |
ACCELERATION IN X-AX

\[
N_x = \frac{1}{2} \rho \cdot C_D \cdot A \cdot \frac{V^2}{2} - \frac{1}{2} \rho \cdot C_L \cdot A \cdot \frac{V^2}{2} \quad \text{(lbs)}
\]

\[
N_y = \frac{1}{2} \rho \cdot C_D \cdot A \cdot \frac{V^2}{2} + \frac{1}{2} \rho \cdot C_L \cdot A \cdot \frac{V^2}{2} \quad \text{(lbs)}
\]

\[
t_X = \frac{1}{2} \rho \cdot C_D \cdot A \cdot \frac{V^2}{2} \quad \text{(lbs)}
\]

\[
t_Y = \frac{1}{2} \rho \cdot C_D \cdot A \cdot \frac{V^2}{2} \quad \text{(lbs)}
\]

\[
T_{Y_{max}} = 2.763 \quad \text{lb.}
\]

\[
T_{X_{max}} = 2.763 \quad \text{lb.}
\]

\[
X_rtr = 130 \quad \text{ft.}
\]

\[
Y_{rtr} = 154 \quad \text{ft.}
\]

\[
T_{rtr_{max}} = 750 \quad \text{lb.}
\]

\[
l = 23,298,000 \quad \text{sl. ft.}^2
\]

\[
x_{rtr} = 32 \quad \text{ft.}
\]

\[\text{DESIGN NO.: B-107/609}\]

\[\psi = 00 \quad \text{Deg. rope}\]

\[c_1 = 2Y_{rtr} T_{X_{max}} + 2(T_{rtr} Y_{Y_{max}} + x_{rtr} T_{Y_{max}}) = 1,617,384 \quad \text{ft.lb.}\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>6.195</td>
<td>17.139</td>
<td>33.729</td>
</tr>
<tr>
<td>Aero Yawing Momen. (M_{trim})</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>\varepsilon_1 = D \sin \psi \quad \text{lb.}</td>
<td>0</td>
<td>1,548</td>
<td>4,297</td>
<td>8,432</td>
</tr>
<tr>
<td>\varepsilon_2 = Y_{rtr} D \cos \psi \quad \text{ft.lb.}</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \varepsilon_1 > T_{Y_{max}}, T_{Y_1} = T_{Y_{max}} and \frac{T_{rtr_{max}}}{T_{Y_1}} = 2 (\varepsilon_1 - T_{Y_{max}})

\[
\varepsilon_1 \leq T_{Y_{max}}, T_{Y_1} = \varepsilon_1 \quad \text{and} \quad \frac{T_{rtr_{max}}}{T_{Y_1}} = 0
\]

<table>
<thead>
<tr>
<th>T_{Y_1}</th>
<th>lb.</th>
<th>0</th>
<th>1.548</th>
<th>2.763</th>
<th>2.763</th>
</tr>
</thead>
<tbody>
<tr>
<td>\frac{T_{rtr_{max}}}{T_{Y_1}}</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>3,068</td>
<td>11,338</td>
</tr>
</tbody>
</table>

\[e_3 = \varepsilon_1 - \varepsilon_2 - 2X_{rtr} T_{Y_1} - 2X_{rtr} T_{rtr_{max}} \quad \text{ft.lb.} \]

\[
F = \frac{M_{trim}}{l_z} \quad \text{rad.} \quad \text{sec.}^{-2}
\]

\[
e_3 + Y_{rtr} \frac{T_{rtr_{max}}}{M_{trim}} l_z = \frac{1}{l_z}
\]

<table>
<thead>
<tr>
<th>T_{p_{max}} (lb)</th>
<th>T_{p_{max}} / l_z \text{ total}</th>
<th>\hat{F}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,540</td>
<td>\text{rad.} \quad \text{sec.}^{-2}</td>
<td>0.0777</td>
</tr>
<tr>
<td>6,500</td>
<td>\text{rad.} \quad \text{sec.}^{-2}</td>
<td>0.1124</td>
</tr>
<tr>
<td>26,000</td>
<td>\text{rad.} \quad \text{sec.}^{-2}</td>
<td>0.2413</td>
</tr>
<tr>
<td>52,000</td>
<td>\text{rad.} \quad \text{sec.}^{-2}</td>
<td>0.4131</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ T_{Y_{\text{max}}} = 10,470 \text{ lb.} \]
\[ T_{Y_{\text{max}}} = 10,470 \text{ lb.} \]
\[ x_{\text{rtr}} = 130 \text{ ft.} \]
\[ y_{\text{rtr}} = 154 \text{ ft.} \]
\[ T_{Y_{\text{rtr}}} = 750 \text{ lb.} \]
\[ I_z = 52,688,000 \text{ in.}^2 \cdot \text{ft.}^2 \]
\[ x_{TR} = 32 \text{ ft.} \]

\[ \Psi = 90 \text{ Degrees} \]

\[ c_1 = 2y_{\text{rtr}} T_{X_{\text{max}}} + 2(x_{\text{rtr}} T_{Y_{\text{max}}} + x_{\text{TR}} T_{Y_{\text{max}}}) = 5,994,960 \text{ ft.} \cdot \text{lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>6,696</td>
<td>18,580</td>
</tr>
<tr>
<td>Aero. Yawing Kom. (M_{2,\text{trim}})</td>
<td>ft. \cdot lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 = \frac{D \cdot \sin \Psi}{V} )</td>
<td>lb.</td>
<td>0</td>
<td>1,674</td>
<td>4,645</td>
</tr>
<tr>
<td>( \epsilon_2 = \frac{T_{Y_{\text{rtr}}} \cdot D \cdot \cos \Psi}{V^2} )</td>
<td>ft. \cdot lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{X_{\text{max}}} \), \( T_{Y_{1}} = T_{X_{\text{max}}} \) and \( T_{Y_{1}} = 2(\epsilon_1 - T_{Y_{\text{max}}}) \)

| \( T_{Y_{1}} \) | lb. | 0 | 1,674 | 4,645 | 9,114 |
| \( T_{Y_{1}} \) | lb. | 0 | 0 | 0 | 0 |
| \( \epsilon_3 = \epsilon_1 - \epsilon_2 - 2T_{Y_{1}} - \frac{T_{Y_{1}}}{T_{Y_{\text{max}}}} \) | ft. \cdot lb. | 5,994,960 | 5,559,720 | 4,787,260 | 3,625,320 |

\[ i = \frac{M_{2,\text{trim}} - M_{2,\text{trim}}}{I_z} \text{ rad. sec.}^{-2} \]

\[ \frac{T_{P_{X_{\text{max}}}}}{T_{P_{X_{\text{max}}}}} = \frac{\epsilon_3 + y_{\text{rtr}} T_{P_{X_{\text{max}}}}}{T_{P_{X_{\text{total}}}}} \text{ rad. sec.}^{-2} \frac{I_z}{I_z} \]

<p>| ( T_{P_{X_{\text{max}}}} ) (lb) | 5,910 | 24,600 | 98,520 | 197,040 |
| ( \frac{T_{P_{X_{\text{max}}}}}{T_{P_{X_{\text{max}}}}} \text{ rad. sec.}^{-2} ) | .030 | .125 | .500 | 1.000 |
| ( \frac{I_z}{I_z} \text{ rad. sec.}^{-2} ) | .1311 | .1228 | .1061 | .0861 |
| ( \frac{I_z}{I_z} \text{ rad. sec.}^{-2} ) | .1857 | .1774 | .1628 | .1407 |
| ( \frac{I_z}{I_z} \text{ rad. sec.}^{-2} ) | .4017 | .3935 | .3788 | .3568 |
| ( \frac{I_z}{I_z} \text{ rad. sec.}^{-2} ) | .6907 | .6814 | .6668 | .6447 |</p>
<table>
<thead>
<tr>
<th>Speed (kt)</th>
<th>L (ft)</th>
<th>I (deg)</th>
<th>L</th>
<th>Y (ft)</th>
<th>X (ft)</th>
<th>L</th>
<th>Y (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>35</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Equation:**

\[
V = 90 \text{ deg} \sin \theta + 2 \text{ (Inr Trax + Inr Trax)}
\]

