5.4 Stability Characteristics of the Boeing 747

5.4.1 Longitudinal Stability Characteristics

In this section we summarize the longitudinal mass distribution and aerodynamic stability characteristics of a large, jet transport aircraft, the Boeing 747, at selected flight conditions. Data are summarized from the report by Heffley et al. [2]. Values for aerodynamic coefficients were scaled directly from plots of these variables, except for the derivatives $\mathbf{C}_{L_q}$ and $\mathbf{C}_{L_{\dot{\alpha}}}$ for which no data are provided. These values were computed from the values of the corresponding dimensional stability derivatives Z_q and $Z_{\dot{w}}$, which are provided in tabular form, with the sign of $Z_{\dot{w}}$ changed to correct a seemingly obvious error.

Condition numbers correspond to those in the report; Conditions 5-10 are for a clean aircraft, Condition 2 corresponds to a powered approach with gear up and 20° flaps. Angles of attack are with respect to the fuselage reference line.

Condition	2	5	7	9	10
h (ft)	SL	20,000	20,000	40,000	40,000
$\mathbf{M}_\infty$	0.25	0.500	0.800	0.800	0.900
α (degrees)	5.70	6.80	0.0	4.60	2.40
W (lbf)	564,032.	636,636.	636,636.	636,636.	636,636.
I_y (slug-ft^2)	32.3×10^6	33.1×10^6	33.1×10^6	33.1×10^6	33.1×10^6
$\mathbf{C}_L$	1.11	0.680	0.266	0.660	0.521
$\mathbf{C}_D$	0.102	0.0393	0.0174	0.0415	0.0415
$\mathbf{C}_{L_\alpha}$	5.70	4.67	4.24	4.92	5.57
$\mathbf{C}_{D\alpha}$	0.66	0.366	0.084	0.425	0.527
$\mathbf{C}_{m_\alpha}$	-1.26	-1.146	-.629	-1.033	-1.613
$\mathbf{C}_{L_{\dot{\alpha}}}$	6.7	6.53	5.99	5.91	5.53
$\mathbf{C}_{m_{\dot{\alpha}}}$	-3.2	-3.35	-5.40	-6.41	-8.82
$\mathbf{C}_{L_q}$	5.40	5.13	5.01	6.00	6.94
$\mathbf{C}_{m_q}$	-20.8	-20.7	-20.5	-24.0	-25.1
$\mathbf{C}_{L_\mathbf{M}}$	0.0	-.0875	0.105	0.205	-.278
$\mathbf{C}_{D_\mathbf{M}}$	0.0	0.0	0.008	0.0275	0.242
$\mathbf{C}_{m_\mathbf{M}}$	0.0	0.121	-.116	0.166	-.114
$\mathbf{C}_{L_{\delta_e}}$	0.338	0.356	0.270	0.367	0.300
$\mathbf{C}_{m_{\delta_e}}$	-1.34	-1.43	-1.06	-1.45	-1.20

Table 5.3: Longitudinal mass properties and aerodynamic stability derivatives for the Boeing 747 at selected flight conditions.

5.4.2 Lateral/Directional Stability Characteristics

In this section we summarize the lateral/directional mass distribution and aerodynamic stability characteristics of a large, jet transport aircraft, the Boeing 747, at selected flight conditions. Data are summarized from the report by Heffley et al. [2]. Values for aerodynamic coefficients were scaled directly from plots of these variables.

Condition numbers correspond to those in the report; Conditions 5-10 are for a clean aircraft, Condition 2 corresponds to a powered approach with gear up and 20° flaps. Moments and products of inertia are with respect to stability axes for the given flight condition. Angles of attack are with respect to the fuselage reference line.

Condition	2	5	7	9	10
h (ft)	SL	20,000	20,000	40,000	40,000
$\mathbf{M}_\infty$	0.25	0.500	0.800	0.800	0.900
α (degrees)	5.70	6.80	0.0	4.60	2.40
W (lbf)	564,032.	636,636.	636,636.	636,636.	636,636.
I_x (slug-ft^2)	14.3×10^6	18.4×10^6	18.2×10^6	18.2×10^6	18.2×10^6
I_z (slug-ft^2)	45.3×10^6	49.5×10^6	49.7×10^6	49.7×10^6	49.7×10^6
I_{xz} (slug-ft^2)	-2.23×10^6	-2.76×10^6	0.97×10^6	-1.56×10^6	$-.35 \times 10^6$
$\mathbf{C}_{y_\beta}$	-.96	-.90	-.81	-.88	-.92
$\mathbf{C}_{l_\beta}$	-.221	-.193	-.164	-.277	-.095
$\mathbf{C}_{n_\beta}$	0.150	0.147	0.179	0.195	0.207
$\mathbf{C}_{l_p}$	-.45	-.323	-.315	-.334	-.296
$\mathbf{C}_{n_p}$	-.121	-.0687	0.0028	-.0415	0.0230
$\mathbf{C}_{l_r}$	0.101	0.212	0.0979	0.300	0.193
$\mathbf{C}_{n_r}$	-.30	-.278	-.265	-.327	-.333
$\mathbf{C}_{l_{\delta_a}}$	0.0461	0.0129	0.0120	0.0137	0.0139
$\mathbf{C}_{n_{\delta_a}}$	0.0064	0.0015	0.0008	0.0002	-.0027
$\mathbf{C}_{y_{\delta_r}}$	0.175	0.1448	0.0841	0.1157	0.0620
$\mathbf{C}_{l_{\delta_r}}$	0.007	0.0039	0.0090	0.0070	0.0052
$\mathbf{C}_{n_{\delta_r}}$	-.109	-.1081	-.0988	-.1256	-.0914

Table 5.4: Lateral/Directional mass properties and aerodynamic stability derivatives for the Boeing 747 at selected flight conditions.