12.6.3 Level Limit Turn Performance Correction

A limit turn is one in which the aircraft performs a level turn beginning from maximum speed and maximum load factor and continues to decelerate at the N_{zb} limit until reaching the maximum C_L. At this point, the aircraft continues its level turning deceleration at the lift limit. This maneuver is also known as a "slow-down" turn.

Test day limit turn data is corrected to a standard specific excess power (P_s) for each given combination of altitude, Mach number and load factor (or AOA) limit. The following correction accounts for changes in trim drag, weight, and atmospheric affects on thrust.

$$P_{s_s} = P_{s_t} + \Delta P_s$$

where $$P_{s_t} = \frac{(F_{ex_t})V_{T_t}}{W_t} = \frac{(m_t a_{xw_t})V_{T_t}}{W_t} = \frac{\left(\frac{W_t a_{xw_t}}{g}\right)V_{T_t}}{W_t} = N_{xw_t}V_{T_t} = Ma_o\sqrt{\theta_t}N_{xw_t}$$

and

$$\Delta P_s = Ma_o\Big\{\left(F_{g_s}\cos\alpha_{F_s} + F_e\right)\tfrac{\sqrt{\theta_s}}{W_s} - \left(F_{g_t}\cos\alpha_{F_t} + F_e\right)\tfrac{\sqrt{\theta_t}}{W_t} + SC_{D_o}\left[\tfrac{q_t\sqrt{\theta_t}}{W_t} - \tfrac{q_s\sqrt{\theta_s}}{W_s}\right]$$
$$+\tfrac{Sq_t\sqrt{\theta_t}}{W_t}\left(m\left[\tfrac{N_{zw_t}W_t - Fg_{n_t}\sin\alpha_{F_t}}{q_t S}\right]^2 + \Delta C_{D_{trim_t}}\right) - \tfrac{Sq_s\sqrt{\theta_s}}{W_s}\left(m\left[\tfrac{N_{zw_s}W_s - F_{g_s}\sin\alpha_{F_s}}{q_s S}\right]^2 + \Delta C_{D_{trim_s}}\right)\Big\}$$

where $$\alpha_{F_t} = \iota_{T_t} - \frac{C_{L_{o\alpha}}}{a} + \frac{N_{zw_t}W_t - F_{g_t}\sin\alpha_{F_t}}{aq_t S} \qquad \text{(Eq'n 12.33)}$$

and $$\alpha_{F_s} = \iota_{T_s} - \frac{C_{L_{o\alpha}}}{a} + \frac{N_{zw_s}W_s - F_{g_s}\sin\alpha_{F_s}}{aq_s S}$$

As with the sustained level turn case, one cannot solve explicitly for α_F, so either assume an approximate value or iterate until a solution converges.

In For the simplified case where $\delta_t = \delta_s$, $cg_t = cg_{std}$, and $\sin\alpha_F = 0$, then the above equation reduces to

$$\Delta P_s = Ma_o\left\{\frac{\sqrt{\theta_s}}{W_s}\left[F_{n_s} - qSC_{D_o} - \frac{(N_{zw_s}W_s)^2}{qS\pi A\mathrm{Re}}\right] - \frac{\sqrt{\theta_t}}{W_t}\left[F_{n_t} - qSC_{D_o} - \frac{(N_{zw_t}W_t)^2}{qS\pi A\mathrm{Re}}\right]\right\} \qquad \text{(Eq'n 12.34)}$$