**Series:**

\[
\sum (\text{Inr Trax + Inr Trax}) = 575,778 \text{ ft} \cdot \text{lb}
\]
ACCELERATION IN YAW

\[ T_{x_{\text{max}}} = 2.763 \text{ lb.} \]
\[ T_{y_{\text{max}}} = 2.763 \text{ lb.} \]
\[ x_{\text{rtr}} = 184 \text{ ft.} \]
\[ y_{\text{rtr}} = 137 \text{ ft.} \]
\[ T_{R_y_{\text{max}}} = 750 \text{ lb.} \]
\[ I_{z} = 29,940,000 \text{ sl. ft.}^2 \]
\[ x_{\text{TR}} = 59 \text{ ft.} \]

SIGN NO. A-184/409

\[ \psi = 90 \text{ Degrees} \]

\[ c_1 = 2y_{\text{rtr}} T_{x_{\text{max}}} + 2(x_{\text{rtr}} T_{y_{\text{max}}} + x_{\text{TR}} T_{R_y_{\text{max}}}) = 1,862,346 \text{ sl. ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>6.466</td>
<td>17.942</td>
<td>35.206</td>
</tr>
<tr>
<td>Aero.Yawing Moment ((M_{z_{\text{trim}}})</td>
<td>ft.lb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\epsilon_1) = (\frac{D_{\min \psi}}{b})</td>
<td>lb.</td>
<td>0</td>
<td>1,616</td>
<td>4,485</td>
<td>8,801</td>
</tr>
<tr>
<td>(\epsilon_2) = (y_{\text{rtr}} \frac{D_{\cos \psi}}{2})</td>
<td>ft.lb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \(\epsilon_1 \geq T_{y_{\text{max}}}, T_{y_1} = T_{y_{\text{max}}} \) and \(T_{R_y_1} = 2(\epsilon_1 - T_{y_{\text{max}}})\)

\(\epsilon_1 \leq T_{y_{\text{max}}}, T_{y_1} = \epsilon_1 \) and \(T_{R_y_1} = 0\)

| \(T_{y_1}\) | lb. | 0 | 1,616 | 2,763 | 2,763 |
| \(T_{R_y_1}\) | lb. | 0 | 0 | 3,444 | 12,076 |
| \(\epsilon_3\) = \(c_1 - \epsilon_2 - 2x_{\text{rtr}} T_{y_1} - 2x_{\text{TR}} T_{R_y_1}\) | ft.lb. | 1,862,346 | 1,267,658 | 439,170 | -579,406 |

\[ t = \frac{M_{z_{\text{max}}} - M_{z_{\text{trim}}}}{I_z} \] \[ \epsilon_3 + y_{\text{rtr}} T_{p_{z_{\text{max}}} - M_{z_{\text{trim}}}} \] \[ \text{rad.} \] \[ \text{sec.}^2 \]

<table>
<thead>
<tr>
<th>(T_{p_{z_{\text{max}}}}) (lb)</th>
<th>(T_{p_{z_{\text{max}}} / I_z})</th>
<th>(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.030</td>
<td>.0693</td>
</tr>
<tr>
<td>6,500</td>
<td>.125</td>
<td>.0919</td>
</tr>
<tr>
<td>26,000</td>
<td>.500</td>
<td>.1812</td>
</tr>
<tr>
<td>52,000</td>
<td>1.000</td>
<td>.3001</td>
</tr>
</tbody>
</table>

-128-
ACCELERATION IN Y DIR

\[ c_1 = 2X_{rtr} T_{Y_{\text{max}}} + 2 \left( X_{rtr} T_{Y_{\text{max}}} + X_{TR_{r}} T_{R_{Y_{\text{max}}}} \right) = 6,810,240 \text{ ft.lbf.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>170</td>
<td>170</td>
<td>32,877</td>
</tr>
<tr>
<td>Aero. Yawing</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yawing</td>
<td>lb.</td>
<td>0</td>
<td>1,725</td>
<td>4,787</td>
<td>9,394</td>
</tr>
<tr>
<td>Yawing</td>
<td>ft.lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| If \( \theta_1 \geq T_{Y_{\text{max}}} \), \( Y_{Y_1} = T_{Y_{\text{max}}} \) and \( T_{R_{Y_1}} = 0 \) \( \theta_1 \leq T_{Y_{\text{max}}} \), \( Y_{Y_1} = \theta_1 \) and \( T_{R_{Y_1}} = 0 \)
| \( T_{Y_{1}} \) | lb. |  0  |  1,725 |  4,787 |  9,394 |
| \( T_{R_{Y_1}} \) | lb. |  0  |  0  |  0  |  0  |
| \( \theta_3 = c_1 - \theta_2 - 2X_{rtr} T_{Y_{1}} - 2X_{TR_{r}} T_{R_{Y_{1}}} \) | ft.lb. |  6,810,240 |  6,175,440 |  5,140,624 |  3,353,248 |
| \( r = \frac{M_{z_{\text{max}}} - M_{z_{\text{trim}}}}{I_{z}} \) | rad. |  0  |  0  |  0  |  0  |
| \( \theta_3 + Y_{rtr} T_{R_{Y_{1}}} - X_{rtr} T_{Y_{1}} \) | rad. |  0  |  0  |  0  |  0  |
| \( T_{P_{Y_{\text{max}}}} (\text{lb}) \) |  5,910 |  0.30 |  0.195 |  0.0855 |  0.0598 |
| \( \theta_{r_{\text{tr}}} / \text{total} \) |  24,600 |  0.125 |  0.1272 |  0.1223 |  0.0966 |
| \( \theta_{r_{\text{tr}}} / \text{rad.} \) |  98,520 |  0.500 |  0.2919 |  0.2679 |  0.2422 |
| \( \theta_{r_{\text{tr}}} / \text{dec.} \) |  1,500 |  1.000 |  0.6089 |  0.4763 |  0.4368 |

\(-129-\)
ACCELERATION IN YAW

\[ c_1 = 2T_{rtr} T_{x_{\text{max}}} + 2(x_{rtr} T_{max} + x_{TR} T_{r_{\text{max}}}) = 370,302 \text{ ft lb.} \]

| Design No. C-76.85-609 |

Velocity (V) (kt.) | 0 | 15 | 25 | 35 |
|-------------------|---|----|----|----|
Drag (D) (lb.) | 0 | 866 | 2,402 | 4,713 |
Aero. Yawing Moment (\( M_{2 \text{ trim}} \)) (ft lb.) | 0 | 0 | 0 | 0 |
\( \epsilon_1 = \frac{D \sin \psi}{\text{lb.}} \) | 0 | 0 | 0 | 0 |
\( \epsilon_2 = \frac{Y_{rtr} D \cos \psi}{2 \text{ ft lb.}} \) | 0 | 70,579 | 195,763 | 384,109 |
If \( \epsilon_1 \geq T_{x_{\text{max}}}, T_{y_{1}} = T_{x_{\text{max}}} \) and \( T_{r_{1}} = 2(\epsilon_1 - T_{x_{\text{max}}}) \), \( \epsilon_1 \leq T_{x_{\text{max}}}, T_{y_{1}} = \epsilon_1 \) and \( T_{r_{1}} = 0 \)

| \( T_{y_{1}} \) (lb.) | 0 | 0 | 0 | 0 |
| \( T_{r_{1}} \) (lb.) | 0 | 0 | 0 | 0 |
\( \epsilon_3 = \epsilon_1 - \epsilon_2 - 2x_{rtr} T_{x_{1}} - 2x_{TR} T_{x_{r}} \) (ft lb.) | 370,302 | 299,723 | 174,539 | -13,807 |
\( \frac{M_{2_{\text{max}}} - M_{2_{\text{trim}}}}{I_{2}} \) (rad sec^2) | \( \epsilon_{3} \) + \( Y_{rtr} \frac{T_{x_{\text{max}}} - M_{2_{\text{trim}}}}{I_{2}} \) |

<table>
<thead>
<tr>
<th>( T_{p_{x_{\text{max}}}} ) (lb)</th>
<th>( \frac{T_{p_{x_{\text{max}}}} / T_{r_{\text{total}}}}{I_{2}} )</th>
<th>( \hat{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>1.09</td>
<td>( \text{rad. sec}^2 )</td>
</tr>
<tr>
<td>6,500</td>
<td>4.55</td>
<td>( \text{rad. sec}^2 )</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>( \text{rad. sec}^2 )</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>( \text{rad. sec}^2 )</td>
</tr>
</tbody>
</table>

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ACCELERATION IN YAW

\[ T_{X_{\text{max}}} = 759 \, \text{lb.} \]
\[ T_{Y_{\text{max}}} = 759 \, \text{lb.} \]
\[ X_{\text{rtr}} = 76 \, \text{ft.} \]
\[ Y_{\text{rtr}} = 163 \, \text{ft.} \]
\[ T_{R_{\text{Y}}_{\text{max}}} = 750 \, \text{lb.} \]
\[ I_2 = 17,645,000 \, \text{sl. ft.}^2 \]
\[ X_{\text{TR}} = 5 \, \text{ft.} \]

**DESIGN NO. C-76/.35/.509**

\[ \Psi = 30 \, \text{Degrees} \]

\[ c_1 = 2 Y_{\text{rtr}} T_{X_{\text{rtr}}} + 2 (X_{\text{rtr}} T_{Y_{\text{max}}} + X_{\text{TR}} T_{R_{\text{Y}}_{\text{max}}}) = 370,302 \, \text{ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>2.582</td>
<td>7.166</td>
<td>14.061</td>
</tr>
<tr>
<td>Aero. Yawing M. Cos. (M_{\text{trim}})</td>
<td>ft. lb.</td>
<td>0</td>
<td>272,836</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>( e_1 = D \sin \Psi )</td>
<td>lb.</td>
<td>0</td>
<td>322</td>
<td>895</td>
<td>1,757</td>
</tr>
<tr>
<td>( e_2 = \frac{Y_{\text{rtr}} D \cos \Psi}{2} )</td>
<td>ft. lb.</td>
<td>0</td>
<td>182,240</td>
<td>505,783</td>
<td>992,440</td>
</tr>
</tbody>
</table>

If \( e_1 \geq T_{Y_{\text{max}}} \), \( T_{Y_1} = T_{Y_{\text{max}}} \) and \( T_{R_{\text{Y}}_1} = 0 \)

\[ e_1 \leq T_{Y_{\text{max}}} \rightarrow T_{Y_1} = c_1 \quad \text{and} \quad T_{R_{\text{Y}}_1} = 0 \]

<table>
<thead>
<tr>
<th>( T_{Y_1} )</th>
<th>lb.</th>
<th>0</th>
<th>322</th>
<th>759</th>
<th>759</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{R_{\text{Y}}_1} )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>272</td>
<td>1,996</td>
</tr>
</tbody>
</table>

\[ e_3 = c_1 - e_2 - 2 X_{\text{rtr}} T_{Y_1} - 2 Y_{\text{rtr}} T_{R_{\text{Y}}_1} \]

\[ r = \frac{M_{\text{max}} - M_{\text{trim}}}{T_{Z_{1}}^2} \]

\[ \frac{e_3 + Y_{\text{rtr}} T_{P_{\text{max}}}}{T_{Z_{1}}} \]

<table>
<thead>
<tr>
<th>( T_{P_{\text{X}_{\text{max}}}} ) (lb)</th>
<th>( T_{P_{\text{X}<em>{\text{max}}}} / T</em>{Z_{1}} )</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>109</td>
<td>0.03640</td>
</tr>
<tr>
<td>6,500</td>
<td>455</td>
<td>0.08103</td>
</tr>
<tr>
<td>26,000</td>
<td>1,077</td>
<td>0.2617</td>
</tr>
<tr>
<td>52,000</td>
<td>3,641</td>
<td>0.5013</td>
</tr>
</tbody>
</table>

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**ACCELERATION IN YAW**

![Diagram of acceleration in yaw](image)

**Design No. C-76/85-609**

\( \Psi = 45 \text{ Degrees} \)

\( c_1 = 2X_{rtr} T_{x_{max}} + 2(X_{rtr} T_{y_{max}} + X_{tr} T_{y_{max}}) = 370,302 \text{ ft.lb.} \)

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>km/h</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>4,039</td>
<td>11,194</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aero. Yawing Com. ( (K_{z_{trim}}) )</td>
<td>ft.lb.</td>
<td>315,050</td>
<td>875,138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \theta_1 = \frac{D \sin \Psi}{4} )</td>
<td>lb.</td>
<td>712.41</td>
<td>1978.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \theta_2 = \frac{T_{rtr} D \cos \Psi}{2} )</td>
<td>ft.lb.</td>
<td>232,246</td>
<td>645,101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If \( \theta_1 \geq T_{y_{max}}, \ T_{y_{1}} = T_{y_{max}} \) and \( T_{r_{1}} = 2(\theta_1 - T_{y_{max}}) \)

\( \theta_1 \leq T_{y_{max}}, \ T_{y_{1}} = \theta_1 \) and \( T_{r_{1}} = 0 \)

<table>
<thead>
<tr>
<th>( T_{y_{1}} )</th>
<th>lb.</th>
<th>712.41</th>
<th>759</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{r_{1}} )</td>
<td>lb.</td>
<td>0</td>
<td>2440</td>
</tr>
</tbody>
</table>

\( \epsilon_3 = \theta_1 - \epsilon_2 - 2X_{rtr} T_{y_{1}} - 2X_{tr} T_{r_{1}} \)

| \( \epsilon_3 \) | ft.lb. | 29769.7 | -414,567 |

\( \frac{M_{z_{max}} - M_{z_{trim}}}{T_{z}} \)

\( \sigma_3 = T_{r_{tr}} T_{y_{max}} - M_{z_{trim}} - \frac{1}{T_{z}} \)

<table>
<thead>
<tr>
<th>( T_{p_{x_{max}}} )</th>
<th>rad.</th>
<th>428</th>
<th>.030</th>
<th>-.0122</th>
<th>-.0691</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_{p_{x_{max}}/T_{z_{total}}} )</td>
<td>rad.</td>
<td>1,785</td>
<td>.125</td>
<td>.0003216</td>
<td>-.0566</td>
</tr>
<tr>
<td></td>
<td>rad.</td>
<td>1,560</td>
<td>.109</td>
<td>-.001757</td>
<td>-.05869</td>
</tr>
<tr>
<td></td>
<td>rad.</td>
<td>6,500</td>
<td>.455</td>
<td>.04388</td>
<td>-.01305</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

DESIGN NO. C-76/85-.609

\( \psi = 60 \text{ Degrees} \)

\( c_1 = 2 Y_{\text{rtr}} T_{X_{\text{max}}} + 2(X_{\text{rtr}} T_{Y_{\text{max}}} + X_{\text{rtr}} T_{Y_{\text{TR}}} ) = 370,302 \text{ ft.lb.} \)

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5,107</td>
<td>14,172</td>
<td>27,810</td>
</tr>
<tr>
<td>Aeroc. Yawing Moment ( (M^2_{\text{trim}}) )</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
<td>1,485,469</td>
</tr>
<tr>
<td>( \epsilon_1 = D \sin \psi )</td>
<td>lb.</td>
<td>0</td>
<td>1,105</td>
<td>3,068</td>
<td>6,021</td>
</tr>
<tr>
<td>( \epsilon_2 = Y_{rtr} \frac{D \cos \psi}{2} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>208,110</td>
<td>577,509</td>
<td>1,133,257</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{Y_{\text{max}}} \), \( T_{Y_1} = T_{Y_{\text{max}}} \) and \( T_{Y_{\text{TR}}} = 2 (\epsilon_1 - T_{Y_{\text{max}}}) \)

\( \epsilon_1 \leq T_{Y_{\text{max}}} \), \( T_{Y_1} = \epsilon_1 \) and \( T_{Y_{\text{TR}}} = 0 \)

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>759</td>
<td>759</td>
<td>759</td>
</tr>
<tr>
<td>Aeroc. Yawing Moment ( (M^2_{\text{trim}}) )</td>
<td>ft.lb.</td>
<td>0</td>
<td>692</td>
<td>4,618</td>
<td>10,524</td>
</tr>
<tr>
<td>( \epsilon_2 = c_1 - \epsilon_2 - 2X_{\text{rtr}} T_{Y_1} )</td>
<td>ft.lb.</td>
<td>370,302</td>
<td>39,604</td>
<td>-368,755</td>
<td>-983,563</td>
</tr>
<tr>
<td>( \epsilon_3 = c_1 - \epsilon_2 - 2X_{\text{rtr}} T_{Y_1} )</td>
<td>ft.lb.</td>
<td>370,302</td>
<td>39,604</td>
<td>-368,755</td>
<td>-983,563</td>
</tr>
<tr>
<td>( \epsilon_3 + Y_{rtr} T_{P_{X_{\text{max}}}} - M^2_{\text{trim}} )</td>
<td>rad. ( \cdot \text{sec}^2 )</td>
<td>.03540</td>
<td>.001193</td>
<td>-.04944</td>
<td>-.1255</td>
</tr>
<tr>
<td>( \epsilon_3 + Y_{rtr} T_{P_{X_{\text{max}}}} - M^2_{\text{trim}} )</td>
<td>rad. ( \cdot \text{sec}^2 )</td>
<td>.001193</td>
<td>.04944</td>
<td>-.1255</td>
<td>-.3404</td>
</tr>
</tbody>
</table>

| \( \epsilon_3 + Y_{rtr} T_{P_{X_{\text{max}}}} - M^2_{\text{trim}} \) | rad. \( \cdot \text{sec}^2 \) | .04944 | -.1255 | -.3404 | 

\[ T_{P_{X_{\text{max}}}} \] (lb) | \( T_{P_{X_{\text{max}}}} \) \( /T_{2_{\text{total}}} \) | \( \epsilon \) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.03540</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>.08170</td>
</tr>
<tr>
<td>28,000</td>
<td>1.821</td>
<td>.2612</td>
</tr>
<tr>
<td>58,000</td>
<td>3.641</td>
<td>.5012</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ T_{Y_{\text{max}}} = 759 \text{ lb.} \]
\[ T_{Y_{\text{max}}} = 759 \text{ lb.} \]
\[ X_{rtr} = 76 \text{ ft.} \]
\[ Y_{rtr} = 163 \text{ ft.} \]
\[ T_{R_{Y_{\text{max}}}} = 750 \text{ lb.} \]
\[ I_2 = 17,645,000 \text{ sl. ft.}^2 \]
\[ X_{TR} = 5 \text{ ft.} \]

DESIGN NO. C-76/85-609

\( \Psi = 90 \text{ degrees} \)

\( c_1 = 2X_{rtr} T_{Y_{\text{max}}} + 2X_{rtr} T_{Y_{\text{max}}} + X_{TR} T_{R_{Y_{\text{max}}}} = 370,302 \text{ ft. lb.} \)

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>Drag (D)</th>
<th>Aero. Yawing mom. (M_{2 trim})</th>
</tr>
</thead>
<tbody>
<tr>
<td>kt.</td>
<td>lb.</td>
<td>ft. lb.</td>
</tr>
<tr>
<td>0</td>
<td>5,938</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>16,532</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>32,440</td>
<td>0</td>
</tr>
</tbody>
</table>

\( \epsilon_1 = \frac{D \sin \psi}{4} \)

\( \epsilon_2 = Y_{rtr} \frac{D \cos \psi}{2} \)

If \( \epsilon_1 \geq T_{Y_{\text{max}}} \), \( T_{Y_{1}} = T_{Y_{\text{max}}} \) and \( T_{R_{Y_{1}}} = 2(\epsilon_1 - T_{Y_{\text{max}}}) \)

If \( \epsilon_1 \leq T_{Y_{\text{max}}} \), \( T_{Y_{1}} = \epsilon_1 \) and \( T_{R_{Y_{1}}} = 0 \)

<table>
<thead>
<tr>
<th>( T_{Y_{1}} )</th>
<th>( T_{R_{Y_{1}}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>lb.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>759</td>
<td>1,460</td>
</tr>
<tr>
<td>759</td>
<td>6,748</td>
</tr>
<tr>
<td>759</td>
<td>14,702</td>
</tr>
</tbody>
</table>

\( \epsilon_3 = c_1 - \epsilon_2 - 2X_{rtr} T_{Y_{1}} - 2X_{TR} T_{R_{Y_{1}}} \)

\( \frac{M_{2_{\text{max}}} - M_{2_{\text{trim}}}}{I_2} \frac{T_{P_{x_{\text{max}}}} - M_{2_{\text{trim}}}}{T_{P_{x_{\text{max}}}}/I_2_{\text{total}}} \)

\( \frac{T_{P_{x_{\text{max}}}}}{I_2_{\text{total}}} \)

<table>
<thead>
<tr>
<th>( T_{P_{x_{\text{max}}}} )</th>
<th>( T_{P_{x_{\text{max}}}}/I_2_{\text{total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb.</td>
<td>rad. sec.</td>
</tr>
<tr>
<td>1,560</td>
<td>.109</td>
</tr>
<tr>
<td></td>
<td>rad. sec.</td>
</tr>
<tr>
<td>.03540</td>
<td>.02803</td>
</tr>
<tr>
<td>.02507</td>
<td>.02053</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
</tr>
<tr>
<td></td>
<td>rad. sec.</td>
</tr>
<tr>
<td>.08103</td>
<td>.07367</td>
</tr>
<tr>
<td>.07067</td>
<td>.06616</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
</tr>
<tr>
<td></td>
<td>rad. sec.</td>
</tr>
<tr>
<td>.2612</td>
<td>.7538</td>
</tr>
<tr>
<td>.2508</td>
<td>.2463</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
</tr>
<tr>
<td></td>
<td>rad. sec.</td>
</tr>
<tr>
<td>.5013</td>
<td>.4940</td>
</tr>
<tr>
<td>.4910</td>
<td>.4865</td>
</tr>
</tbody>
</table>

-1.34-
### ACCELERATION IN YAW

\[ T_{X_{\text{max}}} = 759 \text{ lb.} \]
\[ T_{Y_{\text{max}}} = 759 \text{ lb.} \]
\[ X_{\text{rtr}} = 130 \text{ ft.} \]
\[ Y_{\text{rtr}} = 154 \text{ ft.} \]
\[ T_{R_{Y_{\text{max}}}} = 750 \text{ lb.} \]
\[ I_{z} = 21,567,000 \text{ sl. ft.}^2 \]
\[ X_{\text{TR}} = 32 \text{ ft.} \]

**Design No. B0130/85-.609**

\[ \psi = 0 \text{ degrees} \]

\[ c_{1} = 2X_{\text{rtr}} T_{X_{\text{max}}} + 2(X_{\text{rtr}} T_{Y_{\text{max}}} + X_{\text{TR}} T_{R_{Y_{\text{max}}}}) = 479,112 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aero. Yawing Moment ( (M_{z_{\text{trim}}}) )</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_{1} = D_{\text{min}} \psi )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \delta_{2} = Y_{\text{rtr}} D_{\text{cos}} \psi )</td>
<td>ft. lb.</td>
<td>0</td>
<td>68,299</td>
<td>109,497</td>
</tr>
</tbody>
</table>

If \( \delta_{1} \geq T_{Y_{\text{max}}} \), \( T_{X_{1}} = T_{Y_{\text{max}}} \) and \( T_{R_{Y_{1}}} = 2 (\delta_{1} - T_{Y_{\text{max}}}) \)

### Drag (D)

\[ D_{\text{min}} = \frac{\text{lb.}}{\text{deg.}} \]

\[ D_{\text{cos}} = \frac{\text{ft. lb.}}{\text{deg.}} \]

### Aero. Yawing Moment

\[ (M_{z_{\text{trim}}}) = \frac{\text{lb. ft.}}{\text{deg.}} \]

\[ \delta_{2} = Y_{\text{rtr}} D_{\text{cos}} \psi \]

\[ I_{z} = 21,567,000 \text{ sl. ft.}^2 \]

### Yawing Moment

\[ \delta_{3} = \delta_{1} - \delta_{2} - 2X_{\text{rtr}} T_{X_{1}} \]

\[ \delta_{3} = \delta_{1} - \delta_{2} - 2X_{\text{rtr}} T_{X_{1}} \]

\[ = 2X_{\text{rtr}} T_{R_{Y_{1}}} \]

\[ \delta_{3} = \delta_{1} - \delta_{2} - 2X_{\text{rtr}} T_{X_{1}} \]

\[ = 2X_{\text{rtr}} T_{R_{Y_{1}}} \]

\[ = \frac{M_{z_{\text{max}}} - M_{z_{\text{trim}}}}{I_{z}} \]

\[ = \frac{\text{rad. sec}^2}{\text{ft. lb.}} \]

### Yawing Moment

\[ \delta_{3} + Y_{\text{rtr}} T_{p_{x_{\text{max}}} - M_{z_{\text{trim}}}} \]

\[ = \frac{\text{rad. sec}^2}{\text{ft. lb.}} \]

\[ T_{p_{x_{\text{max}}} - M_{z_{\text{trim}}}} \]

\[ = \frac{T_{p_{x_{\text{max}}} - M_{z_{\text{trim}}}}}{I_{z}} \]

\[ = \frac{\text{rad. sec}^2}{\text{ft. lb.}} \]

<table>
<thead>
<tr>
<th>( T_{p_{x_{\text{max}}} - M_{z_{\text{trim}}}} )</th>
<th>( I_{z} )</th>
<th>( \frac{T_{p_{x_{\text{max}}} - M_{z_{\text{trim}}}}}{I_{z}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.03575</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>.06863</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>.2072</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>.3047</td>
</tr>
</tbody>
</table>

-135-
ACCELERATION IN YAW

\[ \sum F_{y} = ma \]
\[ T_{x} - T_{y} \sin \psi = T_{y} \cos \psi \]
\[ T_{x} = T_{x_{max}} \]
\[ T_{y} = T_{y_{max}} \]
\[ x_{rtr} = 130 \text{ ft.} \]
\[ y_{rtr} = 154 \text{ ft.} \]
\[ T_{y_{max}} = 750 \text{ lb.} \]
\[ I_{z} = 21,567,000 \text{ sl.f.}^{2} \]
\[ L_{TR} = 32 \text{ ft.} \]

DESIGN NO. B-130/.85-.609

\[ \psi = 30 \text{ Degrees} \]

\[ c_{1} = 2x_{rtr} T_{x_{max}} + 2(x_{rtr} T_{y_{max}} + x_{TR} T_{y_{max}}) = 479,112 \text{ ft.lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>-</td>
<td>2,636</td>
<td>7,314</td>
<td>14,352</td>
</tr>
<tr>
<td>Aero.Yawing Moment (Mz trim)</td>
<td>ft.lb.</td>
<td>0</td>
<td>272,838</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>( \phi_{1} = D \sin \psi )</td>
<td>lb.</td>
<td>0</td>
<td>329</td>
<td>914</td>
<td>1,794</td>
</tr>
<tr>
<td>( \phi_{2} = Y_{rtr} \frac{D \cos \psi}{2} )</td>
<td>ft.lb.</td>
<td>0</td>
<td>175,778</td>
<td>487,726</td>
<td>957,048</td>
</tr>
</tbody>
</table>

If \( \phi_{1} \geq T_{y_{max}} \), \( T_{y_{1}} = T_{y_{max}} \) and \( \phi_{3} = 2 (\phi_{1} - T_{y_{max}}) \)

| \( T_{y_{1}} \) | lb. | 0 | 329 | 759 | 759 |
| \( T_{y_{max}} \) | lb. | 0 | 0 | 2,070 | 2,070 |
| \( \phi_{3} = c_{1} - \phi_{2} - 2x_{rtr} T_{x_{1}} - 2x_{TR} T_{y_{1}} \) | ft.lb. | 0 | 0 | 310 | 0 |

\[ \ddot{z} = x_{rtr} T_{x_{max}} - M_{z trim} \]
\[ I_{z} \]

<table>
<thead>
<tr>
<th>( T_{P_{x_{max}}} (lb) )</th>
<th>( T_{P_{x_{max}}} / T_{z_{total}} )</th>
<th>( \dot{z} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.03335</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>.06863</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>.2079</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>.3935</td>
</tr>
</tbody>
</table>

-136-
ACCELERATION IN YAW

\[
\begin{align*}
X_{rtr} &= 130 \text{ ft.} \\
Y_{rtr} &= 154 \text{ ft.} \\
I_2 &= 21,567,000 \text{ sl. ft.}^2 \\
X_{TR} &= 32 \text{ ft.}
\end{align*}
\]

**Design NO.** B-130/85-.609

\( \psi = 45 \text{ Degrees} \)

\[ c_1 = 2Y_{rtr} T_{ymax} + 2(X_{rtr} T_{ymax} + X_{TR} T_{RY}) = 479.112 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity ((V))</th>
<th>(D)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aero. Yawingmom. (Mz trim)</td>
<td>ft. lb.</td>
<td>315.050</td>
<td>875.138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( e_1 = D \sin \psi )</td>
<td>lb.</td>
<td>724.78</td>
<td>2013.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( e_2 = Y_{rtr} D \cos \psi )</td>
<td>ft. lb.</td>
<td>223.234</td>
<td>620.099</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \begin{align*}
&\text{If } e_1 \geq T_{ymax} \Rightarrow T_{Y_1} = T_{ymax} \text{ and } T_{RY_1} = 2(e_1 - T_{ymax}) \\
&\text{If } e_1 \leq T_{ymax} \Rightarrow T_{Y_1} = e_1 \text{ and } T_{RY_1} = 0
\end{align*} \]

| \( T_{Y_1} \) | lb. | 724.78 | 759 |
| \( T_{RY_1} \) | lb. | 0 | 2509 |

\[ e_3 = c_1 - e_2 - 2X_{rtr} T_{Y_1} \]

\[ \frac{M_z_{max} - M_z_{trim}}{I_2} \]

\[ \frac{T_{P_x_{max}}}{T_{P_x_{max}} / I_2 \text{ total}} \]

<table>
<thead>
<tr>
<th>( T_{P_x_{max}} ) (lb)</th>
<th>( T_{P_x_{max}} / I_2 \text{ total} )</th>
<th>( \hat{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.428</td>
<td>0.030</td>
<td>-0.0004</td>
</tr>
<tr>
<td>1.785</td>
<td>0.125</td>
<td>-0.0013</td>
</tr>
<tr>
<td>1.560</td>
<td>0.109</td>
<td>-0.0003</td>
</tr>
<tr>
<td>6.500</td>
<td>0.455</td>
<td>0.0349</td>
</tr>
</tbody>
</table>
ACCELERATION IN YAW

\[ \begin{align*}
T_y &= 759 \text{ lb.} \\
T_y &= 759 \text{ lb.} \\
D_{rtr} &= 130 \text{ ft.} \\
D_{rtr} &= 154 \text{ ft.} \\
T_{RY\max} &= 750 \text{ lb.} \\
I_z &= 21,567,000 \text{ sl. ft.}^2 \\
X_{TR} &= 32 \text{ ft.}
\end{align*} \]

DESIGN NO. 8-130/.85,.609

\[ \psi = 60 \text{ Degrees} \]

\[ c_1 = 2D_{rtr} T_y\max + 2(D_{rtr} T_y\max + X_{TR} T_{RY\max}) = 479,112 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity ((V))</th>
<th>(\text{kt.})</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag ((D))</td>
<td>lb.</td>
<td>0</td>
<td>5,249</td>
<td>14,564</td>
<td>28,579</td>
</tr>
<tr>
<td>Aero. Yawing Momen. ((M_z\trim))</td>
<td>ft. lb.</td>
<td>0</td>
<td>272,538</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>(\delta_1) = D \cdot \sin \psi</td>
<td>lb.</td>
<td>0</td>
<td>1,136</td>
<td>3,153</td>
<td>6,187</td>
</tr>
<tr>
<td>(\delta_2) = T_{rtr} \cdot \frac{D \cdot \cos \psi}{2}</td>
<td>ft. lb.</td>
<td>0</td>
<td>202,086</td>
<td>560,714</td>
<td>1,100,291</td>
</tr>
</tbody>
</table>

If \(\delta_1 \geq T_y\max\), \(T_y = T_y\max\) and \(T_{RY} = 2(\delta_1 - T_y\max)\)

\[ \begin{align*}
\delta_1 &\leq T_y\max, \quad T_y = \delta_1 \quad \text{and} \quad T_{RY} = 0
\end{align*} \]

| \(T_y\max\) | lb. | 0 | 759 | 759 | 759 |
| \(T_{RY}\max\) | lb. | 0 | 754 | 4,788 | 10,856 |
| \(\delta_3\) = \(c_1 - \delta_2 - 2D_{rtr} T_y\max \times D_{rtr} T_{RY}\max\) | ft. lb. | 479,112 | 31,430 | -226,746 | -615,098 |

\[ r = \frac{M_{z\max} - M_{z\trim}}{I_z} \]

\[ \begin{align*}
\delta_3 + Y_{rtr} T_{PX\max} - M_{z\trim} = \frac{T_{PX\max}}{I_z}
\end{align*} \]

<table>
<thead>
<tr>
<th>(T_{PX\max}) (lb)</th>
<th>(T_{PX\max}/I_z\trim)</th>
<th>rad. (\theta)</th>
<th>rad. (\theta)</th>
<th>rad. (\theta)</th>
<th>rad. (\theta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.03335</td>
<td>-.0000541</td>
<td>-.03452</td>
<td>-.0510562</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>.06661</td>
<td>.0352</td>
<td>.0000591</td>
<td>-.0510562</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>.2075</td>
<td>.1745</td>
<td>.1340</td>
<td>.08826</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>.3225</td>
<td>.2601</td>
<td>.1257</td>
<td>.2739</td>
</tr>
</tbody>
</table>
**ACCELERATION IN X-AX**

\[ V \]

\[ \psi \]

\[ X_{\text{max}} = 759 \text{ lb.} \]
\[ Y_{\text{max}} = 759 \text{ lb.} \]
\[ X_{\text{max}} = 130 \text{ ft.} \]
\[ Y_{\text{max}} = 154 \text{ ft.} \]
\[ T_{\text{max}} = 750 \text{ lb.} \]
\[ I_2 = 21,567,000 \text{ sl. ft.}^2 \]
\[ X_{\text{TR}} = 32 \text{ ft.} \]

**DESIGN NO.** B-130/85-609

\[ \psi = 90 \text{ Degrees} \]

\[ c_1 = 2Y_{\text{TR}} T_{\text{max}} + 2(X_{\text{TR}} Y_{\text{max}} + X_{\text{TR}} T_{\text{max}}) = 479,112 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>0</td>
<td>6.15</td>
<td>17.104</td>
<td>33.563</td>
</tr>
<tr>
<td>Aero.Yawing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yawing Yaw.</td>
<td>0</td>
<td>1.541</td>
<td>4.276</td>
<td>6.390</td>
</tr>
<tr>
<td>Yawing Yaw.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \[ \epsilon_i \geq Y_{\text{max}}, T_{\text{TR}} = Y_{\text{max}} \text{ and } T_{R_{Yi}} = 2(\epsilon_i - Y_{\text{max}}) \]

\[ \epsilon_i \leq Y_{\text{max}}, T_{\text{TR}} = \epsilon_i \text{ and } T_{R_{Yi}} = 0 \]

| \(T_{Y_1}\) | 0 | 1.564 | 7.034 | 15.262 |
| \(T_{R_{Y_1}}\) | 0 | 479,112 | 181,676 | -168,404 | -594,996 |

| \(\epsilon_3 = c_1 - \epsilon_2 - 2X_{\text{TR}} T_{X_{\text{TR}}} \) | ft. lb. | 479,112 | 181,676 | -168,404 | -594,996 |

| \(\epsilon_3 + Y_{\text{TR}} X_{\text{max}} - M_{Z_{\text{trim}}} \) | rad. sec.² | 0.03335 | 0.01856 | 0.003331 | 0.01645 |

| \(T_{P_{X_{\text{max}}}} (lb) \) | \(T_{P_{X_{\text{max}}}} / I_2\) | rad. sec.² | 0.03335 | 0.01856 | 0.003331 | 0.01645 |

1.560 | .109 | .03335 | .01856 | .003331 | .01645 |
6.500 | .455 | .06863 | .05484 | .03661 | .01883 |
26,000 | 1.821 | .2079 | .1941 | .1778 | .1581 |
52,000 | 3.641 | .3935 | .3797 | .3635 | .3437 |

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ACCELERATION IN YAW

DESIGN NO. A-184/A.85-609

\( \psi = 0 \) Degrees

\[ c_1 = 2X_{tr} T_{x_{max}} + 2(X_{tr} T_{y_{max}} + X_{tr} T_{y_{max}}) = 575,778 \text{ ft} \cdot \text{lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>898</td>
<td>2,493</td>
<td>4,892</td>
</tr>
<tr>
<td>Aero. Yawing Moment (M_{z_{trim}})</td>
<td>ft. lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_1 = \frac{D \sin \psi}{g} )</td>
<td>lb.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_2 = \frac{Y_{tr} D \cos \psi}{2} )</td>
<td>ft. lb.</td>
<td>0</td>
<td>61,513</td>
<td>170,770</td>
<td>335,102</td>
</tr>
</tbody>
</table>

If \( \epsilon_1 \geq T_{y_{max}} \), \( T_{x_1} = T_{y_{max}} \) and \( T_{p_{y_1}} = 2(\epsilon_1 - T_{y_{max}}) \)

| \( T_{y_1} \) | lb. | 0 | 0 | 0 | 0 |
| \( T_{p_{y_1}} \) | lb. | 0 | 0 | 0 | 0 |
| \( e_3 = c_1 - c_2 - 2X_{tr} T_{y_1} - 2X_{tr} T_{p_{y_1}} \) | ft. lb. | 575,778 | 514,265 | 405,008 | 240,676 |
| \( \dot{r} = \frac{M_{z_{max}} - M_{z_{trim}}}{I_z} \) | rad. sec. | .02923 | .02696 | .02291 | .01683 |
| \( \epsilon_3 + Y_{tr} T_{p_{x_{max}} - M_{z_{trim}}} \) | sec. | .2851 | .2828 | .2788 | .2727 |

<table>
<thead>
<tr>
<th>( T_{p_{x_{max}} (lb)} )</th>
<th>( T_{p_{x_{max}} / I_z_{total}} )</th>
<th>( \dot{r} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.02923</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>.05429</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>.1532</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>.2851</td>
</tr>
</tbody>
</table>
### ACCELERATION IN YAW

**Design No. A-104/85-609**

\[ \Psi = 30 \text{ Degrees} \]

\[ \theta_1 = 2Y_{rtr} T_{x_{max}} + 2(X_{rtr} T_{y_{max}} X_{TR} T_{Ry_{max}}) = 575,778 \text{ ft} \cdot \text{lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>2,705</td>
<td>7,505</td>
<td>14,726</td>
</tr>
<tr>
<td>Aero-Yawing Moment ((M_{Z_{trim}}))</td>
<td>ft.lbf.</td>
<td>0</td>
<td>272,838</td>
<td>775,782</td>
<td>1,485,649</td>
</tr>
</tbody>
</table>

\[ \varepsilon_1 = D \sin \Psi \]

\[ \varepsilon_2 = Y_{rtr} \frac{D \cos \Psi}{2} \]

If \( \varepsilon_1 \geq T_{y_{max}} \):

\[ T_{y_1} = T_{y_{max}} \]

and

\[ T_{r_{y_1}} = 2(\varepsilon_1 - T_{y_{max}}) \]

If \( \varepsilon_1 < T_{y_{max}} \):

\[ T_{y_1} = \varepsilon_1 \]

and

\[ T_{r_{y_1}} = 0 \]

| \( T_{y_1} \) | lb. | 0 | 338 | 759 | 759 |
| \( T_{r_{y_1}} \) | lb. | 0 | 0 | 358 | 2,162 |

\[ \varepsilon_3 = \theta_1 - \varepsilon_2 - 2X_{rtr} T_{y_1} - 2X_{TR} T_{R_{y_1}} \]

\[ \varepsilon_3 = \frac{M_{Z_{max}} - M_{Z_{trim}}}{T_{z_{total}}} \]

\[ \varepsilon_3 \cdot Y_{rtr} T_{y_{max}} - M_{Z_{trim}} \]

\[ \frac{T_{p_{x_{max}}} (lb)}{T_{p_{x_{max}}} / T_{z_{total}}} \]

| \( T_{p_{x_{max}}} \) | rad. sec. \(^2\) | .109 | .109 | .02923 | .008583 | -.0272 | -.07790 |
| \( T_{p_{x_{max}}} \) | rad. sec. \(^2\) | .455 | .455 | .05430 | .036364 | -.002162 | -.05285 |
| \( T_{p_{x_{max}}} \) | rad. sec. \(^2\) | 1.821 | 1.821 | .1532 | .1326 | .09676 | .04607 |
| \( T_{p_{x_{max}}} \) | rad. sec. \(^2\) | 3.641 | 3.641 | .2851 | .2645 | .2286 | .1780 |
ACCELERATION IN YAW

\[
\begin{align*}
\tau_{y_{max}} &= 759 \text{ lb.} \\
\tau_{r_{max}} &= 759 \text{ lb.} \\
X_{r_{tr}} &= 184 \text{ ft.} \\
Y_{r_{tr}} &= 137 \text{ ft.} \\
\tau_{r_{max}} &= 750 \text{ lb.} \\
I_2 &= 27,000,000 \text{ sl. ft.}^2 \\
X_{r_{TR}} &= 59 \text{ ft.}
\end{align*}
\]

DESIGN NO. A-1041/05-609

\[\psi = 45 \text{ Degrees}\]

\[a_1 = 2X_{r_{tr}} \tau_{y_{max}} + 2(X_{r_{tr}} \tau_{r_{max}} + X_{r_{TR}} \tau_{r_{max}}) = 575.778 \text{ ft.lb.}\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>4,300</td>
<td>11,994</td>
<td></td>
</tr>
<tr>
<td>Aero. Yawing Mom. (M_{2,trim})</td>
<td>ft.lb.</td>
<td>315,050</td>
<td>875,138</td>
<td></td>
</tr>
<tr>
<td>(\delta_1)</td>
<td>(\frac{D}{\cos \psi})</td>
<td>lb.</td>
<td>760.14</td>
<td>2,111.4</td>
</tr>
<tr>
<td>(\delta_2)</td>
<td>(\frac{Y_{r_{tr}} D}{\cos \psi})</td>
<td>ft.lb.</td>
<td>208,278</td>
<td>578,529</td>
</tr>
<tr>
<td>If (\delta_1 \geq \tau_{r_{max}}), (\tau_{r_{1}} = \tau_{r_{max}}) and (\tau_{r_{2}} = 2(\delta_1 - \tau_{r_{max}}))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\delta_1 \leq \tau_{r_{max}}), (\tau_{r_{1}} = \delta_1) and (\tau_{r_{2}} = 0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\tau_{r_{1}})</td>
<td>lb.</td>
<td>759</td>
<td>759</td>
<td></td>
</tr>
<tr>
<td>(\tau_{r_{2}})</td>
<td>lb.</td>
<td>2.28</td>
<td>2.705</td>
<td></td>
</tr>
<tr>
<td>(\delta_3)</td>
<td>(\delta_1 - \delta_2 - 2X_{r_{tr}} \tau_{r_{1}})</td>
<td>ft.lb.</td>
<td>87,919</td>
<td>-601253</td>
</tr>
<tr>
<td>(r)</td>
<td>(\frac{M_{2,\text{max}} - M_{2,\text{trim}}}{I_2})</td>
<td>rad. sec. (^2)</td>
<td>(\frac{\delta_3 + Y_{r_{tr}} \tau_{y_{max}} - M_{2,\text{trim}}}{I_2})</td>
<td>(\frac{\tau_{y_{max}}}{I_2})</td>
</tr>
<tr>
<td>(T_{P_{X_{max}}, (lb.}} \quad \frac{T_{P_{X_{max}}}}{I_2} \quad \text{rad. sec.}^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>428</td>
<td>.030</td>
<td>.2890</td>
<td>-.05250</td>
<td></td>
</tr>
<tr>
<td>1,785</td>
<td>.125</td>
<td>.006448</td>
<td>-.04561</td>
<td></td>
</tr>
<tr>
<td>1,560</td>
<td>.109</td>
<td>.0004966</td>
<td>-.04676</td>
<td></td>
</tr>
<tr>
<td>6,500</td>
<td>.453</td>
<td>.02456</td>
<td>-.02149</td>
<td></td>
</tr>
</tbody>
</table>
ACCELERATION IN XAW

\[ m = \begin{bmatrix} m_x \\ m_y \end{bmatrix} \]

\[ T_x = 759 \text{ lb.} \]
\[ T_y = 759 \text{ lb.} \]
\[ X_{rtr} = 184 \text{ ft.} \]
\[ Y_{rtr} = 137 \text{ ft.} \]
\[ T_{tr} = 750 \text{ lb.} \]
\[ I_z = 27,007,000 \text{ sl. ft.}^2 \]
\[ X_{tr} = 59 \text{ ft.} \]

Design No. A-184/1.85-.609

\[ \psi = 60 \text{ Degrees} \]

\[ c_1 = 2Y_{rtr} T_{r_{max}}^* + 2(X_{rtr} T_{r_{max}}^* + X_{tr} T_{r_{max}}^*) = 575.778 \text{ ft. lb.} \]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>kt.</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>lb.</td>
<td>0</td>
<td>5.447</td>
<td>15.116</td>
<td>29.661</td>
</tr>
<tr>
<td>Aero. Yawing Moment (M_{z_{trim}})</td>
<td>ft. lb.</td>
<td>0</td>
<td>272,836</td>
<td>757,882</td>
<td>1,485,449</td>
</tr>
<tr>
<td>[ \varepsilon_1 = \frac{D \sin \psi}{4} ]</td>
<td>lb.</td>
<td>0</td>
<td>1,179</td>
<td>3,272</td>
<td>6,421</td>
</tr>
<tr>
<td>[ \varepsilon_2 = \frac{Y_{rtr} D \cos \psi}{2} ]</td>
<td>ft. lb.</td>
<td>0</td>
<td>186,559</td>
<td>517,723</td>
<td>1,015,889</td>
</tr>
</tbody>
</table>

If \[ \varepsilon_1 > T_{r_{max}}, T_{y_{1}} = T_{r_{max}} \] and \[ T_{r_{y_{1}}} = 2(\varepsilon_1 - T_{r_{max}}) \]

\[ \varepsilon_1 \leq T_{r_{max}}, T_{y_{1}} = \varepsilon_1 \] and \[ T_{r_{y_{1}}} = 0 \]

<table>
<thead>
<tr>
<th>T_{y_{1}}</th>
<th>lb.</th>
<th>0</th>
<th>759</th>
<th>759</th>
<th>759</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_{r_{y_{1}}}</td>
<td>lb.</td>
<td>0</td>
<td>840</td>
<td>5,026</td>
<td>11,324</td>
</tr>
<tr>
<td>[ \varepsilon_3 = c_1 - \varepsilon_2 - 2X_{rtr} T_{y_{1}} ]</td>
<td>ft. lb.</td>
<td>575,778</td>
<td>10,787</td>
<td>-614,325</td>
<td>-2,055,655</td>
</tr>
</tbody>
</table>

\[ \dot{r} = \frac{M_{z_{max}} - M_{z_{trim}}}{T_z} \]

<table>
<thead>
<tr>
<th>[ \varepsilon_3 + Y_{rtr} T_{p_{x_{max}}} - M_{z_{trim}} ]</th>
<th>rad. sec^2</th>
<th>[ T_{p_{x_{max}}} (lb) ]</th>
<th>[ \frac{T_{p_{x_{max}}}}{T_{z_{total}}} ]</th>
<th>[ \dot{r} ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
<td>rad. sec^2</td>
<td>.02923</td>
<td>-.001790</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
<td>rad. sec^2</td>
<td>.05427</td>
<td>.02327</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
<td>rad. sec^2</td>
<td>.1782</td>
<td>.1222</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
<td>rad. sec^2</td>
<td>.2851</td>
<td>.2541</td>
</tr>
</tbody>
</table>
### ACCELERATION IN YAW

**Design No.** A-184/85-.609

**\( \psi = 90 \text{ Degrees} \)**

\[
\omega_1 = 2Y_{rtr} T_{x_{max}} + 2 I_{rtr} T_{y_{max}} + I_{rtr} T_{r_{y_{max}}} = 575,778 \text{ ft.lb.}
\]

<table>
<thead>
<tr>
<th>Velocity (V)</th>
<th>0</th>
<th>15</th>
<th>25</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag (D)</td>
<td>0</td>
<td>6,374</td>
<td>17,687</td>
<td>34,707</td>
</tr>
<tr>
<td>Aero.Yawing Mom. ((M_{z_{trim}}))</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \varepsilon_1 = \frac{D \sin \psi}{D} )</td>
<td>0</td>
<td>1,593</td>
<td>4,421</td>
<td>8,626</td>
</tr>
<tr>
<td>( \varepsilon_2 = \frac{Y_{rtr} D \cos \psi}{I_{rtr}} )</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

If \( \varepsilon_1 \geq T_{y_{max}}, \quad T_{y_1} = T_{y_{max}} \) and \( T_{r_{y_1}} = 2(\varepsilon_1 - T_{y_{max}}) \)

If \( \varepsilon_1 \leq T_{y_{max}}, \quad T_{y_1} = \varepsilon_1 \) and \( T_{r_{y_1}} = 0 \)

| \( T_{x_1} \) | 0 | 759 | 759 | 759 |
| \( T_{r_{y_1}} \) | 0 | 1,668 | 7,324 | 15,834 |
| \( \varepsilon_3 = \varepsilon_1 - \varepsilon_2 - 2X_{rtr} T_{x_1} \) | 575,778 | 99,642 | -567,766 | -1,571,946 |

\( X = \frac{M_{z_{max}} - M_{z_{trim}}}{T_z} \)

\( \varepsilon_3 + Y_{rtr} T_{r_{tr}} T_{p_{x_{max}} - M_{z_{trim}}} \)

\[
\frac{T_{p_{x_{max}}} \text{ (lb)}}{T_{p_{x_{max}} \text{ / } T_z \text{ total}}} = \frac{1}{2}
\]

<table>
<thead>
<tr>
<th>( T_{p_{x_{max}}} \text{ (lb)} )</th>
<th>( T_{p_{x_{max}} / T_z \text{ total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,560</td>
<td>.109</td>
</tr>
<tr>
<td>6,500</td>
<td>.455</td>
</tr>
<tr>
<td>26,000</td>
<td>1.821</td>
</tr>
<tr>
<td>52,000</td>
<td>3.641</td>
</tr>
</tbody>
</table>

\( \psi_1 = 90 \text{ Degrees} \)
<table>
<thead>
<tr>
<th>DISTRIBUTION</th>
<th>NO. OF COPIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAVAIRSYS (AIR-03P32)</td>
<td>2</td>
</tr>
<tr>
<td>DDC</td>
<td>12</td>
</tr>
<tr>
<td>NAVAIRDEVCEN (6096)</td>
<td>10</td>
</tr>
</tbody>
</table>